PROJECT REPORT

ON

Standardization and Efficacy of Biochar in Waste Water Treatment

Submitted By:

Dr. SOURABH JAIN

Associate Professor & Head, Faculty of Bioscience
Shri Ram College, Muzaffarnagar

Submitted To:

JAIN CARBON INDUSTRIES, MUZAFFARNAGAR

2018 - 2019

CERTIFIED

Co-ordinator
IQAC, Shri Ram College,
Muzaffarnagar

Principal
Shri Ram College
Muzaffarnagar

JAIN

Jain Carbon Industries

Mfs. of ACTIVATED CARBON, ACTIVATED CHARCOAL, CARBON BLACK

Off. : 31-State Bank Colony, Jansath Road, Muzaffarnagar-251 001 (U.P.)
Ph.: +91-131-2661051 • Fax : +91-131-2661051 • Mob.: +91-9412211935
E-mail : jaincarbon@yahoo.com • Web : www.jaincarbon.com

Ref.: J-KP/ 2017-18/67

Date: 05.02.2019

To

Dr Sourabh Jain
Head, Department of Biosciences
Shri Ram College, Muzaffarnagar

Subject: Sanction of funds for Research Project **"Standardization and Efficacy of Biochar in waste water treatment"**.

Dear Sir,

Please refer to our letter dated 07.01.2019 and submission of your synopsis on the above subjected project.

We are pleased to sanction Rs. 25,000/- as the expenses to be incurred on the Project. You are requested to complete the work within stipulated period.

Thanks & regards,

Rishabh

For Jain Carbon Pvt. Ltd.
Muzaffarnagar

Copy to: Principal, Shri Ram College, Muzaffarnagar.

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Muzaffarnagar

Principal
Shri Ram College
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GOEL RAKESH & CO.
CHARTERED ACCOUNTANTS

57-A, Agarwal Market, First Floor
,Mahavir Chowk,
Muzaffarnagar (U.P) – 251001
Phone No. 0131-2622405

10/2

Utilization Certificate

S.N.	Detail of sanction of Fund with Project name and Duration	Amount
1.	90-Days project on Standardization & Efficiency of Biochar in Waste Water Treatment , Date of Sanction of Fund- 07.01.2019 as per Sanction Letter	25000.00/-
	TOTAL	25000.00/-

It is Certified that out of Rs. 25000.00/- (Twenty Five Thousands Only) of grants sanctioned by Jain carbons (P) Limited, Muzaffarnagar during the year 2018-19 in favor of **Shri Ram College, Muzaffarnagar**, a sum of Rs. 25000.00 has been utilized for the purpose of the project for which it was sanctioned and that the balance of Rs. **Nil** remaining unutilized at the end of the year has been surrendered. The Extra amount (If any) is met out by Shri Ram College.

2. Certified that we have satisfied our self that the conditions on which the grant was sanctioned have been duly fulfilled/are being fulfilled and that we have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercise-

1 Checking of cash book
2 Checking of payment vouchers.
3 Checking of expenses bills.

For Shri Ram College

Secretary
Place: Muzaffarnagar
Date: 28.04.2019

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Principal
Shri Ram College
Muzaffarnagar

Co-ordinator
IQAC, Shri Ram College,
Muzaffarnagar

For Goel Rakesh & Co.
Chartered Accountants

Rakesh Kumar Goel
(Proprietor)
M.NO. : 071858
FRN : 003374C

Objectives of the study

The project was undertaken to achieve following objectives:

1. Cost difference between activated carbon and Biochar when used as adsorbent in waste water treatment.
2. To compare environmental performance of Biochar and activated carbon.

Duration of Study

One year (Jan 2019 to Jan 2020)

Sanctioned Amount of Project

Rs. 25,000/-

Supervisor

Dr. Sourabh Jain, HoD, Faculty of Bioscience, Shri Ram College

Students engaged in project

2 students were involved in research and data collection for the project.

