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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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