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GLOBAL WARMING AND CLIMATE CHANGE

Sanjay Prasad

Research Scholar, B.R.A.B.Univ. Muzaffarpur.

Abstract: The world is going through an energy crisis in terms of depletion of resources; it is true that new oil and gas reserves have constantly been found. Most exciting have been the new geological surveys that show that as much as a fifth of the world's exploitable gas and oil reserves lie under the Arctic ice (McCarthy 2008). Potential oil and gas refining will therefore increase fossil fuel reserves, thus risking an exponential increase in the greenhouse effect, which could result in all kinds of catastrophes for the Earth and its inhabitants.

Keywords: Resources, Geological surveys & Global warming .

INTRODUCTION

Natural disasters linked to global warming can cause tremendous damage to local areas in terms of the economy, people's health and safety, and transportation (Cai et al. 2012).

CO_2 emissions have clearly increased in the last 35–40 years, and the total amount of CO_2 emissions related to the burning of fossil fuels has reached about 26 billion tons (Saito 2010). The statistical data show that at present CO_2 concentration in the atmosphere is about 380 ppm, compared to 280 ppm before the Industrial Revolution. Figure 4 shows CO_2 emissions in 2004 and the estimated emissions in 2030 for different countries. The total global CO_2 emissions in 2030 will be 1.6 times higher than in 2004. One evident problem is the high number of on-road diesel vehicles, since emissions from these engines significantly contribute to the atmospheric levels of the most important greenhouse gas, CO_2, as well as other urban pollutants such as CO, NO_x, unburned hydrocarbons, particulate matters, and aromatics (Kalam et al. 2003). The use of conventional fossil fuels can cause fast-rising CO_2 emissions (Krumdieck et al. 2008; Roman-Leshkov et al. 2007), and with the ever-increasing pace of modern industrialized development this trend will continue if a feasible alternative energy source cannot be found in time.

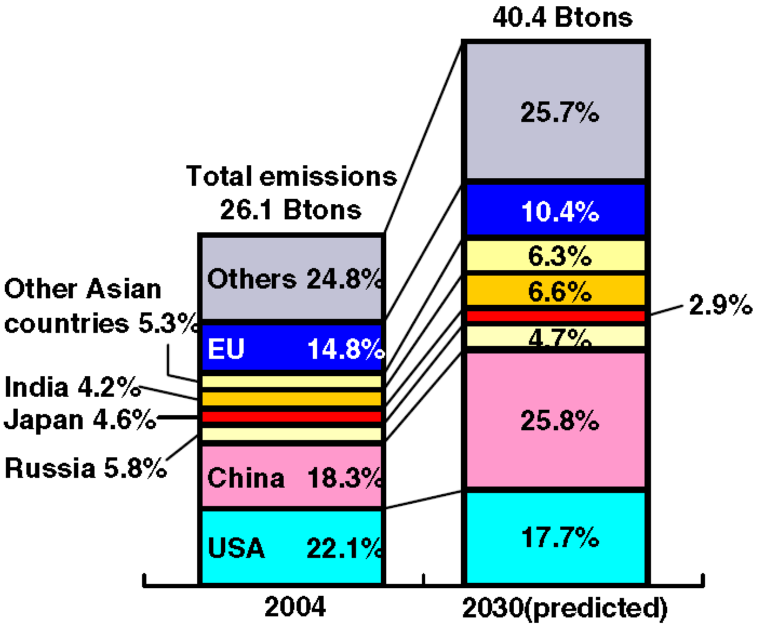

Figure 1. Status of CO_2 emissions in 2004 and the outlook in 2030, by country (Saito 2010).

The Inter-governmental Panel on Climate Change (IPCC) has demonstrated that a temperature increase of 2°C above preindustrial levels will dramatically increase the risk of severe climate change impacts (EPA 2006). In the EU-15 member countries transport-related greenhouse gases (GHG) emissions accounted for 21% of the total EU-15 GHG emissions in 2008, an increase of 20% from 1990 (EEA 2011). Several studies have shown that the two-degree limit for temperature rise will be broken during the next couple of decades if GHG emissions continue to intensify (EPA 2006; MTC 2008). If international efforts can achieve effective international agreements and GHG emissions can be decreased at least by half by 2050 in an attempt to mitigate climate change, the temperature rise can be kept at 2°C (MTC 2008). These tasks are challenging and require mutual action internationally to mitigate GHG emissions.

