Republic of the Philippines

TARLAC AGRICULTURAL UNIVERSITY

Camiling, Tarlac

DEPARTMENT OF RESEARCH AND DEVELOPMENT

RESEARCH PROPOSAL FORM

BASIC INFORMATION		
Research Title:	**Utilization of Biodegradable Wastes for Biochar Production: An Initiative towards Zero Waste TAU**	☐ Program ☑ Project ☐ Study
Sustainable Development Goal (SDG) Addressed	1 ☐ 2 ☐ 3 ☑ 4 ☑ 5 ☑ 6 ☐ 7 ☑ 8 ☑ 9 ☐ 10 ☐ 11 ☐ 12 ☑ 13 ☑ 14 ☐ 15 ☑ 16 ☐ 17 ☑	
Lead College:	College of Engineering and Technology	
Collaborating College(s)	College of Agriculture and Forestry TAU- Affiliated Renewable Energy Center (TAU-AREC) Ecological Solid Waste Management Unit (ESWM)	
Cooperating Agency(ies):	n/a	
Project Duration:	1 year	
Project Location:	Tarlac Agricultural University	
Total Budget Requested:		
Other Sources:		

Proponent(s)	
Name and Signature: Catherine DR. Pueyo Specific Role of Researcher: Assist in the fabrication of the prototype from canvassing of materials up to the final output. Assist in the data gathering, analysis, interpretation, presentation and publication of the research output. .	Sex: Male ☐ Female ☑ Intersex ☐ Agency & Address: Tarlac Agricultural University/ Malacampa, Camiling, Tarlac Email Address: cdrpueyo@tau.edu.ph Contact Number: 09922052279
Name and Signature: Benjie M. Dela Vega Specific Role of Researcher: Assist in the fabrication of the prototype from canvassing of materials up to the final output. Assist in the data gathering, analysis, interpretation, presentation and publication of the research output .	Sex: Male ☐ Female ☐ Intersex ☐ Agency & Address: Email Address: Contact Number:
Name and Signature: Bennidict P. Pueyo Specific Role of Researcher: . Assist in the fabrication of the prototype from canvassing of materials up to the final output. Assist in the data gathering, analysis, interpretation, presentation and publication of the research output	Sex: Male ☐ Female ☐ Intersex ☐ Agency & Address: Email Address: Contact Number:

add rows as needed

TECHNICAL DESCRIPTION

1. RATIONALE

Tarlac Agricultural University is a biomass rich university since some of the areas are covered with trees, grass, and vegetable production areas. The wastes are properly collected, segregated, and managed by the Ecological Solid Waste Management Unit of the university. Every week an estimated 0.032kg of waste per capita was generated in the university). There are three significant types of wastes generated: namely, biodegradable waste, residual wastes and recyclable wastes. Among the three types, biodegrable wastes has the highest percentage collected comprising of 50.8% (dry leaves and food waste 41.64%, and paper and tissues (9.16%), followed by residual wastes with 44.05%, recyclable wastes 4.51% and the remaining 0.65% are the e-wastes generated in the university. (Marucut K., & Ollado, JA.D., 2023.

Biochar can be a helpful technology to address some of the most urgent environmental problems such as soil degradation, food insecurity, water pollution from agrichemicals, and climate change (Lehmann, 2011). Biochar is the carbon-rich product when biomass such as wood, manure or crop residues are heated in a closed container with little or no available air (Lehmann and Joseph, 2012).

Biochar with its aromatic structure and long mean residence time in the soil has a potential for long-term carbon sequestration in the soil. It can also produce significant benefits when applied to agricultural soils. Biochar application also reduces CO2 respiration, nitrous oxide and methane production and decrease dissipation rate of herbicide in the soil (Jha, P.,et.al., 2010).

To further utilize the biodegradable waste generated and collected in the university, production of these biodegradable wastes into biochar for agricultural productivity is thereby proposed.

2. OBJECTIVES

The study generally aims to produce biochar from the biodegradable wastes collected in TAU and utilize for agricultural productivity. Specifically, it aims to:

1. Fabricate a multi-purpose carbonizer for biodegradable waste biochar production;
2. Evaluate the performance of the multi-purpose carbonizer using biodegradable materials;
3. Characterize the biochar produced from biodegradable materials using proximate analysis; and,
4. Perform a simple cost analysis of using biochar prior to application as soil amendment.

3. REVIEW OF RELATED LITERATURE

Biochar

Biochar and charcoal are the same, having organic parent material being charred/ pyrolize without the presence of sufficient oxygen. The term “biochar” is used when the material is charged with the intention of amending it to soils, using it as carbon sink or filtration of percolating soil water, whereas the term “charcoal” is intended to be applied mainly as a source of energy (Lehmann and Joseph, 2012).

