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Technological Strategies to Mitigate the Climate Change: Current Status and Future Trends

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Abbreviations: WMO: World Meteorological Organization; GWP: Global Warming Potential; UV: Ultraviolet; NETs: Negative Emissions Technologies; BECCS: Bioenergy with Capture and Storage; EW: Enhanced Weathering; AR: Afforestation and Reforestation; DAC: Direct Capture of CO_2

Introduction

The debate and controversy started by Arrhenius and Chamberlin in 1896 [1], about how anthropogenic changes have produced, since industrial age, an increase in greenhouse gases such as carbon dioxide, methane, and nitrous oxide in the Earth's atmosphere; that consequently have produced a climate change; seems now closed. The CO_2, CH_4 and NO_2 concentration in the atmosphere in pre-industrial age were 278 ppm, 721 ppb, and 269 ppb. Nowadays these levels have increased dramatically in 143%, 253%, and 121%, respectively [2]. The World Meteorological Organization (WMO) estimates that just the CO2 contributes with the 80% of the greenhouse gases problematic, because of its higher concentration than its global warming potential (GWP). The environmental efforts of countries focus on reducing emissions of these gases through the proposal and implementation of increasingly restrictive programs, in many cases by minimizing technology emissions. The aim of this work is to summarize the current state of these technologies.

The potential risk of climate change

As consequence of climate change, the global average temperature has increased 0.6°C, glacial and ice extent have diminished, the rise of 10-20cm in the sea level, heat waves, drought, flooding, more frequent and intense hurricanes, storms, and wildfire. Currently, many studies concluded significant relative risk of event's occurrence such as rise more than 3°C in temperature average, reduction in quantity and quality of water's sources, acceleration in biodiversity extinguish, ocean acidification, disruption and depletion of stratospheric ozone, damage in ecosystems, threat to food security, desertification, soil degradation, loss of agricultural productivity, and immersion, flooding and erosion in the coast by rise sea level [3]. Climate change is nowadays the biggest threat in all over the world and it will impact negatively in wellbeing in rich countries and slow down the development in poor counties. Of all problems associated to climate change, the health issues attract citizen and political attention, and they have become in a pressure tool to achieve policies, actions, and systems to mitigate and adapt to the problem [3].

There are direct and indirect implications of climate change-related on health. Asthma, respiratory allergies and airway diseases may become more prevalent because of increased human exposure to pollen, molds, air pollution and dust. Cancer risk caused by extended human exposure to ultraviolet (UV) rays, chemicals, and toxins. Cardiovascular diseases and stroke, the existing pathologist may be exacerbated by increasing heat stress, body burden of airborne particles, and change of zoonotic vector that because infectious diseases associated with cardiovascular diseases. Foodborne diseases and malnutrition unleashed by staple food shortage and food contamination. Morbidity and mortality related to heat and water-related events such as hurricanes, floods, droughts, and wildfires. Effects in human developmental because of malnutrition and exposure to contaminants and biotoxins. Mental health and stress-related disorders caused by extreme events, population displacement, damage to property, the death of the loved ones, and chronical stress. Neurological diseases and disorders due to exposure to neurological hazards such as biotoxins, metals, chemicals, and pesticides. Vectorborne and zoonotic diseases increasing their risk due to shortening of pathogen incubation periods, and disruption and relocation of large human population. Waterborne diseases by the incidence of water contaminated with harmful pathogens and chemicals because of increases in water temperature, precipitations, evaporation-transpiration rates, and changes in coastal ecosystem health [4-6].