Water pollution

Water pollution is a major global problem. There are three main pollution sources: agriculture, industry, and municipalities. Agricultural wastewater is the biggest polluter, since agriculture accounts for more than 70% of global water use (GEO 2007). A large amount of fertilizers and pesticides is used during agricultural production, and these can cause the contamination of groundwater and surface waters through run-off. Animal wastes are another contributor of pollution in some areas. Industrial wastewater contains a lot of inorganic and organic matters, as well as heavy metals such as lead, mercury, and cadmium. Municipal wastewater is a representative organic wastewater, which contains a lot of organic matters and organisms like bacteria.

Once the wastewater flows into a waterbody without treatment, it can cause disasters for the respective ecosystems. Nutrient imbalance in water can give rise to eutrophication, threatening the development and stability of biodiversity. In developing countries, up to 90 % of wastewater flows into rivers, lakes and seas without any treatment, threatening people's health and food security and affecting access to safe and clean water for drinking and bathing (WWAP 2012). It is estimated that 700 million Indians have no access to a proper toilet (The Economist 2008). Around 90% of cities in China suffer from some degree of pollution by wastewater, and nearly 500 million Chinese in total cannot access clean drinking water (The New York Times 2007). Fully industrialized countries continue to struggle with water pollution problems as well. For example, in the USA 45% of assessed streams and 47% of assessed lakes are classified as polluted waterbodies, according to a national report on water quality in the United States (EPA 2007). Another example is that 97% of groundwater samples in France do not meet standards for nitrates (UN WWAP 2009).

It has been suggested that water pollution is the leading worldwide contributor to deaths and diseases and that it directly or indirectly deprives the lives of more than 14,000 people daily (West 2012). For instance, 1,000 Indian children die of sickness every day due to dirty water (The Economist 2008). Wastewater must be treated before discharge, according to the quality requirement of the usage (Figure 2).

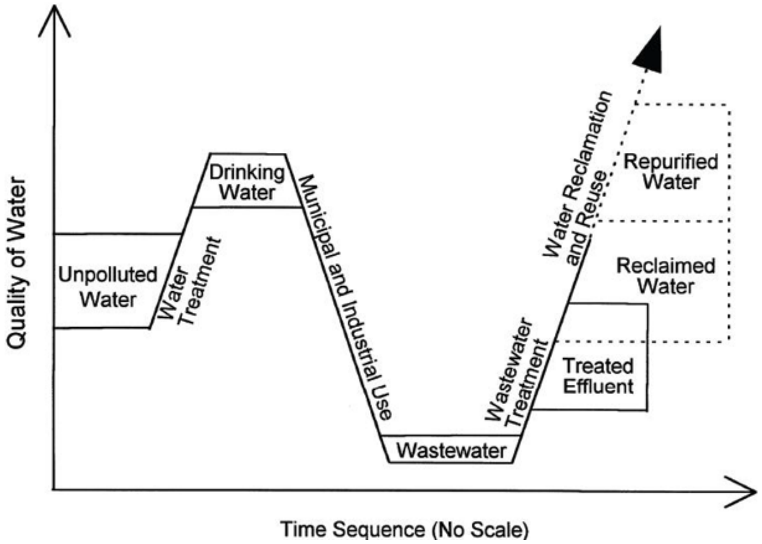

Figure 2. Water quality changes during water uses in a time sequence (Asano and Bahri 2009).

There are many methods that have been developed to treat wastewater. These include activated sludge treatment methods, constructed wetlands, artificial floating beds (Zhu et al. 2011a), and others. Currently, there is a lot of on-going research on the treatment of industrial, municipal and agricultural wastewaters by microalgae culture systems (Yang et al. 2008; Zhang et al. 2012; Samori et al. 2013). When cultivating Arthrospira platensis in olive-oil mill wastewater it has been found that the maximum removal of chemical oxygen demand (COD) was 73.18%, while phenols, phosphorus and nitrates in some runs were completely removed (Markou et al. 2012). Ruiz-Marin et al. (2010) compared two species of microalgae growing as immobilized and free-cells to test their abilities to remove total nitrogen (TN) and total phosphate (TP) in batch cultures with urban wastewater. Kothari et al. (2012) found that Chlorella pyrenoidosa could remove about 80–85% TP and 60–80% of TN from dairy wastewater.

Sustainable development

Recently, more and more concerns have been expressed regarding sustainable development. Sustainable development refers to a mode of human development where an activity can meet the needs of the present generation in an environmentally friendly manner while maintaining options for future generations (Bruntland 1987). The concept of sustainable development can be divided into four parts: environmental sustainability, economic sustainability, social sustainability, and cultural sustainability (Figure 3).