Expenditure

Head	Number of units	Amount (in Rs.)
Manpower	2 students	2x10000 = 20000.00
Softwares	RISK ver. 7 (Provided by Jain Carbons)	0.00
Honorarium	Given to Project supervisor	5000.00
	Total	**25000.00**

Result Highlights

- Average energy demands were 6.1 MJ/kg biochar and 97 MJ/kg PAC.
- Cost of biochar lower than activated carbon to adsorb chromium and zinc
- Cost of biochar comparable to activated carbon to adsorb lead and copper
- Biochar has lower impacts than activated carbon even after transportation phase

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Introduction

As the commercial production and distribution of biochar continues to grow internationally, and its applications diversifying from its early uses as soil amendment, it is important to study the environmental impacts and economic performance of biochar in comparison to activated carbon in order to assess its value. The goal of the study was to assess, through a meta-analysis, the environmental and economic performance of biochar in comparison to activated carbon under an equivalent functional unit to adsorb heavy metals. More than 80 data points on adsorption capacity of biochar and activated carbon were identified through literature, which were statistically analyzed as part of the study. Biochar was found to have lower energy demand and global warming potential impact than activated carbon, where average energy demands were calculated as 6.1 MJ/kg and 97 MJ/kg and average greenhouse gas emissions calculated as -0.9 kg CO 2 eq/kg and 6.6 kg CO 2 eq/kg for biochar and activated carbon, respectively. When adsorption of heavy metals were used as the functional unit during analysis, results indicate that there is typically an order of magnitude difference between the two materials, where biochar was found to have lower environmental impacts. The environmental impact resulting from long distance transportation of biochar would not overturn this conclusion. The adsorption cost of biochar was lower than activated carbon to remove chromium and zinc with a 95% confidence. Adsorption cost for lead and copper were found to be comparable, and therefore the specific type of biochar and its price could shift results both ways. There is evidence that biochar, if engineered correctly for the task, could be at least as effective as activated carbon and at a lower cost.

Methods

Evaluating the environmental impact of biochar and activated carbon

Data on the environmental impact of biochar and activated carbon were collected mainly through peer-reviewed journal articles on life cycle assessment (LCA) of biochar and activated carbon. A total of 84 different types of biochar and activated carbon were identified from literature, and corresponding data recorded. However, as is typical with most LCA studies, the results were based on a particular product, for a specific case. Furthermore, the majority of LCA studies did not report results other than for energy demand and global warming potential (GWP). While there were several data points for photochemical oxidation, acidification, and eutrophication impact categories, they were not sufficient for a statistical analysis and therefore were not included in the scope of the study. A lack of environmental impact data was a big impediment to study other impact categories such as human toxicity; abiotic depletion; ozone layer depletion; and aquatic ecotoxicity. The unit conversion factors were taken from the Environment Protection Agency (EPA) report on greenhouse gas (GHG) inventories (EPA 2014). Energy consumption was also converted to MJ/kg when reported in other units.

Data points for biochar and activated carbon made from similar materials obtained from different sources were condensed to bring down the number of different products to manageable levels.

The statistical analysis tool Risk version 8 was used to analyze environmental impacts of biochar and activated carbon resulting from adsorption of heavy metals. The chi-squared test was used to fit distributions for each set of adsorption capacity and environmental impact. Monte Carlo analysis was conducted to analyze environmental impacts of biochar and activated carbon resulting from adsorption of heavy metals.

Evaluating the economic performance of biochar compared to activated carbon

To assess the economic performance of biochar in comparison to activated carbon when used for adsorption purposes, the adsorption capacity of each material together with their market prices were used. Current market value prices for different types of biochar and activated carbon were sought during the study. Values reported in scholarly publications and online listing of companies from around the world commercially trading biochar was used to gather market price data. Most of the companies that were located on the directory were from developed countries; namely the U.S., Canada, Australia, and several Western European countries, and a few were from developing countries such as India and Turkey.