Sources of Biochar

Various types of feedstocks can result into different properties of biochar produced. Biochar can give varying responses when applied to different soils and climates. Some of the materials that can be used to make biochar includes wood charcoal, rice hull, rice straw, corn cobs, coconut husk, forest products, and other agricultural residues (Figure 2). Biodegradable wastes can also be processed as biochar.

Woodchip is small to medium sized solid wood materials made from remains of cutting, and chipping larger pieces of wood. It may be used as biomass fuel, raw material for producing wood pulp, and also as a biomass source for producing biochar. Corn cob is the central core of an ear of maize (*Zea mays* ssp. *mays*). It is the part of the ear on which the kernels grow. The ear is also considered a "cob" or "pole" but it is not fully a "pole" until the ear is shucked, or removed from the plant material around the ear. Coconut husk and shell that can be used for fuel are sources of charcoal. Activated carbon manufactured from coconut shell is considered extremely effective for the removal of impurities. Almost 85-90% surface area of coconut shell activated carbon exists as micro-pores. This made coconut a renewable source of carbon. Coconuts grow throughout the year with harvesting generally occurring 3-4 times a year and they can be preserved for many years. Rice hull is the outer covering of the rice grain which is removed during the process of milling. It constitutes 20-25 % of the rice grain that is harvested from the field, making it one of the most abundant agricultural residues of the country (Jenkins, 1989).

Biochar Properties

Biochar properties can be described if char is treated as the “carbon” fraction and the inorganic ash fraction. The carbon fraction include hydrogen, oxygen and other elements bonded to carbon and is the fraction affected by reaction conditions such as reaction time, temperature, heating rate. The inorganic ash fraction is the fraction affected by feedstock properties and incurs an effect on the ash properties and ash-to-carbon ratio of the char.

Physical and chemical properties of biochar depend on the type of feedstock used and the production process (pyrolysis or gasification, temperature, conversion technology, and pre and post treatment processing) being undertaken. Some of the physical properties of biochar include particle size distribution, specific gravity, density, porosity and surface area. Hydraulic properties of biochar include hydraulic conductivity and water holding capacity. Chemical and electrochemical properties of biochar include organic matter, organic carbon contents, pH, oxidation-reduction potential, electrical conductivity, Carbon-Hydrogen-Nitrogen elemental composition, polycyclic aromatic hydrocarbons, and the presence of heavy metals (Yarficoglu, Sadasivam, Readdy & Spokas, 2014).

Biochar can be produced via process called pyrolysis. Pyrolysis is a thermo-chemical decomposition process in which organic material is converted into a carbon-rich solid and volatile matter by heating in the absence of oxygen (Demirbas and Arin, 2002). The solid, termed variously as char, biochar, or charcoal is generally of high carbon content and may contain around half the total carbon of the original organic matter. Biomass that is heated under pyrolytic conditions (i.e. the heat causes the decomposition of a substance) releases gases and produces charcoal. The released gases and heat can be captured for power generation. Charcoal can be used as a fuel for barbeques; as a natural purification and filtering material; as a drawing material; a dietary supplement for gastric problems; cooking; industrial; automotive fuel; as a natural dehumidifier; odor neutralizer; and, for soil amendment.

Biochar Production

Biochar production can be done using different methods of pyrolysis, namely: slow, medium, and fast pyrolysis. Slow pyrolysis can be divided into traditional charcoal making and more modern processes. It is characterized by slower heating rates, relatively long solid and vapor residence times and usually a lower temperature than fast pyrolysis, typically 400 °C. The target product is often the char, but this will always be accompanied by liquid and gas products although these are not always recovered. In moderate pyrolysis, a temperature of around 500 °C is used during the process of biochar production (Figure 3). Fast pyrolysis is characterized by high heating rates and short vapor residence times.

Biochar can be produced using traditional kilns, drum retorts, pits, and developed multi-purpose carbonizer. Traditional steel kilns offer the ability to produce small quantities of biochar at low cost. For large production, industrial-scale, automated and continuously operated kilns are required. Typically, traditional kilns and retorts are only capable in processing the largest size class.

Adsorption

Adsorption is a process by which ions or molecules present in one phase tend to condense and concentrate on the surface of another phase. Adsorption occurs when molecules in the fluid phase are held for a period of time by forces emanating from an adjacent surface. The surface represents a gross discontinuity in the structure of the solid, and atoms at the surface have a residue of molecular forces called the van Der Waals forces which are common to all surfaces. The only reason certain solids are designated adsorbents is that they can be manufactured in a highly porous form, giving rise to a large internal surface (Coulson and Richardson, 2002). In adsorption, molecules diffuse from the bulk of the fluid to the surface of the solid adsorbent forming a distinct adsorbed phase. Adsorption which can either be physical or chemical is therefore a surface phenomenon, and the extent of adsorption depends on the surface area available (Coulson and Richardson, 2002).