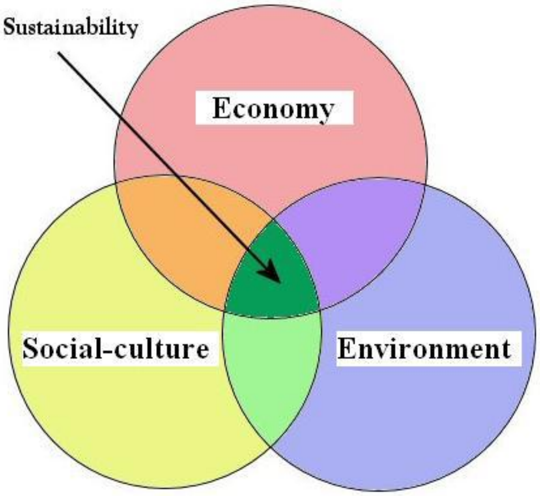

Figure 3. Sustainability concepts and their inter-relationships.

Today more than ever before, unpredictable environmental issues strongly bound with economic, social and cultural impacts are dominating the international agenda, and much importance has been attached in particular to the sustainability of industry. Identifying the core environmental, economic, social and cultural impacts is the first step in supporting the development of a sustainable industry. Unsustainable aspects can be identified using the techniques of risk assessments (Gupta et al. 2002) and environmental impact assessments (Salvador et al. 2000). Potential risks can thus be forecast and then either mitigated or eliminated to some degree.

It is a long-term goal to achieve sustainable economic development along with sustainability of energy. Many significant problems lie in energy production and consumption, such as shortage of resources, low energy efficiency, high emissions, damage to environment, and lack of effective management systems (Zhang et al. 2011). As an example of the scale of the challenge, from 1990 to 2006 China observed an increase of nearly 6% annually in CO_2 emissions, ending up with 5.65 billion tons CO_2 in 2006, accounting for 20.3% of the global amount (Jiang et al. 2010). Therefore, it is a long journey for developing countries to optimize energy structures, improve energy efficiency, enhance environmental protection, and carry out efficient energy management in pursuit of sustainable development.

Biofuels have become a hot research topic due to their advantages over fossil fuels (Figure 4). The desire to reduce reliance on foreign oil imports, to improve energy security and to reduce the effects of global warming and climate change has sparked a lot of interest in terms of research and development (R&D) of alternative fuels (Coplin 2012). Policymakers, academics, business representatives, and members of relevant associations are pushing development of biofuels for various reasons. Some think of biofuels as a substitute for high-priced petroleum, while others emphasize their potential to extend available energy resources to confront the increasing world demand for fuels in the transportation sector. Others see biofuels as a substitute for carbon-neutral energy or as an economic opportunity for business. Nonetheless, there are still some skeptical voices arguing that not all biofuel types are sustainable. Many of the biofuels which are currently being supplied have been criticized on the basis of potential adverse effects on the natural environment, food security and land use.

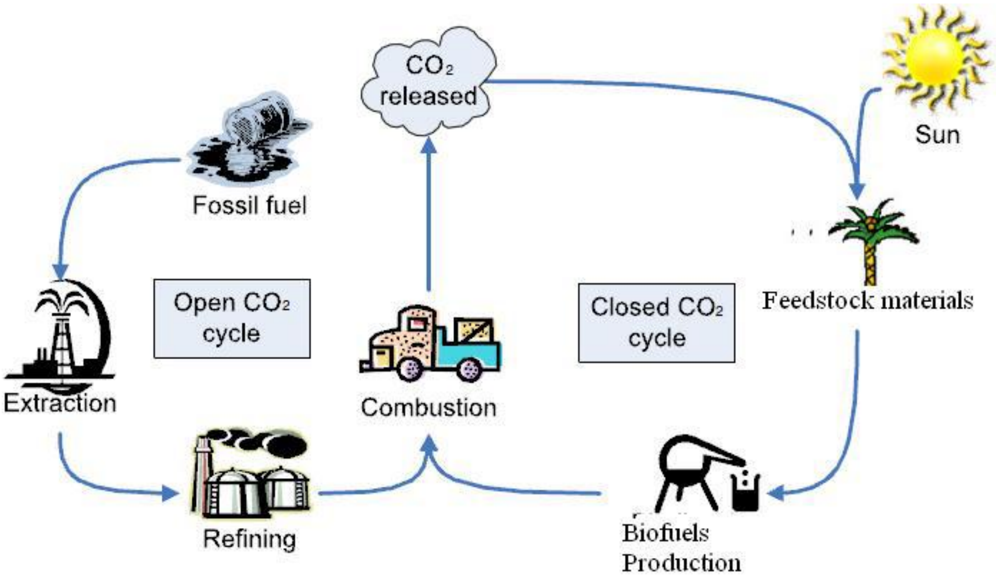

Figure 4. CO_2 cycle for fossil fuel and biofuels.