Mitigation and Adaptation to Climate Change

The Paris 2014 agreement establishes a global warming goal of 2°C on pre-industrial average and to pursue efforts to limit increase to 1.5°C. It obligates all parties involved in climate change mitigation and adaptation. To achieve the goal, the world has to reduce greenhouse emissions, avoiding that CO_2 concentration in atmosphere reaches 550ppm [7], and to adopt negative emissions technologies (NETs) such as bioenergy with capture and storage (BECCS) [8], air direct capture of CO_2 from the environment (DAC) [9,10], enhanced weathering of minerals (EW) [11,12], afforestation and reforestation (AR) [13,14], acidification of oceans [15,16], carbon storage in soils [17,18], and conversion of biomass in recalcitrant biochar for use in soils [19]. The implementation of NETs could not be enough to mitigate the climate change because of the low potential to reduce CO_2 to high scale, the biophysical and economical recourse implications and the competence with social challenges such as food, water, and food security [20]. The CO_2 emissions to the atmosphere can be controlled to reduce the CO_2 levels that affect to global warming using adsorbents, such as zeolites, carbon derived materials, hydrotalcites, amine-functionalized mesoporous silicas and metal organic frameworks (MOFs) [21-25].

The CO_2 uptake capacities under several conditions have been evaluated as important aspects to select the suitable adsorbents. In the same way, the development of effective CO_2 low-cost adsorbents from waste precursors have been reported including by-products derived from coal, biomass, water treatment, eggshells and mussel shells, lime mud, fly ash, among others [25-30]. A more intensive action to mitigate climate change is to complement the NETs application with the development of CO_2 valorization technologies. There is a huge network of possibilities to produce value-added products from diluted and concentrated CO_2, through of mineralization, physical, biological, and chemical processes [7]. The supercritical CO_2 is considerate a green solvent with physicochemical properties that potentiate as a swelling agent [31,32], fluid in Rankine cycles [33], fracturing fluid [34], bioactive compounds in food and pharmaceutical industry [35,36], catalytic processes [37,38], and polymer industry [39,40].

The mineralization of CO_2 is a process of precipitation that produce stable compounds such as green concretes [41], cement [42], calcium carbonates [43], and use CO_2 as the precursor of concrete block and cement mortar with enhanced properties [44,45]. Chemical transformation of raw materials, CO_2 and biomass, into value-added and neutral-carbon products, such as urea [46], formaldehyde [47], carbonates [48], carbamates [49], polycarbonates y polycarbamates [50]; is a promissory way to create a carbon economic system. The most important valorization route is the catalytic reduction of CO_2 to organic fuel for transport. This process is compatible with the concept of sustainable organic fuel transport SOFT, focused on the attack the GHG emissions from transportation remain the current technology but development carbon-neutral liquid fuels through three key components such as H_2, CO_2, and catalysts [51,52]. The chemical transformation through catalytic routes with active, selective, and thermal and mechanical stable materials lead the production of methanol [53,54], dimethyl ether [55,56], synthesis gas [57,58], and fuels that could reduce current GHG emission in 82-86%, minimize pollutants such as SOx and NOx, and reduce fuel depletion in 82-91% [7].

Conclusion

Many studies alert about deep consequences in the environment, wellbeing, and health caused by climatic change. Actions to mitigate and adapt to this phenomenon are needed and were agreed into 160 countries in Paris in 2014. The main actions promoted are the application of NETs, however, seems improbable that just NETs could slow down the global warming. The complement of capture technologies attached to CO_2 valorization routes, specifically the production of fuel to transport could have synergetic positive effects in the environment. The implementation of CO_2 capture and valorization technologies lead the industrialization and economic development all around the world under sustainable principles and offer various options to reduce step by step the dependence of chemical and fuel from fossil sources.

