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Study of Biochar and its Applications: A Review

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Abstract: ***Charcoal is made by anaerobic decomposition of plant and animal bodies and it is found inside the earth ever since start of life on earth. The charcoal found today, is million years old. Fossil fuels found from the earth are also the result of anaerobic combustion due to high pressure and temperature inside the earth. Anaerobic combustion of biomass or organic waste is known as pyrolysis. In the history of biochar from terra preta to activated carbon many researches and advancements are done. The biochar as soil amendment is used in agricultural field practices for crop growth. The biomass available on earth is vast amount, burning these biomasses wastes in the form of crop residue, paddy straw, leaves and wood, pollute the environment and as well as there is a great loss of potential wastes which otherwise can be utilized in the form of Biochar in farm field and environmental applications.***
This review paper discusses about biochar, production techniques, activated biochar, present global scenario, and applications of biochar, benefits and potential impacts in agriculture and in water treatment.
Keywords: Biochar, activated biochar, biomass, pyrolysis, crop residue.

I. INTRODUCTION

Biochar is carbon rich product obtained when biomass such as wood, manure, or leaves, are heated in a closed container with little or no air. Biochar is produced through the thermochemical conversion of biomass in the absence of oxygen. Potential feed stocks are defined as woody biomass and include forestry and agriculture residues, along with a limited set of other biomass-based materials approved for use under the International Biochar Initiative's (IBI) Biochar standards (2013). When biomass decomposes under aerobic conditions like combustion in open air it releases carbon dioxide, if decomposition occurs under anaerobic conditions no CO_2 releases because there is absence of oxygen in such process. Today biochar can be produced in an environment friendly way through Pyrolysis burning with limited oxygen in a closed system, allowing material to be burnt at high temperatures whose all the emissions captured. In this process CO_2 and other greenhouse gasses are not released but re-burnt in the system or broken down into less harmful elements.

Biochar produced through pyrolysis process can be used to solve problems like climate change; growing energy demands; poor soil health, to feed more people, declining water quality, and excessive biomass waste. But so exciting about biochar is our emerging understanding of what it can do for us and the planet, for increasing the health and productivity of soil for crops and forests.

II. BIOMASS

Biomass is a organic matter, renewable over a period of time. In other words, biomass is a stored form of energy, the biomass in plant matter is produced by the process of photosynthesis in which carbon dioxide and water from the environment are converted using energy from sunlight, into the carbohydrates (sugars, starches, cellulose and lignin) that are constituents of the plants. Animals which feed on the plants and/or other animals are also a form of biomass. The energy in the sunlight is thus stored as chemical energy in the various forms of biomass. Biomass may then be regarded as an energy resource which can be used to provide heat, electricity and transport fuels for mankind, biomass includes wood from plantation forests, residues from forest production and the timber industry, residues from agricultural production, vegetable oils, animal fats and organic wastes from industry, animal husbandry etc. There are primary biomasses like Forestry products, grasses, crops, animal manure & aquatic products (seaweed), likewise materials that undergone significant changes from raw biomass. Paper, cardboard, cotton, natural rubber products, and used cooking oils comes under secondary biomass.

III. GLOBAL BIOMASS SCENARIO

The annual global primary production of biomass is equivalent to the 4,500 EJ of solar energy captured each year. The potential of global biomass as a sustainable energy source is widely recognized. At present, a bioenergy supply of 270 EJ, possible on a sustainable basis, can cover almost 50% of the world's total primary energy demand. Moreover, this amount of bioenergy can be achieved by only 6% of the annual global primary production of biomass. The potential for energy from biomass depends in part on land availability. Currently, the amount of land devoted to growing energy crops for biomass fuels is only 0.19% of the world's total land area and only 0.5-1.7% of global agricultural land. [11]

Figure 1: Biomasses from paddy briquette, sugarcane bagasse, wood, coconut shells

IV. BIOCHAR

Biochar is a solid material obtained from the carbonization of biomass".It may be added to soils with the intention to improve soil functions and reduces emissions from biomass that would otherwise naturally degrade to greenhouse gases, Biochar has appreciable carbon sequestration value. In other words, biochar is the carbon rich product obtained when biomass, such as wood, manure, or leaves, is heated in a closed container in limited oxygen. Biochar is a form of charcoal produced from super-heating biomass. In fact biochar is found naturally in soils around the world as a result of vegetation fires. Biochar has also been created and used by humans in traditional agricultural practices in the Amazon Basin of South America for more than 2,500 years. Terra preta was discovered in the 1950's by Dutch soil scientist Wim Sombroek in the Amazon rainforest. Terra preta still covers 10% of the Amazon Basin. Similar sites have been found in Ecuador, Peru, Benin and Liberia in West Africa. [12]

Figure 2: Biochar, converted from the biomasses

Biochar is not a fertilizer basically, yet a nutrient carrier and a habitat for microorganisms. Biochar is extremely porous and has a huge surface area. Due to its high porosity, biochar can take up water including the dissolved nutrients of up to five times its own weight.

