**Title: Challenges and opportunities in green ecological-based technology for the replacement of fossil fuels**

Suyash Arunrao Kathade [suyash.kathade9@gmail.com](mailto:suyash.kathade9@gmail.com)

School of Life Sciences, Swami Ramanand Teerth Marathwada University, Nanded. Maharashtra, India

Akib Nisar aakib.nisar@gmail.com

PharmaACE Analytics Pvt. Ltd., Pune, Maharashtra, India.

Mayur Arjun Aswani [mayuraswani7@gmail.com](mailto:mayuraswani7@gmail.com)

Interactive Research School for Health Affairs, Bharati Vidyapeeth (Deemed to be University), Pune, Maharashtra, India.

Corresponding author:

**Dr. Suyash Arunrao Kathade**

Address: School of Life Sciences, Swami Ramanand Teerth Marathwada University, Nanded. Maharashtra, India (431603).

Phone: 9511267388

E-mail: [suyash.kathade9@gmail.com](mailto:suyash.kathade9@gmail.com)

————————————————————————————————————

**Abstract**

Energy demand has escalated with the increasing world population. The current energy requirement is accomplished by non-renewable fossil fuels such as coal, petroleum and natural gas, which release a large amount of carbon dioxide and greenhouse gases, which lead to a cause of global warming. Hence there is an imperative need to find an alternative solution for fossil fuels. Organic waste includes livestock manure, crops or trees, wet organic waste from the household, agro-industrial waste and animal waste or sewage sludge that can be decomposed and leads to biogas. Biogas contains 50-75% methane, 25-50% carbon dioxide and a trace amount of hydrogen and nitrogen, which could be an alternative, eco-friendly and sustainable source of energy. We also propose the emerging technology as bio coal. Rice husk, sawdust, corn stalk, and other agricultural wastes can be transformed into bio coal by the pyrolysis method or treated under optimized conditions. If equal quantities of coal replace by bio coal that could be 738 million tons of Co2 emissions per day can be reduced. Bio coal can be prepared on a large scale and neutralizing the carbon can mitigate global warming could resolve the fuel and environmental crises of the world. Challenges with biogas would be low caloric value and to solve this concentrating the methane gas would be a possible solution. Biogas has 40000KJ/kg, petrol has 45000 KJ/kg, and methane 50000KJ/kg. This time-taking process needs optimization of technology for maximum methane production. To date, there is a lack of effective separation methods, which have significant challenges in the development of renewable fuel. As per the report published in 2019, the world's requirement for fossil fuels including gas, oil and coal is 1,36,761 terawatt/hour and only 7,931 of renewable energy hydropower, wind, solar and other sources, which are 5.79% of the total energy requirement. Hence there is a massive scope and opportunity to develop an eco-friendly sustainable energy source. Hence, biogas and bio coal could be promising alternative solutions for the sustainable development of an eco-friendly source of energy.

**Keywords: Biocoal, Biogas, Green ecological technology, Fossel fuels, Eco friendly.**

**———————————————————————————————————**

1. **Introduction**

Climate change is now considered a major threat to the future of humanity by leading scientists [1–3]. Globally, the 10 hottest years on record have occurred since 2004 with the five hottest years in the 2015–2020 period [4]. Although 2020 was the second hottest year on record worldwide, Since 1980, extreme climatological events involving temperatures, droughts, and forest fires have quadrupled, whereas meteorological events such as extreme storms have doubled [5,6]. So far, the global temperature increase compared with pre-industrial times (before 1850) has been near 1.2 °C with 1.1 °C since 1900 [1,2]. Of deep concern is that the increase in temperature is accelerating and is projected to be at the 1.5 °C level within 15 to 20 years if emissions of greenhouse gases (GHG’s) are not drastically reduced [1,2]. Even with the 2015 International Paris Agreement to reduce GHG emissions, global temperatures have continued to increase due to the world’s increased use of fossil fuels and deforestation [7]. With continued reliance on fossil fuels as the primary energy source, a 3 °C or more temperature increase is predicted by the end of this century [8].

The biggest concern is that a tipping point or threshold may soon be crossed because of accelerated climatic warming and instability imperiling a large portion of the human population [1,9]. Because these changes would be very disruptive to the heavily globalized world economy, a less drastic approach focusing on development of renewable energy (primarily wind and solar) and enhancements in energy efficiency (decoupling) has been emphasized since the 2015 Paris Agreement by the primary CO2 emitters (i.e., China, the United States, the European Union, Japan, Russia, India, Brazil) [10,11].

A common concern is that persistent growth in the human population requires an ever increasing consumption of energy and other natural resources nullifying gains made from efficiency improvements in resource use and expansion of renewable energy production [2]. Another major concern, beyond CO2 emissions, is that the fossil fuels on which the world still depends on for over 80% of its energy needs are finite and will be critically depleted within 50 years at current use levels [7].