4. METHODOLOGY

The project will commence at the Tarlac Agricultural University. Collected biodegradable wastes of the ESWM unit will be used as samples for the project. Each sample will be segregated and grouped as leaves and twigs, rice hull, mahogany husk and others. The detailed staff from ESWM unit will be in charge in the collection, selection and segregation of samples. Figure 3 shows the conceptual framework of the project.

Figure 3. Conceptual framework of the project

INPUT	PROCESS	OUTPUT
Different biodegradable materials collected by ESWM. (woodchips, twigs, and others)	Carbonization of the different biomass sources using an existing continuous-type rice hull carbonizer	• Carbonized biochar

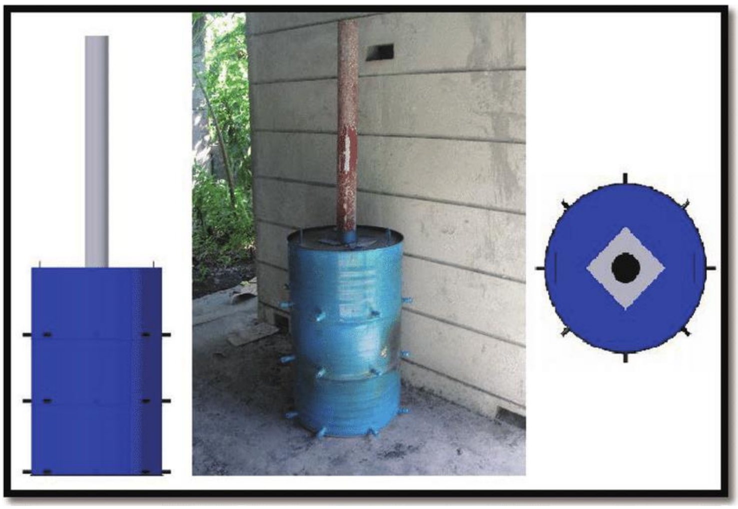
Carbonized biochar	Proximate analysis of carbonized biochar following the ASTM tests for coals.	• Fixed carbon, moisture content, volatile matters and ash content of the different biochar sources.
Carbonized biochar	Quantifying the amount of biochar produced from the selected biodegradable materials.	• Amount of biochar produced
Amount of biochar produced,	• Perform a simple cost analysis of using biochar prior to application as soil amendment.	• Viability of processing TAU biodegradable wastes into biochar.

4.2 Preparation of the Biomass Samples

The collected biomass samples will be sorted and segregated before carbonization. First in first out (FIFO) scheme will be practiced. The initial moisture content of samples will be measured and recorded.

4.2.1. Fabrication of Carbonizer

A 200li- drum type multi-purpose carbonizer will be fabricated and use in this project. The efficiency will be determined during the performance evaluation of the developed carbonizer. Three drum type carbonizer will be used for leaves and twigs, mahogany fruit, rice hull and other biomass. Locally available materials will be procured and it will be contracted to an available fabricator near the area. The carbonizer will be fueled by wood and other wood scraps available in the area.



1. **Carbonization**

The fabricated carbonizer will be used to carbonize the biomass samples. For each batch of the biomass samples, the capacity of the drum will be maximized per batch of loading. It will be fueled with wood and other wood scraps regularly during the whole duration of the carbonization process. The biomass samples were subjected to heat with minimum presence of oxygen at an average of five hours. To check whether the samples were fully carbonized, the top chamber was opened from time to time.

2. Cooling of Carbonized Samples

After carbonization, samples will be cooled and left inside the kiln to release the heat inside the kiln and to make sure that it would not become ash when in contact with air.