Biochar can be activated by either physical activation method or chemical activation methods.

Activated biochar is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption. The source material is developed into activated carbons using hot gases like nitrogen. Air is then introduced to burn out the gasses, creating a fine grade, and de-dusted form of activated carbon.

Chemical activation methods are popular in where different type of chemicals are used time as an activation agent, to activate biochar, when making biochar feedstock should be heated and pass through Nitrogen followed by any chemical agents- ZnCl, FeCl3, H2SO4, H3PO4, HCl, HNO3, NaOH/KOH, Na2CO3/K2CO3, Urea [2], is used to activate.

NaOH activation method was used here to activate biochar. Thermally-treated biochar (3g) was mixed with 40 mL NaOH aqueous solution and incubated at room temperature for 2 hours under intermittent shaking (15 min intervals). After NaOH impregnation, the

excess solution was discarded with vacuum filtering and the chemically-treated solid was dried overnight in an oven at 105 ^{o}C. The dried sample was heated in a quartz-tube furnace to 800 ^{o}C, with a heating rate of 3 ^{o}C /min under inert atmospheric conditions (2 L per min N_2 flow) for 2 h. After activation, the samples were pulled out from the heating element and cooled down to ambient temperature under nitrogen flow.

The activated samples were washed with 2 L of deionized (DI) water followed by HCl solution (200 mL) and washed again with DI water until the pH of filtrates was about 7.0. The washed activated carbon samples were dried in an oven set at 105 ^{o}C and stored in a desiccator for further analysis. Each activated sample was denoted as ‘‘N-treatment temperature AC’’ [8].

A. Biochar Production

Some of popular methods of producing biochar, are following:

1) Heap method is the oldest method of biochar production, in this method people simply make heap and cover wood, then allows it to burn slowly in the limited air. But this method adds smoke and toxic gases in atmosphere.

Figure 4: Heap method of biochar preparation in Tamil Nadu. (Source- NICRA Bulletin 1/2013)

2) Two barrel retort method uses two steel drums of different sizes, the smaller one be inside the bigger one and stay at one or more bricks, to maintain gap to the bottom. Between the walls of cylinders coal or other substance which can be used as fuel like wood etc. are filled which is used as heat source for the smaller drum, the biomass put into smaller container because all the process or conversion of biomass executes here, so it can be called as reactor, at the top of the bigger cylinder a cap is there to cover the whole setup and a chimney is fixed, exhaust gases can out from this only exit of the setup.

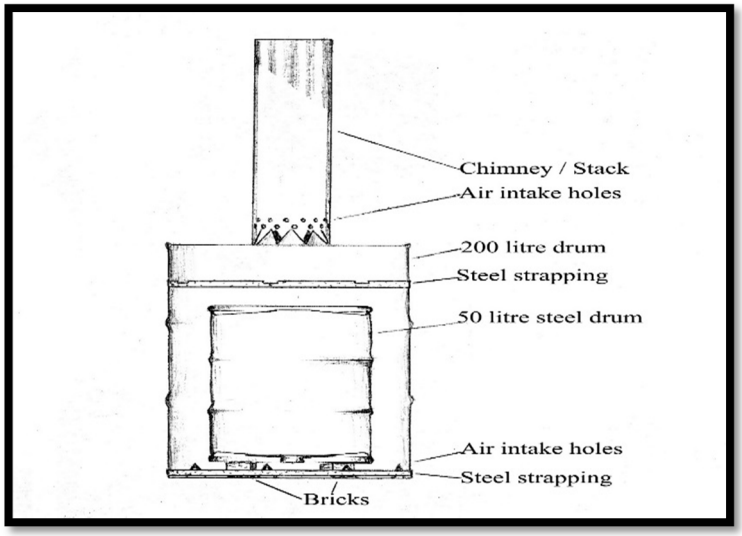


Figure 5: Two barrel retort kiln setup

3) Pyrolysis reactor method is a thermal decomposition of organic material or solid biomass at higher temperatures in the absence of oxygen. Pyrolysis generally consists of heating the material above its decomposition temperature, breaking chemical bonds in its molecules. The fragments usually become smaller molecules, but may combine to produce residues with larger molecular mass, even amorphous covalent solids. This is Endothermic process.

