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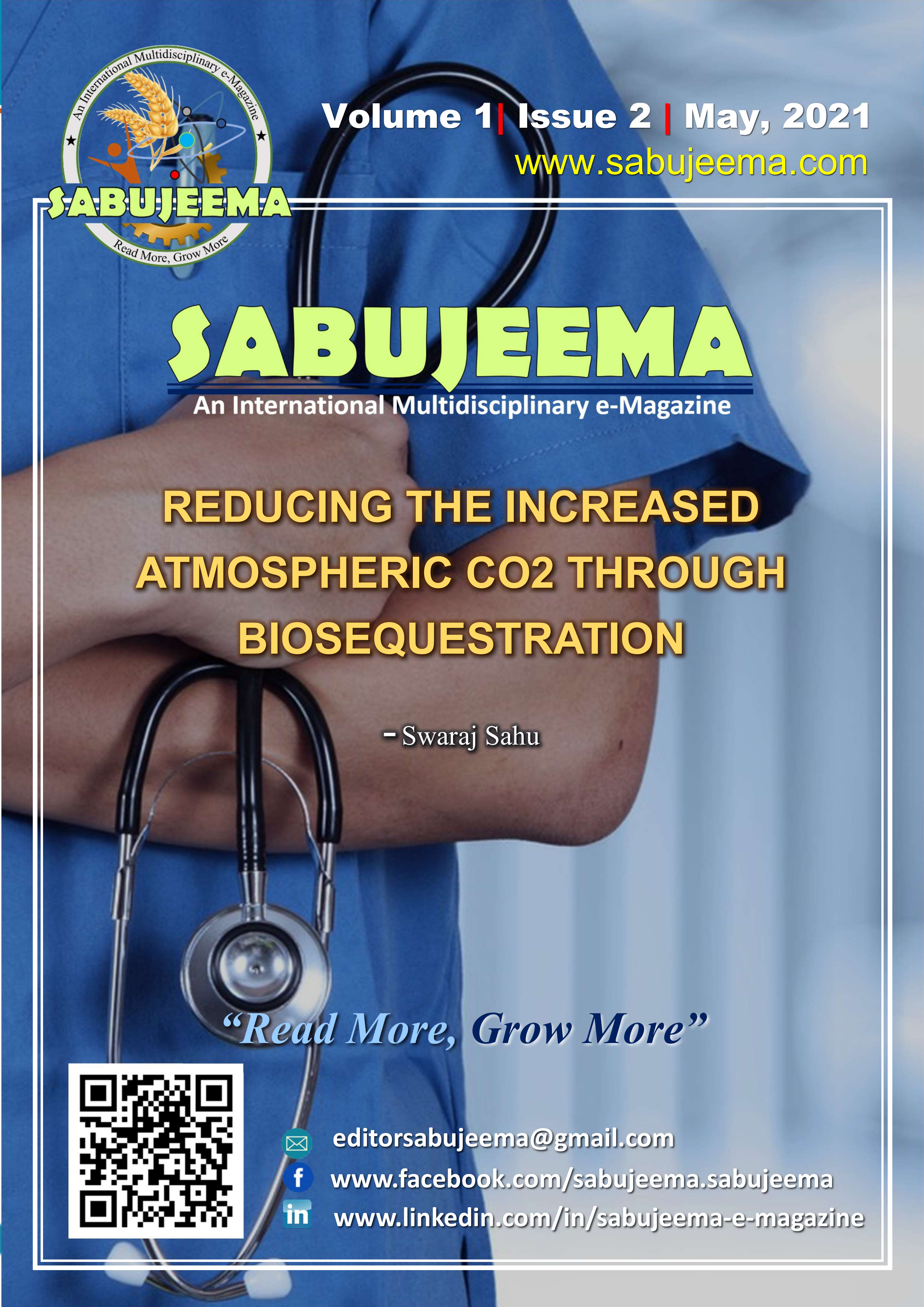

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REDUCING THE INCREASED ATMOSPHERIC CO2 THROUGH BIOSEQUESTRATION

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REDUCING THE INCREASED ATMOSPHERIC CO2 THROUGH BIOSEQUESTRATION

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ABSTRACT:

The disastrous increase in the amount of CO2 has created an overabundance of greenhouse gases that traps additional heat, which causes alteration in the circulation of atmospheric and oceanic currents, increased melting of snow and ice, abnormal sequestration of CO2 by plants, amount and types of clouds formed and alters atmospheric water vapour.The processes involving CO2 capture and storage (CCS) are gaining attention as an alternative for reducing CO2 concentration in the ambient air. This scenario can be mitigated by the capture and storage of atmospheric greenhouse gas carbon dioxide by various biological processes i.e., biosequestration. One of the ways is by improving photosynthetic activities by modifying RUBISCO genes in plants to increase its catalytic activity of that enzyme, promoting C4 photosynthetic pathway. The bioenergy plantations are ideal agro forestry sources of carbon sequestration such as bamboo, one of the highest terrestrial carbon sequestration plant with a potential of 392T CO2 over 7 years of biomass accumulation period. Biochar, an organic charcoal material, is the final product of pyrolysis. The limitation of oxygen in the system prevents the complete burning, instead producing the charcoal that captures much more of the natural carbon from the biomaterial. Such a form of carbon will not only be able to capture additional carbon, but also store carbon dioxide in sinks and out of the atmosphere for thousands of years. Another technology could be the biological capture of CO2 using microalgae due to its unmatched advantages over higher plants and ocean fertilization. Specific pathways include autotrophic production via both open pond or closed photo bioreactor (PBR) systems. Photosynthetic efficiency of microalgae ranges from 10– 20 % in comparison with 1–2 % of most terrestrial plants. Each of these approaches has a potential, but there are several technical, fiscal challenges as well as well as economic issues posing a setback to the idea. If these huddles are cleared off then effect of global warming can be reduced significantly.

Kew words: CCS, Biosequestration, Rubisco, Bamboo, Biochar, Microalgae, PBR

INTRODUCTION:

The disastrous consequences arising from increasing levels of anthropogenic carbon dioxide (CO2) emissions and predicted catastrophe if unabated, is now widely recognized. Climate changes due to global warming, pressure of carbon tax and increasing environmental awareness are driving policy makers towards a solution for global warming. This concentration of CO2 has increased from about 280 ppm in the pre – industrial era to almost 400 ppm at present

(WMO 2008). The 2007 Nobel peace prize was awarded to Rajendra Pachauri (chairperson of the Intergovernmental Committee on Climate Change –IPCC) and ALBERT Arnold Gore for their "efforts to build up and disseminate greater knowledge about man-made climate change and to lay the foundations for the measures that are needed to counteract such change. Fossil fuel power plants are responsible for 40% of total CO_2emissions. Since the concentration of CO_2 in flue gas is about 500 times higher than that in the atmosphere, carbon dioxide sequestration as point source solution has been give much thought. Among many carbon capture and storage technologies, biotechnology of using carbonic anhydrase (CA) in an immobilized enzyme reactor at these plants holds much promise because it is a viable and environmental benign technology (Liu et al. 2005). Increases in atmospheric CO_2 concentration are considered by many to underlie dangerous climate change (IPCC 2007) there is perhaps an urgent need to develop method that can securely reduce and sequester carbon emission.The Kyoto Protocol under the United Nations Framework Convention on Climate Change allows countries to receive credits for their carbon- sequestration activities in the area of land use, land-use change, and forestry as part of their obligations under the protocol. Such activities could include CO_2 capture and storage (CCS), modifying RUBISCO genes in plants to increase its catalytic activity of that enzyme, promoting C4 photosynthetic pathway, micro algal operation, using of bamboo species and biochar application.

CARBON CAPTURE AND STORAGE (CCS):

CCS is the process of capturing waste carbon dioxide from large point sources, such as fossil fuel power plants, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological formation. It is a potential means of mitigating the contribution off to fossil fuel emissions to global warming and ocean acidification. 'CCS' can also be used to describe the scrubbing of CO_2 from ambient air as a climate engineering technique. CCS applied to a modern conventional power plant could reduce CO_2 emissions to the atmosphere by approximately 80–90% compared to a plant without CCS. The IPCC estimates that the economic potential of CCS could be between 10% and 55% of the total carbon mitigation effort until year 2100. Carbon dioxide can be captured out of air or fossil fuel power plant flue gas using adsorption (or carbon scrubbing), membrane gas separation, or adsorption technologies. Amines are the leading carbon scrubbing technology.

Capturing CO_2 is most effective at point sources, such as large fossil fuel or biomass energy facilities, industries with major CO_2 emissions, natural gas processing, synthetic fuel plants and fossil fuel-based hydrogen production plants. Extracting CO_2 from air is also possible, Capturing and compressing CO_2 may increase the energy needs of a coal-fired CCS plant by 25–40%.

Broadly, three different configurations of technologies for capture exist: post-combustion, pre- combustion, and oxyfuel combustion.

In post combustion capture, the CO_2 is removed after combustion of the fossil fuel — this is the scheme that would be applied to fossil-fuel burning power plants. Here, carbon dioxide is captured from flue gases at power stations or other large point sources. Post combustion capture is most popular in research because existing fossil fuel power plants can be retrofitted to include CCS technology in this configuration.