Towards bioenergy

In response to the challenges outlined above, renewable energies have received a lot of attention and will hopefully become one of the main energy sources for the world. According to calculations, renewable energy in 2010 covered only 13% of the global primary energy demand (IEA 2012b).

Bioenergy is thought of as the renewable energy with the highest potential to satisfy the energy needs of modern society for both developed and developing countries (Ong et al. 2011). At present, bioenergy contributes around 10–15% of the world energy use (Demirbas et al. 2009). Biofuels, mainly in the form of biodiesel, bioethanol, biogas and biohydrogen, have therefore received increasing attention (Antoni et al. 2007; Johnson and Wen 2010).

Biodiesel, which is usually produced from either animal fat or oil crops, such as soybean, corn, rapeseed, palm, and castor bean, is a non-toxic, renewable and biodegradable fuel, and thus one of the potential alternatives to fossil fuel. Nevertheless, this feedstock has low oil yield and entails high demand for land, water and fertilizer.

Bioethanol is considered to have the potential to replace the fossil-derived petrol (Prasad et al. 2007). Bioethanol is produced via fermentation using a variety of sugars, which are derived through hydrolyzing starch from, for instance, corn, sugarcane and sorghum. Bioethanol from lignocellulosic feedstock is also being developed (Dwivedi et al. 2009). Lignocellulosic feedstock includes woody sources such as aspen, energy crops such as switchgrass, agricultural wastes such as corn stover (Huang et al. 2009), as well as dairy and cattle manures involved in a few studies (Chen et al. 2004).

Biogas generation is widely used for the treatment of all kinds of wastes (Pham et al. 2006). Biomass used for anaerobic digestion can be obtained from (1) terrestrial sources including mechanically sorted and hand-sorted municipal solid wastes, various types of fruit and vegetable solid wastes, leaves, grass, wood and weed, and (2) aquatic sources including both marine and freshwater biomass, such as seaweed and sea-grass (Zamalloa et al. 2012).

Biohydrogen is a clean biofuel type, since it can be used in a fuel cell with water as the only exhaust product and without any pollutant emissions. Large-scale electrolysis of water is possible, but costs more energy than can be generated by hydrogen. However, several bacteria, such as purple non-sulfur bacteria (Lee et al. 2002; Bianchi et al. 2010), can use a wider range of organic substrates (such as food wastes, agricultural residues and wastewaters) and light to produce hydrogen.

Microalgal biofuels have received a great deal of attention. Algae, which can absorb CO_2 photo-autotrophically, are ideal candidates for CO_2 sequestration and greenhouse gas mitigation during algae-based biofuels production. Microalgae have been found to have several constituents, mainly including lipids (7–23%), carbohydrates (5–23%), proteins (6–52%), and some fat (Brown et al. 1997). Previous studies have shown that microalgae are consequently a versatile feedstock for the production of biofuels including biodiesel, bioethanol, biogas, biohydrogen, and many other fuel types like biobutanol, bio-oil, syngas, and jet fuel (Li et al. 2008; Koller et al. 2012) via thermochemical and biochemical methods (Figure 5).

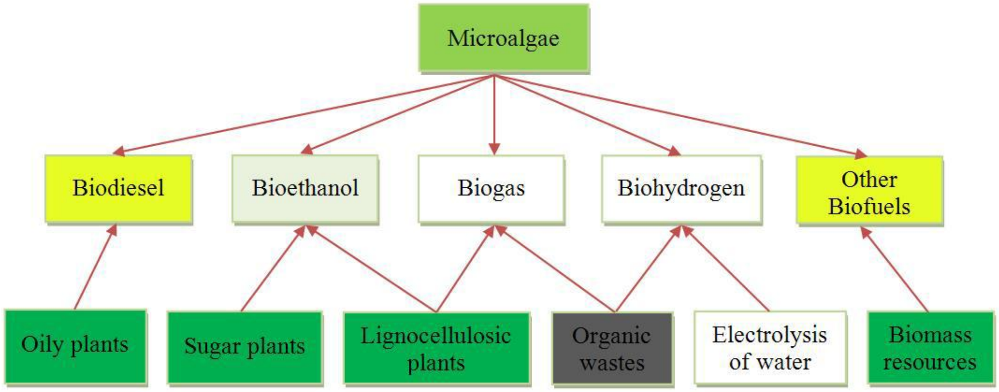

Figure 5. Flexible biofuels production from microalgae (Zhu et al. 2012).