Dry Biomass → char + (CO, CO_2, H_2, H_2O (g), CH_4) + tars + Ash

Solid – charcoal, liquid – bio oil, gas – syn gas or producer gas.

Reactor is used to store biomass that is a closed container so that no air can enter during the process and reactor is heated by a heat source like induction or electric heater or other means. The biomass in a reactor when heated starts converting into biochar and biogas. This is ecofriendly process of producing Biochar.

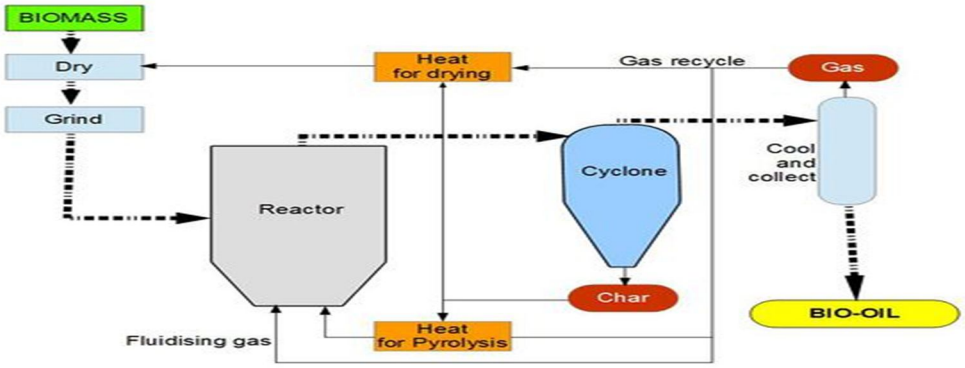


Figure 6: Pyrolysis process at industrial level (Source- http://wiki.zero-emissions.at)

B. Applications Of Biochar In The Field Of Agriculture And Environment

Biochar has a large scope both in agriculture and environment, it enhances the soil fertility, improve soil texture, increases alkalinity by increasing pH. It also increases organic carbon percentage, soil nitrogen, phosphorous and potassium which is essential for plant growth. It also improves adsorption for nutrients which can help in reducing the use of fertilizer which decreases pollution through fertilizer run off. Biochar increases in the crop production and yield. Biochar increases the water holding capacity, so that if you irrigate the crop little late it will still remain green by using stored water [12]. Biochar lowers the carbon level in atmosphere by sequestration. It purified water by trapping the oil and grease, organic matter, and decreases the BOD and COD, activated carbon being used in water purify filters [12].

V. RESULT AND DISCUSSION

A. Global Status

The global biochar market size was worth USD 1.3 billion in 2018, while demand was estimated at 395.3 kilo tons in the same year. Increasing consumption of product in producing organic food and its ability to enhance soil fertility and plant growth are expected to be the key growth drivers. The industry comprises the organized and unorganized sector owing to presence of very few large scale manufacturers and growing number of small and medium scale manufacturers, especially in North America and Europe. Asia Pacific and Middle East countries are expected to grow at a slower rate with lack of awareness regarding product benefits and its long-term advantages. Manufacturing of high quality biochar requires heavy capital investment. As a result of it, several companies have exited the market place in past few years, full potential of biochar is yet to realize in other sectors than agricultural sector. Growing demand from the food sector is expected to be an extremely important factor in boosting the biochar market growth. In 2018, the agriculture application segment accounted for 71.1% of the total biochar demand. Biochar helps to enhance water and fertilizer holding capacity and improve soil's biological productivity, which helps in providing crop nutrition and accelerating growth. However, a large number of farmers still lack in knowledge about the product and its benefits. [3]

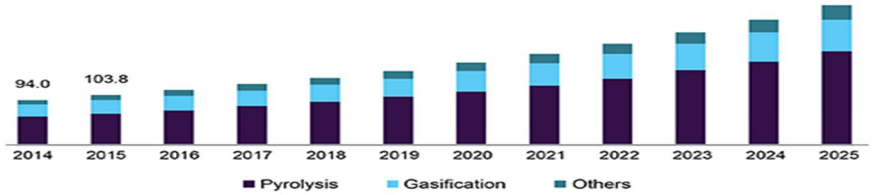


Figure 7: U.S. biochar market demand by technology, 2014-2025 (kilotons)[4]