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References

1. A Costello, M Abbas, A Allen, S Ball, S Bell, et al. (2009) Managing the health effects of climate change: Lancet and University College London Institute for Global Health Commission. The Lancet 373(9676): 1693-1733.
2. B C O Neill, M Oppenheimer, R Warren, S Hallegatte, RE Kopp, et al. (2017) The Bank's response to climate change. Nature Climate Change 7: 28-37.
3. A Rossati (2017) Global Warming and Its Health Impact. The International Journal of Occupational and Environmental Medicine 8(1): 963-967.
4. P Wayne, S Foster, J Connolly, F Bazzaz, P Epstein (2002) Production of allergenic pollen by ragweed (Ambrosia artemisiifolia L.) is increased in CO_2-enriched atmospheres. Annals of Allergy, Asthma & Immunology 88(3): 279-282.
5. CJ Portier, TK Thigpen, SR Carter, CH Dilworth, AE Grambsch, et al. (2010) A human health perspective on climate change: a report outlining the research needs on the human health effects of climate change.
6. M Wei, S Brandhorst, M Shelehchi, H Mirzaei, CW Cheng, et al. (2017) Fasting-mimicking diet and markers/risk factors for aging, diabetes, cancer, and cardiovascular disease. Science Translational Medicine 9(377): 1-12.
7. SY Pan, PC Chiang, W Pan, H Kim (2018) Advances in state-of-art valorization technologies for captured CO_2 toward sustainable carbon cycle. Critical Reviews in Environmental Science and Technology pp. 1-64.
8. M Fajardy, N Mac Dowell (2017) Can BECCS deliver sustainable and resource efficient negative emissions? Energy & Environmental Science 10(6): 1389-1426.
9. J Wilcox, PC Psarras, S Liguori (2017) Assessment of reasonable opportunities for direct air capture. Environmental Research Letters 12(6): 065001.
10. Y Ishimoto, M Sugiyama, E Kato, R Moriyama, K Tsuzuki, et al. (2017) Putting Costs of Direct Air Capture in Context. FCEA Working Paper Series (2): 1-21.

11. F Montserrat, P Renforth, J Hartmann, M Leermakers, P Knops, et al. (2017) Olivine Dissolution in Seawater: Implications for CO_2 Sequestration through Enhanced Weathering in Coastal Environments. Environmental Science & Technology 51: 3960-3972.

12. FJ Meysman, F Montserrat (2017) Negative CO_2 emissions via enhanced silicate weathering in coastal environments. Biology Letters 13: 20160905.

13. A Harper, T Powell, P Cox, J House, C Huntingford, et al. (2018) Land-use emissions play a critical role in land-based mitigation for Paris climate targets. Nature Communications p. 1-13.

14. Noumi N, L Zapfack, P Pelbara, Awe Djongmo V, Tabue Mbobda RB (2018) Afforestation/Reforestation Based on Gmelina Arborea (Verbenaceae) in Tropical Africa: Floristic and Structural Analysis, Carbon Storage and Economic Value (Cameroon). Sustainability in Environment 3(2): 161-176.

15. MD Eisaman, JL Rivest, SD Karnitz, CF de Lannoy, A Jose, et al., (2018) Carbon Dioxide Removal/Negative Emissions Technologies Bibliography. International Journal of Greenhouse Gas Control 70: 254-261.

16. CF De Lannoy, MD Eisaman, A Jose, SD Karnitz, RW De Vaul, et al. (2018) Carbon Dioxide Removal/Negative Emissions Technologies Bibliography. International Journal of Greenhouse Gas Control 70: 243-253.

17. RJ Zomer, DA Bossio, R Sommer, LV Verchot (2017) Global Sequestration Potential of Increased Organic Carbon in Cropland Soils. Scientific Reports 7: 1-7.

18. A Bharali, KK Baruah, N Gogoi (2016) Methane emission from irrigated rice ecosystem: relationship with carbon fixation, partitioning and soil carbon storage. Paddy and Water Environment 15: 221-236.

19. M Krauss, R Ruser, T Müller, S Hansen, P Mäder, et al. (2017) Impact of reduced tillage on greenhouse gas emissions and soil carbon stocks in an organic grass-clover ley - winter wheat cropping sequence. Agriculture, Ecosystems & Environment 239: 324-333.

20. P Smith, SJ Davis, F Creutzig, S Fuss, J Minx, et al. (2015) Nature Climate Change 6: 42-50.

21. S Choi, JH Drese, Ch W Jones (2009) Adsorbent Materials for Carbon Dioxide Capture from Large Anthropogenic Point Sources. ChemSusChem 2: 796-854.

22. J Wang, L Huang, R Yang, Z Zhang, J Wu, et al. (2014) Recent advances in solid sorbents for CO_2 capture and new development trends. Energy Environ Sci. 7(11): 3478-3518.