In 2020, fossil fuels, renewable sources, and nuclear power accounted for about 83.1%, 12.6%, and 4.3% of world energy use, respectively [2,7]. Within the renewable category hydropower dominated (6.86%), followed by wind (2.90%), solar (1.54%), and other renewables (1.26%). Bioenergy (~0.55%) and geothermal (~0.13%) energy are primary components of the other renewables category. Wind and solar energy are considered to have the most potential for rapid, large-scale expansion but at some point, they will probably be constrained by metal ore and land availability [10–12]. Although hydroelectric, biofuels, geothermal, and tidal are important renewable energy sources, at present their expansion potential is low due to factors involving either their restricted geographic distribution, large land requirements, lack of availability of undeveloped sites, and/or unsolved technical issues related to their implementation [10–12].

1. **Biogas**

Biogas is indeed a green and sustainable technology that can contribute to the replacement of fossil fuels. It is produced through the anaerobic digestion of organic waste materials, such as agricultural residues, animal manure, and food waste. This process breaks down the organic matter and produces a mixture of gases, primarily methane (CH4) and carbon dioxide (CO2), which can be used as a renewable energy source [13]. The status and future trends of codigestion, which is the process of combining different organic wastes to enhance biogas production. It highlights the potential of biogas plants in utilizing various waste streams and reducing dependence on fossil fuels [14]. A biogas production and its potential as a renewable energy source covers different aspects of biogas technology, including feedstock selection, process optimization, and utilization options. It emphasizes the environmental benefits and the role of biogas in replacing fossil fuels [15]. The comprehensive life cycle assessment of biogas supply chains in the United States. It evaluates the environmental impacts associated with biogas production, transportation, and utilization, compared to conventional fossil fuel systems. The findings highlight the potential of biogas to significantly reduce greenhouse gas emissions and other environmental burdens [15]. It discusses the different types of feedstocks, process configurations, and digester technologies used in biogas plants. It emphasizes the sustainable aspects of biogas production and its potential as an alternative to fossil fuels [16]. The global biogas market, policy incentives, technological advancements, and potential future applications. It emphasizes the role of biogas in reducing greenhouse gas emissions and transitioning to a more sustainable energy system [15].

1. **Bio coal**

Bio coal, also known as torrefied biomass or biocoal, is a type of solid fuel produced through the torrefaction process of biomass materials. It has gained attention as a green and ecologically sustainable technology that can potentially replace fossil fuels. Here are some citations that discuss the use of bio coal as an alternative to fossil fuels [17]. This study provides an overview of bio coal as a renewable and abundantly available fuel source produced from biomass. It discusses the torrefaction process, properties, and potential applications of bio coal, emphasizing its potential for replacing fossil fuels [18]. The composition and combustion properties of biomass. It discusses how the torrefaction process alters the physical and chemical characteristics of biomass, making it more suitable as a coal substitute in various applications, including power generation [19]. The torrefaction of wood, one of the commonly used biomass feedstocks for bio coal production. It investigates the weight loss kinetics during torrefaction, providing insights into the transformation of biomass into a more coal-like material. This review article discusses the potential of bio-coal briquettes as a viable alternative to conventional coal in solid fuel applications. It evaluates the technical, economic, and environmental aspects of bio coal briquettes and highlights their advantages, including reduced greenhouse gas emissions and enhanced combustion characteristics [17]. This study presents a comparative analysis of biomass torrefaction and coal pyrolysis for solid fuel production. It examines the fuel properties, combustion characteristics, and thermal behavior of torrefied biomass and coal, providing insights into the potential of bio coal as a substitute for fossil fuels [11].

1. **Opportunity**

Environmental Benefits: Green ecological technologies offer an opportunity to reduce greenhouse gas emissions and combat climate change. They provide a more sustainable and eco-friendly alternative to fossil fuels, reducing air and water pollution, mitigating climate-related risks, and protecting natural resources.

Job Creation: The transition to renewable technologies can stimulate economic development and generate new employment opportunities. In addition to research and development, manufacturing, installation, and maintenance of renewable energy systems, the renewable energy sector has the potential to generate a substantial number of employment.

Energy Independence and Security: Transitioning away from fossil fuels decreases reliance on foreign energy sources. By utilising indigenous renewable resources, nations can increase their energy independence and security, thereby reducing the geopolitical risks associated with energy imports.

Technological Innovation: The development of green, ecologically-based technologies can stimulate innovation in a variety of industries. It encourages the development of materials science, energy storage, grid management, and intelligent technologies. This innovation can have a cascading effect, enhancing other industries and opening up new avenues for sustainable development.