Using the highest carbon content of the wood-based biochar (i.e. 80%) and the CO_2 offset price range, the approximate value of biochar C sequestration is $2.93-$90.83 per metric ton of biochar. The potential economic returns to farmers if they utilize biochar as a substitute for agricultural lime under three price scenarios: (a) $114.05 per metric ton based on the energy content of a wood-based biochar; (b) $87 per metric ton; and (c) $350.74 per metric ton. [4]

B. Potential of Biochar use in India

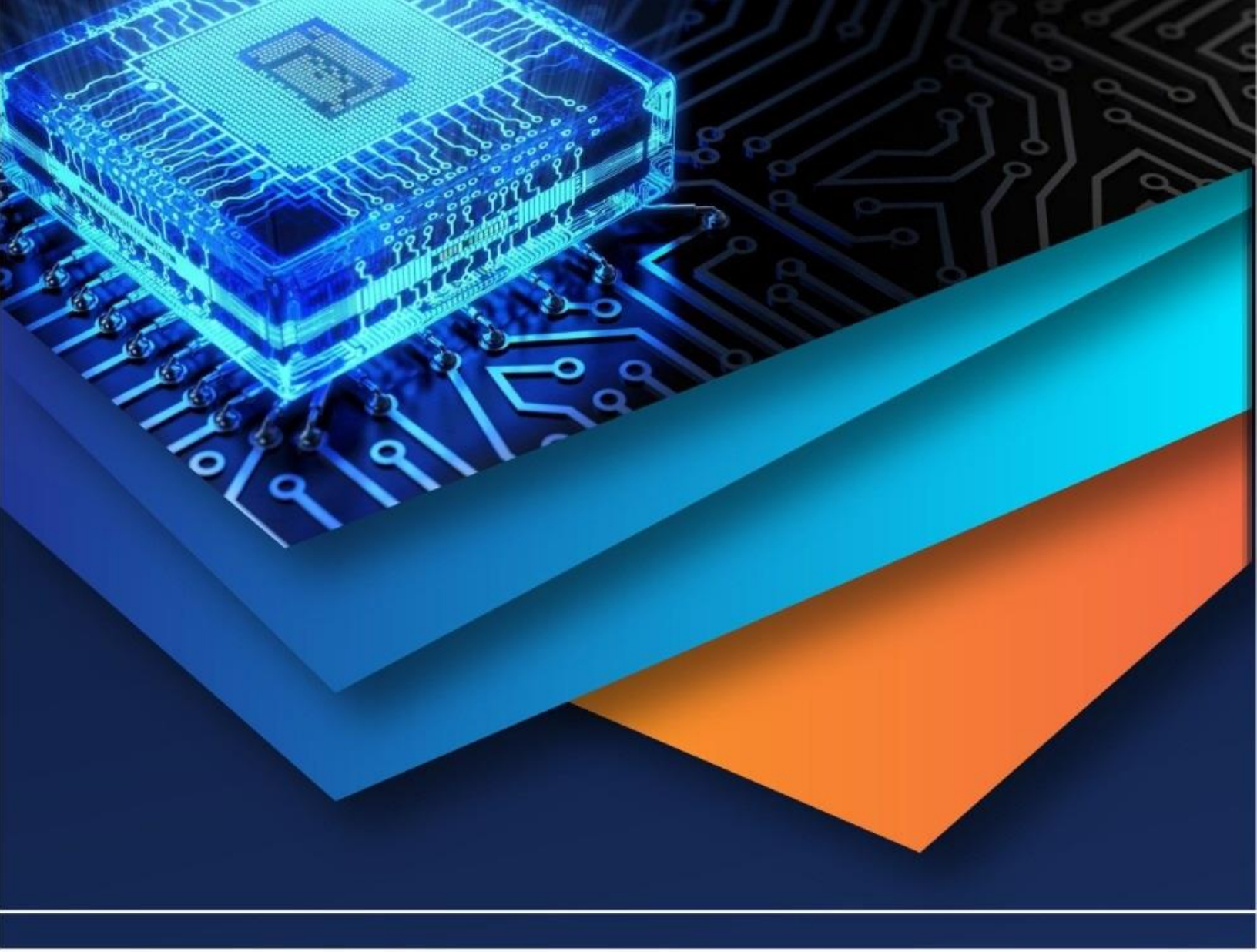
With a production of 93.9 million tons (Mt) of wheat, 104.6 Mt of rice, 21.6 Mt of maize, 20.7 Mt of millets, 357.7 Mt of sugarcane, 8.1 Mt of fiber crops (jute, mesta, cotton), 17.2 Mt of pulses and 30.0 Mt of oilseeds crops, in the year 2011-12 (MoA, 2012), it is but natural that a huge volume of crop residues are produced both on-farm and off-farm. It is estimated that approximately 500-550 Mt of crop residues are produced per year in the country (IARI, 38 2012). Efficient and sustainable disposal of organic waste remains a key issue in rural farm areas and in urban societies. Most wastes are either burnt or end up in landfill, which degrade the environment and also produce large amounts of GHGs. The production of biochar from farm wastes and their application in farm soils offer multiple environmental and financial benefits. Biochar use has a very promising potential for the development of sustainable agricultural systems in India, and also for global climate change mitigation. The current availability of biomass in India (2010-2011) is estimated at about 500 million metric tons/year. Studies sponsored by the Ministry of new and Renewable Energy in the year of 2012, Govt. of India have estimated surplus biomass availability at about 120–150 million metric tons/annum. Biochar having high pH value can be a good remedy for acid soil amelioration. North-East India has the potentiality of producing 37 million tons of agricultural waste biomass. If only 1% of this biomass is converted to biochar, about 74 thousand tons of carbon can be sequestered annually. Out of this, if 1% of the process of producing biochar is carried out through modern equipment, about 1300 and 900 tons of bio-oil and biogas can be produced, respectively which is equivalent to 31 terra joule of energy. [4]