Advantages of microalgae as the biofuel feedstock

The feedstock used for biofuel production mainly includes the following materials: straw, sugarcane, wood materials, wood wastes, manure, energy plants, and many other co-products or byproducts from a wide range of agricultural processes (Zhu et al. 2012). According to the feedstock differences, biofuels can be classified into three types: the first generation, the second generation and the third generation. Biodiesel and bioethanol are the most popular types of first- or secondgeneration biofuels. Biodiesel is made from, for example, canola and palm, and bio-ethanol from crops such as sugarcane and corn starch. It is believed that biofuels production can bring job opportunities and increase farmers' incomes, especially in developing countries. Meanwhile, it can also reduce a country's reliance on crude oil imports (Zhu et al. 2012). As such, biofuels production is of strategic importance to the future development of our society.

Nevertheless, biofuels, which are derived from food or non-food crops, are not thought of as renewable and sustainable energy types. The growth of these nonfood crops targeted for biofuels production will lead to competition for arable farmland with food crops. Farms are limited and should be used to grow food crops. If the food crops grown in farmlands are used to produce biofuels, it will affect food security, and food prices will increase rapidly, subsequently impacting the access of poor populations to food (von Braun et al. 2008). Microalgal biofuels can deal with most of the concerns connected to first- and second-generation biofuels, and are thus referred to as third-generation biofuels. Microalgal biofuels are currently attracting a lot of research attention (Lam and Lee 2012).

Strengths of microalgae as a biofuel feedstock

There is no denying the fact that there exist some disadvantages to employing microalgae as the biofuel feedstock. First, microalgae can grow very fast and have a high photosynthesis rate. Compared to all the terrestrial crops investigated until now, one unit of growing area of microalgae can produce much more biomass and oil, as shown in Table 1. It is expected that 50 times more biomass can be produced from microalgae than that from switchgrass, which is the fastest growing terrestrial crop (Demirbas 2006). The doubling time for microalgal biomass during the exponential growth phase can be as short as 3.5 h (Chisti 2007), and up to 20–22 g dry weight•m^{-2}•day^{-1} of average productivity has been achieved in raceway ponds.

Table 1. Yields of bio-oils produced from a variety of crops and algae (Avagyan 2008).

Substance	Gallons of oil per acre per year
Corn	15
Cotton	35
Soybeans	48
Mustard seed	61
Sunflower	102
Rapeseed (canola)	127
Jatropha	202
Oil palm	635
Microalgae	
Based on actual biomass yields;	1,850
Theoretical laboratory yields	5,000–15,000

Second, less freshwater is required to grow microalgae than for land crops. In addition, water used in the process can be largely recycled for the algal biomass production system.

Third, the algal biofuel industry has low land occupancy. Unproductive land, such as arid or semiarid areas, infertile farms, saline soils, polluted land, and other land with low economic value (e.g. deserts) can be used to establish microalgae growth and biofuel refineries. The advantage here is that the biofuels do not compete with food crops for farmland.

Fourth, all kinds of wastewaters, such as municipal, agricultural and industrial wastewaters, can be utilized to culture microalgae. The wastewater provides nutrients to form algal biomass; thus, wastewater can be purified mainly by algal cell uptake, physical processes and microbial activity (Zhu et al. 2011a; Zhu et al. 2013). This provides a new measure for wastewater treatment, since the inorganic and organic matters in wastewaters can also be degraded.

Fifth, microalgae systems can be filled with flue gas (rich in CO_2) as a carbon source, since some species can tolerate CO_2, NO_x, SO_x, dust, and other elements in flue gas (Imhoff et al. 2011).

Sixth, the methods to harvest and pretreat microalgae are easy, although the costs are high, thus accelerating the biofuel production process in practice.

Seventh, many value-added chemicals, like protein and glycerol, can be coproduced during the biofuel production process (Nilles 2005). For example, more than 400,000 tons of glycerol could be simultaneously co-produced when 1 billion gallons of algal biodiesel are produced (Oswald 1988).

Eighth, engineering tools can be applied to microalgae. The genes of the algal cells can be modified and mutated via a certain technological method or by changing growth conditions. This can significantly increase the biomass quantity and algal oil content.

Ninth, several biofuel types, mainly in biodiesel, bioethanol and biogas, can be produced from microalgae. Thus, microalgae are versatile.

CONCLUSION

Finally, the physical and fuel properties (e.g. density, viscosity, acid value, heating value, etc.) of biodiesel from microalgal oil are generally comparable to those of fossil fuel diesel.

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