All companies listed on the directory were contacted by email to inquire regarding price and raw material used to produce biochar. Most companies sold biochar by volume rather than mass or weight, which was the preferred unit used in this study for adsorption calculations. It was found out that the practical reason for this was to enable biochar to be shipped wet to avoid dust problems that may arise when shipped dry, while the removal of volatile carbon during shipping could also lead to problems in a business transaction if the material were sold by mass. Biochar density data were analyzed statistically to convert volume to mass. Data were analyzed statistically and the mean of the biochar density data was used in this study.

Similar to adsorption calculations, the statistical analysis tool Risk version8 was used to compare adsorption cost for heavy metals. The chi-squared test was used to fit distributions for each set of adsorption capacity and price. After the data sets were converted to distributions, Monte Carlo simulation with 10,000 iterations was used to setup distributions for adsorption cost of biochar and activated carbon for each heavy metal analyzed.

Results

A. Environmental impact of biochar compared with activated carbon

Environmental impact data related to the production of biochar and activated carbon reviewed from literature were used for comparison. Energy demand and GWP were two categories considered in this study, and results were summarized in Table 1. Although environmental impact data based on different raw materials used for production of activated carbon were limited, a diverse list was found for raw materials that can be used for biochar production including many types of organic wastes, woods and residual plants that indicate increased adaptability of biochar production to local conditions.

Material Type	Energy demand, MJ/kg	Global Warming Potential, kg CO_2-eq/kg
Activated carbon (Virgin), hard coal	44[a]	3, 3[a], 8, 11
Activated carbon, olive-waste	170	11
Activated carbon, Recycled		1.2
Activated carbon, Granular	79.8	9.3
Agroforestry biochar		-0.2
Anaerobic digestion biochar	1.1[a,b]	-0.7
Barley straw biochar	1.1 – 2.2[b]	-0.7 – -0.9
Biomass crops biochar (woody)		-0.2
Canadian forestry residue chips biochar	1.4 – 2.9	-0.9 – 1.1
Cardboard biochar	1.8[a,b]	-0.1
Cattle manure biochar		-0.2
Cereals excluding rice biochar		-0.2 – -0.1
Corn Stover biochar	0.84, 1.5-3[a], 8	-0.7 – -0.8, -4 – -2
Dense refuse derived fuel	1.8[a,b]	-0.3
Food waste biochar	1.3[a,b]	-1.1
Forestry residue chips biochar	1.4 – 2.9[b]	-1.3 – -1.1, -0.2 – -0.1
Green waste biochar	1.8[a]	-1.1, -0.3
Maize cobs biochar		-0.1 – 0.1
Miscanthus biochar	1.4 – 2.9 – 10	-3.5 – -3.1, -1 – -1.2, -0.6
Paper sludge biochar	1.1[a,b]	-0.7
Pig manure biochar		-0.4
Poplar biochar	16	-1.2
Poultry litter biochar	1.1[a]	-0.5, -0.2
Rice biochar		-0.4
Sewage sludge biochar	1.8[a]	-0.8
Sugarcane biochar		-0.2
Switch grass biochar	1.5[a], 11	-2.8 – -2.5, -0.4 – 0
Wheat straw biochar	1.1 -2.2[b], 8.3	-2.1 – -1.9, -0.9 – -0.7, -0.7
Whisky draff biochar	1.1[a,b]	-0.8
Wood waste biochar	2.1[a,b]	-1.3, -0.2
Yard waste biochar	3[a]	-0.9

[a] Estimated from figure, [b] Produced energy.

B. Evaluating environmental impact of biochar as adsorbent compared to activated carbon

As the main goal of adsorbent materials are to remove contaminants, heavy metals in this case, an appropriate functional unit for the comparison of environmental impact of biochar and activated carbon would be impacts per mass of contaminant removed, rather than impacts per mass of adsorbent material. Therefore, the two metrics of MJ/kg contaminant, and kg CO 2 eq/kg contaminant were used to compare the two materials. Statistical distributions combined with a Monte Carlo analysis yielded the results presented in Figures 1 and 2 together with the indicated 95% confidence interval. Figure 1 indicate that the energy demand for biochar is significantly lower than activated carbon for most heavy metals. Only in the case of lead adsorption, the figure illustrates that the difference in confidence intervals is not large enough to warrant a clear answer.