VI. CONCLUSION

This review paper provides an overview of biomass, biochar vis a vis activated biochar and its production techniques. It discusses about its global potential with India. The biochar has immense possibilities and its wide application in areas of agriculture enhancing the crop yield, soil water and nutrient holding capacity. Making of biochar from biomass is a carbon negative process as it mitigates carbon dioxide from atmosphere. Biochar is used for purifying water since it absorbs the organic pollutants from the water. Chemically treated biochar so called activated biochar is widely used in cosmetics too instead being used as water purifiers and so on are as well.

REFERENCES

[1] Lehmann, J.; Joseph S, Biochar for environmental management: An introduction In Biochar for Environmental Management: Science, Technology and Implementation; Lehmann, J., Joseph, S., Eds.; Routledge: Oxford, UK, 2015.
[2] Nikolas Hagemann , Kurt Spokas , Hans-Peter Schmidt, Ralf Kägi , Marc Anton Böhler and Thomas D. Bucheli., Activated Carbon, Biochar and Charcoal: Linkage and Synergies across Pyrogenic Carbon's ABCs, Water 2018, 10, 182.
[3] https://www.grandviewresearch.com/industry-analysis/biochar-market.
[4] Ch. Srinivasarao, K.A. Gopinath, G. Venkatesh, A.K. Dubey, Harsha Wakudkar, T.J. Purakayastha, H. Pathak, Pramod Jha, B.L. Lakaria, D.J. Rajkhowa, Sandip Mandal, S. Jeyaraman, B. Venkateswarlu and A.K. Sikka, Use of Biochar for Soil Health Enhancement and Greenhouse Gas Mitigation in India:Potential and Constraints, NICRA Bulletin 1/2013.
[5] http://wiki.zero-emissions.at/index.php?title=Biomass_pyrolysis_in_food_production.
[6] Smith, K.A.; Mullins, C.E. Soil and Environmental Analysis: Physical Methods, 2nd ed.; Marcel Dekker, Inc.:New York, NY, USA; pp. 1–64.
[7] Junyeong Park a, Ivan Hung b, Zhehong Gan b, Orlando J. Rojas a,c, Kwang Hun Lim d, Sunkyu Park, Activated carbon from biochar: Influence of its physicochemical properties on the sorption characteristics of phenanthrene, Bio resource Technology 149 (2013) 383– 389.
[8] https://in.pinterest.com/pin/514325219938036633/visualsearch/?x=16&y=12&w=530& h=376.
[9] Obemah D. Nartey and Baowei Zhao, Biochar Preparation, Characterization, and Adsorptive Capacity and Its Effect on Bioavailability of Contaminants: An Overview, Volume 2014, Article ID 715398.
[10] Svetlana Ladanai, Johan Vinterbäck, Global Potential of sustainable Biomass for Energy, Report 013, ISSN 1654-9406.
[11] Biochar then and now by sustainable obtainable solutions, http://www.s-o- solutions.org/htdocs/biochar
[12] Atul pratap singh, Activated biochar and its application in the field of agriculture and environment, department of mechanical engineering, B.S. Dr. BRACAET 2019.



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