The technology for pre-combustion is widely applied in fertilizer, chemical, gaseous fuel (H_2, CH_4), and power production. In these cases, the fossil fuel is partially oxidized, for instance ina gasifies. The resulting syngas (CO and H_2) is shiftedinto CO_2 and H_2. The resulting CO_2 can be captured from a relatively pure exhaust stream. The H_2 can now be used as fuel; the carbon dioxide is removed before combustion takes place. There are several advantages and disadvantages when compared to conventional post combustion carbon dioxide capture. The CO_2 is removed after combustion of fossil fuels, but before the flue gas is expanded to atmospheric pressure.

In oxy-fuel combustion the fuel is burned in oxygen instead of air. To limit the resulting flame temperatures to levels common during conventional combustion, cooled flue gas is recirculated and injected into the combustion chamber. The flue gas consists of mainly carbon dioxide and water vapour, the latter of which is condensed through cooling. The result is an almost pure carbon dioxide stream that can be transported to the sequestration site and stored.

Various forms have been conceived for permanent storage of CO_2. These forms include gaseous storage in various deep geological formations (including saline formations and exhausted gas fields), and solid storage by reaction of CO_2 with metal oxides to produce stable carbonates. Geo-sequestration involves injecting carbon dioxide, generally in supercritical form, directly into underground geological formations. Oil fields, gas fields, saline formations, unmineable coal seams, and saline-filled basalt formations have been suggested as storage sites. Various physical (e.g., highly impermeable cap rock) and geochemical trapping mechanisms would prevent the CO_2 from escaping to the surface.

MICROALGA CULTURE:

Alga culture is a form of aquaculture involving the farming of species of algae. The study of these freshwater and marine algae has generated a wealth of information concerning their physiology, biochemistry, and cultivation (Anderson 2005). Under natural growth conditions, phototrophic algae absorb sunlight, and assimilate CO_2 from the air and nutrients from the aquatic habitats. n. While microalgal culturing is expensive, microalgae can also produce a variety of high value compounds that can be used to generate revenues. Those revenues could pay for the cost of carbon capture and sequestration. Microalgal photosynthesis can also result in the precipitation of calcium carbonate, a potentially long-term sink of carbon. The advantages of using a microalgal-based system are that: High purity CO_2 gas in not required for algal culture. Flue gas containing varying amounts of CO_2 can be fed directly to the microalgal culture. This will simplify CO_2 separation from flue gas significantly. Therefore, as far as possible, artificial production should attempt to replicate and enhance the optimum natural growth conditions. The majority of algae that are purposefully cultivated fall into the category of microalgae. Macro algae, commonly known as seaweed, also have various commercial and industrial uses, but due to their size and the particular requirements of the environment in which they grow, they do not lend themselves as readily to cultivation. The most relevant environmental factors that affect the growth of microalgae include light, pH, temperature, salinity, nutrient profiles (mainly (C)> (N)> (P)), and dissolved oxygen (DO), as well as biological factors such as predation, viruses and competition (Kumar et al. 2010). Finally, operating conditions that might constrain micro algal growth rates include harvesting rates, gas transfer and mixing, because they affect CO2 availability, shear rates and light exposure.

Enclosed bioreactors and open ponds are the two predominant methods for growing algae. The traditional way to farm microalgae is in large, circulating ponds; however, a serious drawback is the risk of contamination by other microbes or algal species (Benemann and Oswald 1996).

Thus, high production rates in open ponds are achieved with algal strains resistant to severe culture environment. Besides the technological simplicity, the production in open systems is not cheap due to the downstream processing cost. Closed photoreactors provide sterility and allow for much greater control over culture parameters such as light intensity, carbon dioxide, nutrient levels, and temperature (Miron et al. 1999) and thus higher biomass productivities can be reached (Harun et al. 2010; Pires et al. 2012). Flue gas from coal fired power stations comprises around 12–15% CO2, together with other oxide gases such as Sox and NOx. The ASP study conducted several trials in both laboratory and scaled-up processes growing microalgae in water with simulated flue gas and found no inhibitory effects from flue gas on the productivity of microalgae. Microalgae can assimilate all the constituents of the flue gas mixture because they can utilize NOX as their nitrogen supplement for growth, CO2 for photosynthesis an they can tolerate an absorb up to 300 ppm Sox.