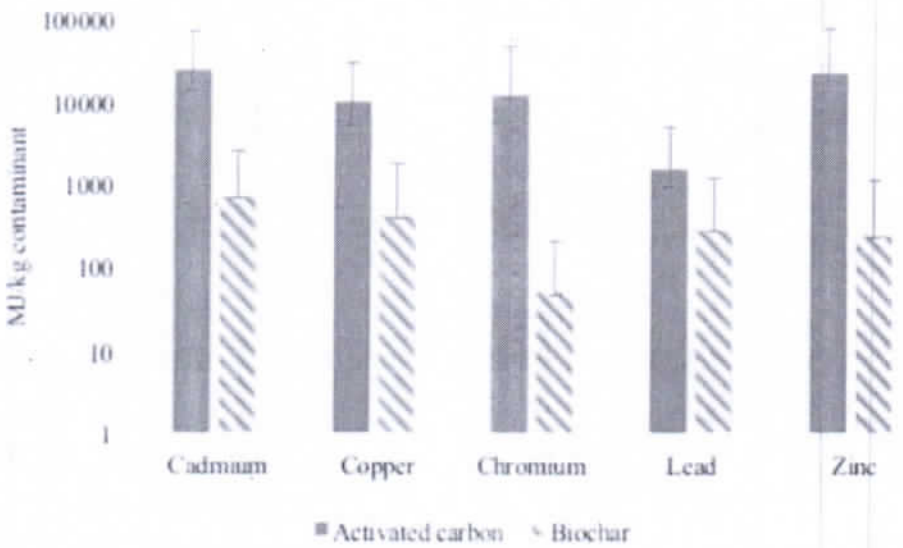

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Figure 1. Energy demand for adsorption of heavy metals by biochar and activated carbon. Bars indicate the mean, and the error bars indicate the 95% confidence interval of results.

Results of analysis presented in Figure 2 illustrates that GHG emissions resulting from adsorption of heavy metals by activated carbon are higher than GHG emissions of biochar. The differences were found to be statistically significant. It is interesting to note that biochar has a negative emissions value for all the heavy metals studied due to its ability to sequester carbon.

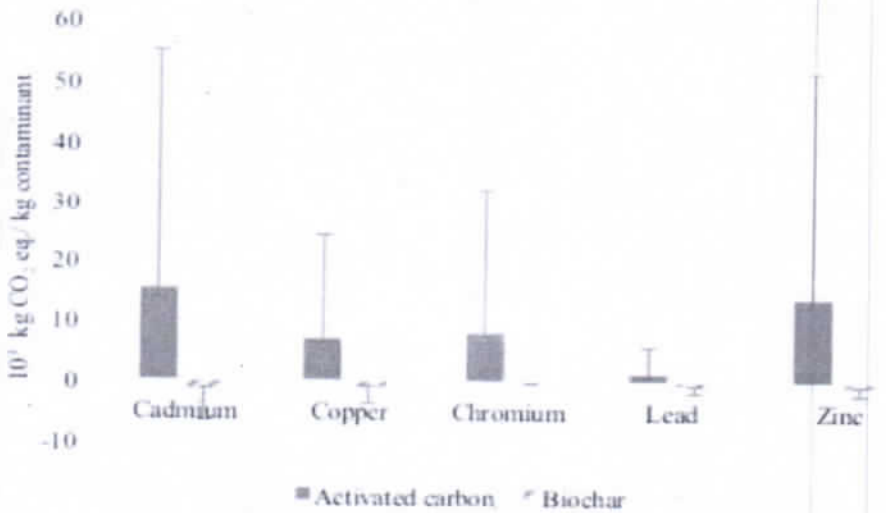

Figure 2: Greenhouse gas emissions resulting from adsorption of heavy metals by biochar and activated carbon. Bars indicate the mean, and the error bars indicate the 95% confidence interval of results.