23. SI Garcés, J Villarroel Rocha, K Sapag, SA Korili, A Gil (2013) Comparative Study of the Adsorption Equilibrium of CO_2 on Microporous Commercial Materials at Low Pressures. Ind Eng Chem Res 52(20): 6785-6793.

24. SI Garcés Polo, J Villarroel Rocha, K Sapag, SA Korili, A Gil (2018) Adsorption of CO_2 on mixed oxides derived from hydrotalcites at several temperatures and high pressures. Chem Eng J 332: 24-32.

25. DMD Alessandro, B Smit, JR Long (2010) Carbon dioxide capture: prospects for new materials. Angew Chem Int Ed 49(35): 6058-6082.

26. M Olivares Marín, MM Maroto Valer (2012) Development of adsorbents for CO_2 capture from waste materials: a review. Greenhaouse Gases: Sci Technol 2(1): 20-35.

27. M Ives, RC Mundy, PS Fennell, JF Davidson, JS Dennis, et al. (2008) Comparison of Different Natural Sorbents for Removing CO_2 from Combustion Gases, as Studied in a Bench-Scale Fluidized Bed. Energy Fuels 22(6): 3852-3857.

28. Y Li, C Liu, R Sun, H Liu, S Wu, et al. (2012) Ind Eng Chem Res 51: 16042-16048.

29. M Olivares Marin, TC Drage, MM Maroto Valer (2010) Novel lithium-based sorbents from fly ashes for CO_2 capture at high temperatures. Int J Greenhouse Gas Control 4(4): 623-629.

30. A Gil, E Arrieta, MA Vicente, SA Korili (2018) Synthesis and CO_2 adsorption properties of hydrotalcite-like compounds prepared from aluminum saline slag wastes. Chem Eng J 334: 1341-1350.

31. N Loganathan, GM Bowers, AO Yazaydin, HT Schaef, JS Loring, et al. (2018) Clay Swelling in Dry Supercritical Carbon Dioxide: Effects of Interlayer Cations on the Structure, Dynamics, and Energetics of CO2 Intercalation Probed by XRD, NMR, and GCMD Simulations. The Journal of Physical Chemistry C 122(8): 4391-4402.

32. J Dubois, E Grau, T Tassaing, M Dumon (2018) On the CO_2 sorption and swelling of elastomers by supercritical CO2 as studied by in situ high pressure FTIR microscopy. The Journal of Supercritical Fluids 131: 150-156.

33. YM Kim, JL Sohn, ES Yoon (2017) Supercritical CO_2 Rankine cycles for waste heat recovery from gas turbine. Energy 118: 893-905.

34. J Wang, Z Wang, B Sun, Y Gao, X Wang, et al. (2019) Fuel 235: 795-809.

35. HA Martinez Correa, RG Bitencourt, ACA Kayano, PM Magalhães, FT Costa, et al. (2017) Integrated extraction process to obtain bioactive extracts of Artemisia annua L. leaves using supercritical CO_2, ethanol and water. Industrial Crops and Products 95(C): 535-542.

36. M Correa, MC Bombardelli, PD Fontana, F Bovo, IJ Messias Reason, et al. (2017) The Journal of Supercritical Fluids 122: 63-69.

37. AE Masunov, EE Wait, SS Vasu (2018) Molecular Dynamics Study of Combustion Reactions in Supercritical Environment. Part 3: Boxed MD Study of $CH_3 + HO_2 \rightarrow CH_3O + OH$ Reaction Kinetics. The Journal of Physical Chemistry 122(13): 6355-6359.

38. AP Ribeiro, LM Martins, EC Alegria, IA Matias, TA Duarte, et al. (2017) Catalytic Performance of Fe (II)-Scorpionate Complexes towards Cyclohexane Oxidation in Organic, Ionic Liquid and/or Supercritical CO_2 Media: A Comparative Study. Catalysts 7(8): 230-240.

39. SC Alcazar Alay, JF Osorio Tobón, T Forster Carneiro, CJ Steel, MA Meireles (2017) Polymer modification from semi-defatted annatto seeds using hot pressurized water and supercritical CO_2. The Journal of Supercritical Fluids 129: 48-55.