PHOTOSYNTHETIC ACTIVITY OF RUBISCO GENE:

Biosequestration may be enhanced by improving photosynthetic efficiency by modifying Rubisco genes in plants to increase the catalytic and/or oxygenation activity of that enzyme. One such research area involves increasing the Earth's proportion of C4 carbon fixation photosynthetic plants. In the oxygenation reaction, when rubisco instead of CO2 binds oxygen (O2), only one molecule of 3-PGA is formed from RuBP, together with one molecule of the 2-C compound phosphoglycolate (PG). PG is a dead end, and to reclaim the C in PG, and possibly to avoid toxic effects of PG accumulation, plants engage in a series of reactions that convert PG to 3-PGA for the Calvin cycle. C4 plants represent about 5% of Earth's plant biomass and 1% of its known plant species, but account for around 30% of terrestrial carbon fixation. In leaves of C3 plants, captured photons of solar energy undergo photosynthesis which assimilates carbon intocarbohydrates (triosephosphates) in the chloroplast of the mesophyll cells. The primary CO2fixation step is catalyzed by ribulose-1,5-bisphosphate carboxylase /oxygenase (Rubisco) which reacts with O2 leading to photorespiration thatprotects photosynthesis from photoinhibition but wastes 50% of potentially fixed carbon. The C4 photosynthetic pathway, however, concentrates CO2 at the site of the reaction of Rubisco, thereby reducing the bio sequestration-inhibiting photorespiration.

BIOCHAR:

Biochar refers to charcoal produced from plant matter and stored in the soil as a means of removing carbon dioxide from the atmosphere. Charcoal is made by heating wood or other organic material with a limited supply of oxygen (pyrolysis). Depending on the nature of the raw material used and the process of pyrolysis, the end products vary; volatile hydrocarbons and most of the oxygen and hydrogen in the biomass are generally burned or driven off, leaving C- enriched black solids, called charcoal. Addition of biochar to soils has been recognized as one of the important strategy to counterbalance the impact of climate change through sequestering the carbon dioxide (CO2) into the soils so the load of excess atmospheric CO2 will have reduced (Lehmann et al., 2006).Biochar is a stable product when applied to soil, it remains in soil for centuries and securely store C for long-term C sequestration due to more resistance towards decomposition by soil microbes. Charcoal can be used as fuel for transportation, industry, or cooking, and has various other applications, such as water purification and filtration. Charcoal, which holds twice as much C than ordinary biomass, can also be applied to soil for long-term C sequestration—such charcoal is referred to as biochar. Partly because of its low hydrogen-to- carbon ratio and its aromatic nature, biochar is a poor microbial substrate, and the half-life of C in soil biochar is in the range of several hundred to several thousand years. Furthermore, biochar has several important impacts on soils: It (a) can increase the soil's capacity to adsorb plant nutrients and agrochemicals; (b) contains most of the plant nutrients from the harvested biomass and can slowly release those nutrients to the rhizosphere; and (c) has a low-density structure, and helps increase drainage, aeration, and root penetration in soils.

BAMBOO SPECIES:

Bamboo stands occupy an area of 36 million hectares worldwide which is equivalent to 3.2 percent of the total forest area in the world. It is estimated that bamboo occupies over one percent of the tropical and subtropical forest area - over 22 million hectares. There are different reports on the number of genera and species of bamboo found in India. As per the latest compilation 18 genera and 128 species were reported (Seethalakshmi and Kumar 1998). The fastest growing species among the bamboos may grow up to 1.2 m a day. This unique growing capacity makes bamboo a valuable sink for carbon storage.The dry matter accumulation by Chusquea culeou (Chile) is in the tune of 156- 162 t ha-1, while that of Phyllostachys pubescence (Japan), and Gigantochloa alter (Indonesia) is 138-ton ha-1 and 45 t ha-1, respectively. The lowest dry matter accumulation (0.35-ton ha-1) has been reported by Bashania fangiana (China). In the last two decades bamboo has emerged as a valuable wood substitute and the carbon captured by bamboos is sequestered effectively for a long time. The degree to which carbon is sequestrated in these products depends on its durability. Over 90% of bamboo carbon can be sequestered in durable products such as boards, panels, floors, furniture, buildings, cloth, paper and activated charcoal. The decay resistant litter produced by the bamboos also helps to sequester the carbon even though its contribution is small.Bamboo plantations, which are the great carbon sinks have significant advantage over other biomass resources due to the species diversity, vigorous growth, early establishment, adaptability to various soil and climatic conditions, short harvesting period, sustainability in yield and its multifarious uses (over 5000 applications). Hence, it may be regarded as the best among the biomass resources. It has immense potential as a bio-energy resource which helps in the retention of carbon already sequestered in the fossil fuels such as coal, oil and gas and can save the vast natural forests.

CONCLUSION:

Carbon Sequestration can assist significantly in maintaining the natural carbon cycle. Therefore, requirement is that we need to implement this practice properly. Containment of greenhouse gases in the modern industrial world is imperative to abate further dire consequences of climate change.Our efforts to mitigate elevated levels of atmospheric CO2 by various methods, should be viewed as a continuing process, as the strategies and technologies employed will evolve over time depending on the nature of public and political will, economic incentives, and environmental sustainability projections. There is a need to go for natural sequestration first, thus conservation of existing forests and more and more reforestation is required. Only then we will be able to reduce carbon emission and corresponding harmful impacts.

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