C. Economic performance of biochar and activated carbon when utilized as an adsorbent

One of the main goals of the study was to compare the economic performance of biochar and activated carbon when used as an adsorbent, rather than costs per mass or volume. Therefore, economic performance of materials as an adsorbent were evaluated by analyzing adsorption capacity of the alternatives and their commercial prices. Economic analysis included defining and evaluating distributions to seek overall trends in performance, rather than investigate a specific adsorbent or raw material used. Monte Carlo simulation was used to estimate and compare the cost of heavy metal adsorption by biochar and activated carbon. A representative outcome was presented in Figure 3, where adsorption cost to remove copper is being displayed. Results indicate that a significant difference between biochar and activated carbon does not exist to adsorb a unit mass of copper.

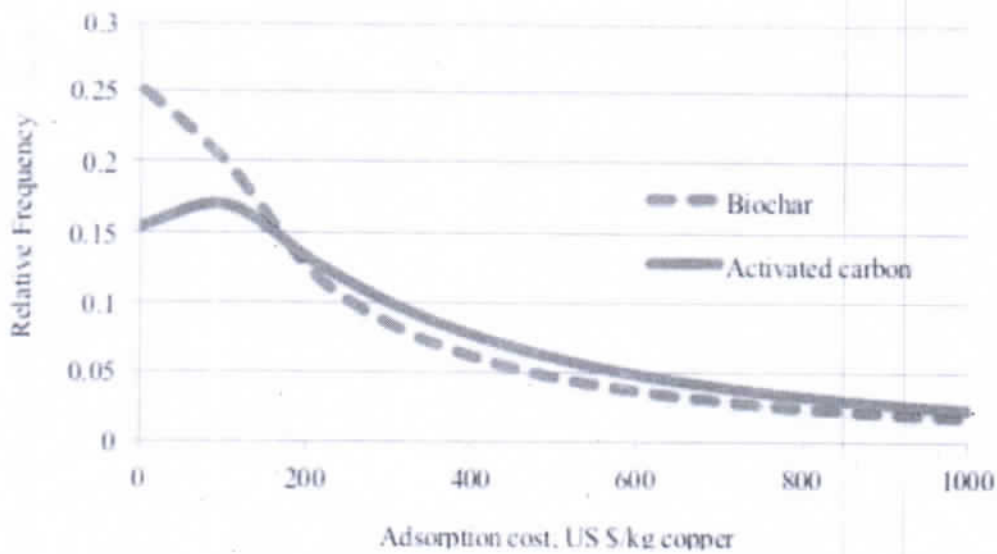

Figure 3: Adsorption cost distribution for copper removal using biochar and activated carbon. Results indicate that a significant difference between biochar and activated carbon does not exist to adsorb a unit mass of copper.

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Conclusion

The main goal of the study was to conduct a meta-analysis to evaluate the environmental and economic performance of biochar in comparison to activated carbon. Due to a lack of data regarding full environmental impacts of biochar from LCA studies, the environmental focus of the study was mainly on the most commonly reported environmental impacts of energy demand and GWP.

Data in these categories indicate that -

- Biochar has lower environmental impact than activated carbon.
- For GHG emissions, biochar on average was found to have negative emissions of -0.9 kg CO 2 eq./kg due to its ability to sequester carbon, while activated carbon demonstrated higher on average GHG emissions of 6.6 kg CO 2 eq./kg.
- The average energy consumption to produce 1 kg of activated carbon and biochar was calculated to be 97 MJ/kg and 6.1 MJ/kg, respectively.
- The adsorption cost of biochar was lower than activated carbon to remove chromium and zinc with a 95% confidence.

(DR. SOURABH JAIN)
PROJECT SUPERVISOR

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