40. H Wakayama (2018) $CaCO_3$-Polymer Nanocomposite Prepared with Supercritical CO_2. International Journal of Polymer Science 2018: 1-6.

41. AF Alshalif, JM Irwan, N Othman, MM Zamer, LH Anneza (2017) In: Carbon Dioxide (CO_2) Sequestration in Bio-Concrete. An Overview: 05016.

42. A Ebrahimi, M Saffari, D Milani, A Montoya, M Valix, et al. (2017) Sustainable transformation of fly ash industrial waste into a construction cement blend via CO_2 carbonation. Journal of Cleaner Production 156: 660-669.

43. S Eloneva, S Teir, H Revitzer, J Salminen, A Said, et al. (2009) Reduction of CO_2 Emissions from steel plants by using steelmaking slags for production of marketable calcium carbonate. Steel Research International 80(6): 415-421.

44. MF Bertos, SJR Simons, CD Hills, PJ Carey (2004) A review of accelerated carbonation technology in the treatment of cement-based materials and sequestration of CO_2. Journal of Hazardous Materials 112(3): 193-205.

45. SC Kou, Bj Zhan, CS Poon (2014) Use of a CO_2 curing step to improve the properties of concrete prepared with recycled aggregates. Cement and Concrete Composites 45: 22-28.

46. M Aresta, A Dibenedetto, A Angelini (2013) Catalysis for the Valorization of Exhaust Carbon: from CO_2 to Chemicals, Materials, and Fuels. Technological Use of CO_2. Chemical Reviews 114(3): 1709-1742.

47. K Nakata, T Ozaki, C Terashima, A Fujishima, Y Einaga (2014) High-yield electrochemical production of formaldehyde from CO_2 and seawater. Angewandte Chemie International Edition 53(3): 871-874.

48. WJ Kruper, DD Dellar (1995) The Journal of Organic Chemistry 60: 725-727.

49. JM Hooker, AT Reibel, SM Hill, MJ Schueller, JS Fowler (2009) One-pot, direct incorporation of [11C] CO_2 into carbamates. Angewandte Chemie International Edition 48(19): 3482-3485.

50. DM Rudkevich, H Xu (2005) Carbon dioxide and supramolecular chemistry. Chemical Communications (21): 2651-2659.

51. B Hu, C Guild, SL Suib (2013) Thermal, electrochemical, and photochemical conversion of CO2 to fuels and value-added products. Journal of CO_2 Utilization 18-27.
52. C Graves, SD Ebbesen, M Mogensen, KS Lackner (2011) Sustainable hydrocarbon fuels by recycling CO_2 and H_2O with renewable or nuclear energy. Renewable and Sustainable Energy Reviews 15(1): 1-23.
53. XM Liu, GQ Lu, ZF Yan, J Beltramini (2003) Recent advances in catalysts for methanol synthesis via hydrogenation of CO and CO_2. Industrial & Engineering Chemistry Research 42: 6518-6530.
54. LC Grabow, M Mavrikakis (2011) Mechanism of Methanol Synthesis on Cu through CO_2 and CO Hydrogenation. ACS Catalysis 1: 365-384.
55. F Frusteri, M Cordaro, C Cannilla, G Bonura (2015) Multifunctionality of Cu–ZnO–ZrO_2/H-ZSM5 catalysts for the one-step CO_2-to-DME hydrogenation reaction. Applied Catalysis B: Environmental 162: 57-65.
56. SP Naik, T Ryu, V Bui, JD Miller, NB Drinnan, et al., (2011) Synthesis of DME from CO_2/H_2 gas mixture. Chemical Engineering Journal 167(1): 362-368.
57. M Usman, WW Daud, HF Abbas (2015) Dry reforming of methane: Influence of process parameters-A review. Renewable and Sustainable Energy Reviews 45(C): 710-744.
58. JM Lavoie (2014) Review on dry reforming of methane, a potentially more environmentally-friendly approach to the increasing natural gas exploitation. Frontiers in Chemistry 2: 81.

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