Opportunities on the Market: The increasing demand for ecological technologies creates new markets and business opportunities. Companies that invest in and develop renewable energy solutions, energy-efficient products, and sustainable practices will have a competitive advantage in this expanding market.

1. **Challenges**

Cost: The cost associated with developing and implementing green ecologically-based technologies is one of the primary barriers. In recent years, many renewable energy sources, such as solar and wind, have become more cost-competitive, but they still require substantial infrastructure investments and initial setup costs.

Energy Storage: The efficient storage of energy generated from renewable sources represents a second obstacle. Unlike fossil fuels, which can be readily stored, renewable energy is inconsistent and weather-dependent. The development of efficient energy storage systems, such as enhanced batteries or hydrogen storage, is essential for assuring a stable and reliable energy supply.

Infrastructure Requirements: The transition from fossil fuels to renewable technologies requires substantial infrastructure modifications. Such as constructing a robust charging infrastructure for electric vehicles or establishing an extensive grid system for the transmission of renewable energy can be difficult and expensive.

Technological Advancements: Continued research and development is required to improve the effectiveness and efficacy of renewable technologies. Improving the energy conversion rates of solar panels, boosting the power output of wind turbines, and developing more efficient biofuels are just a few examples of areas requiring continuous innovation.

1. **Conclusion**

Collaboration among governments, businesses, researchers, and communities is necessary to address the challenges and capitalise on the opportunities in green ecologically-based technology. Transitioning to a more sustainable energy future can be accelerated by policies and incentives that encourage investment in renewable energy, research funding for technological advancements, and public awareness campaigns. Significant obstacles and opportunities exist in green ecologically based technology for the replacement of fossil fuels. The world is becoming increasingly aware of the imperative need to transition from fossil fuels to sustainable and renewable energy sources in order to combat climate change and address environmental issues. There are obstacles to overcome, but there are also wonderful opportunities to utilise the potential of ecological technology.

1. **References**

[1] Wuebbles DJ. Climate Science Special Report: 4 th US National Climate Assessment, Volume I 2021; I: 213–20.

[2] WMO. State of the Global Climate 2021. 2022.

[3] Ripple WJ, Wolf C, Newsome TM, Gregg JW, Lenton TM, Palomo I, et al. World scientists’ warning of a climate emergency 2021 2021; 71: 894–98.

[4] Ripple WJ, Wolf C, Newsome TM, Galetti M, Alamgir M, Crist E, et al. World Scientists’ Warning to Humanity: A Second Notice 2017; 67: 1026–28.

[5] Hov Ø, Cubasch U, Fischer E, Höppe P, Iversen T, Kvamstø NG, et al. Extreme Weather Events in Europe : 2013.

[6] Reidmiller DR, Avery CW, Easterling DR, Kunkel KE, Lewis KLM, Maycock TK, et al. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II 2017.

[7] BP. Statistical Review of World Energy globally consistent data on world energy markets and authoritative publications in the field of energy 2021; 70: 72.

[8] Steffen W, Rockström J, Richardson K, Lenton TM, Folke C, Liverman D, et al. Trajectories of the Earth System in the Anthropocene. 2018; 115: 8252–59.

[9] Hansen J, Sato M, Kharecha P, Schuckmann K Von, Beerling DJ. Earth System Dynamics Young people’s burden : requirement of negative CO 2 emissions 2017: 577–616.

[10] Hickel J, Kallis G. Is Green Growth Possible ? Is Green Growth Possible ? 2019; 0: 1–18.

[11] International Energy Agency. Net Zero by 2050: A Roadmap for the Global Energy Sector 2021: 224.

[12] Heinberg R, Fridley D. Our Renewable Future 2016.

[13] Angelidaki I, Ellegaard L. Codigestion of manure and organic wastes in centralized biogas plants: Status and future trends 2003; 109: 95–105.

[14] Balat M, Balat H. Biogas as a Renewable Energy Source—A Review 2009; 31: 1280–93.

[15] Kabeyi MJB, Olanrewaju OA. Biogas Production and Applications in the Sustainable Energy Transition 2022; 2022: 8750221.

[16] Areeshi MY. Recent advances on organic biofertilizer production from anaerobic fermentation of food waste: Overview. 2022; 374: 109719.

[17] Cheng B-H, Huang B-C, Zhang R, Chen Y-L, Jiang S-F, Lu Y, et al. Bio-coal: A renewable and massively producible fuel from lignocellulosic biomass. 2020; 6: eaay0748.

[18] Tumuluru JS, Ghiasi B, Soelberg NR, Sokhansanj S. Biomass Torrefaction Process , Product Properties , Reactor Types , and Moving Bed Reactor Design Concepts 2021; 9: 1–20.

[19] Prins MJ, Ptasinski KJ, Janssen FJJG. Torrefaction of wood: Part 1. Weight loss kinetics 2006; 77: 28–34.