3. Performance of the Multi-Purpose Carbonizer

The performance of the fabricated multi-purpose carbonizer with different biodegradable wastes will be evaluated in terms of specific energy requirement, energy demand, and fuel consumption rate.

a. Specific Energy Requirement. This refers to the amount of heat that needs to be supplied to the oven.

$$SER = Wf / T$$

where:

SER = Specific Energy Requirement, kg/hr
Wf= weight of fuel used
T= time to consume the fuel used

b. Energy Demand. This refers to the amount of energy needed to carbonize the materials in the multi-purpose carbonizer.

$$ED = SER * Mc$$

where:

ED= energy demand
SER= Specific Energy Requirement, kg/hr
Mc= multi-purpose carbonizer capacity

c. Multi-purpose carbonizer heat requirement. This refers to the amount of heat required by the carbonizer.

$$MHR = ED/e$$

where:

ED= energy demand
e= carbonizer efficiency

d. Thermal output. Tis refers to the amount of energy necessary to operate the multi-purpose carbonizer.

$$TO= MHR * HV$$

where:

MHR = multi purpose carbonizer heat requirement
HV = heating value of the fuel to be used.

e. Fuel Consumption Rate. This refers to the amount of fuel consume per operation of the multi-purpose carbonizer.

$$FCR = TO/ (HVf * Eg)$$

where:

FCR= Fuel consumption rate
TO= Thermal Output
Eg= efficiency of the carbonizer

f. Actual biochar recovery. This refers to the amount of biochar recovered after carbonization.

$$R_{actual} = (W_{biochar} / W_{initial}) * 100$$

where:
R_{actual} = actual biochar recovery
$W_{biochar}$ = is the weight of biochar recovered
$W_{initial}$ = initial weight of the sample

g. Maximum recovery of the system. This refers to the amount of biochar recovered less the volatile matter and water.

$$R_{max} = (W_{initial} - W_m - W_{vm} / W_{initial}) * 100$$

where:
R_{max} is the maximum recovery of the system
$W_{initial}$ is the initial weight of wet samples
W_{vm} is the weight of the volatile matter
W_m is the weight of water in the sample

h. System efficiency. This refers to the overall efficieny of the designed system.

$$E_{system} = (R_{actual} / R_{max}) * 100$$

where:
E_{system} is the system efficiency
R_{actual} is the actual recovery of the system
R_{max} is the maximum recovery of the system

4. Evaluation of the Produced Biochar from Collected Biodegradable Materials

Proximate analysis will be performed to determine the percentage by weight of the fixed carbon, volatiles, ash and moisture content of the different biochar sources. The American Society for Testing and Materials (ASTM) standard method for proximate analysis of wood will be used. Three samples for each biomass source will be subjected to proximate analysis.
Samples will be tested and analysed at the DOST-ITDI, Taguig City.

5. Viability of Carbonizing Biodegradable Wastes into Biochar

The unit cost of fabricating multi-purpose carbonizer will be calculated. The viability of carbonizing the biodegradable waste into biochar utilized in the university will also be determined. The following are the parameters to be used for the computation of the viability of the proposed project.

5. REFERENCES

(1) Asada, T., Ishinara, S., Yamane, T., Toba, A., Yamada, A., and Oikawa, K. 2002. Science of Bamboo Charcoal: Study on Carbonizing Temperature of Bamboo Charcoal and Removal Capability of Harmful Gases. **Journal of Health Science,** 48(6) 473-479.

(2) Berger, C. 2012. **Biochar and activated carbon filters for greywater treatment-comparison of organic matter and nutrients removal**. Master Thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden. 45 pp.

(3) Dubey, S.P., K. Gopal, and J.L. Bersillon. 2009. Utility of Adsorbents in the Purification of Drinking water: A Review of Characterization, Efficiency and Safety Evaluation of Various Adsorbents. **Journal of Environmental Biology** 30:327-332.

(4) Ebeling, J. 2020. Biofiltration- Nitrification Design Overview. https://cals.arizona.edu/azaqua/ista/ISTA7/RecircWorkshop/Workshop%20PP%20%20&%20Misc%20Papers%20Adobe%202006/7%20Biofiltration/Nitrification-Biofiltration/Biofiltration-Nitrification%20Design%20Overview.pdf. Cited 20 January 2020.

(5) Ekubo, A.A., and J.F.N. Abowei, 2011. Review of Some Water Quality Management Principles in Culture Fisheries, **Research Journal of Applied Sciences, Engineering and Technology**, 3(2), pp 1342-1357.

(6) Helfrich, A., Libey, G. 2019. **Fish Farming in Recirculating Aquaculture Systems**. http://fisheries.tamu.edu/files/2013/09/Fish-Farming-in-Recirculating-Aquaculture-Systems-RAS.pdf. Cited 14 January 2020.

(7) Jha, P., Biswas, A. K., Lakaria, B. L., & Rao, A. S. (2010). Biochar in agriculture – prospects and related implications. *Current Science*, *99*(9), 1218–1225. http://www.jstor.org/stable/24068517

(8) Lehmann, J. and Joseph, S. 2009. **Biochar for Environmental Management: Science and Technology**. pp. 289-296. 22883 Quicksilver Drive, Sterling,VA 20166-2012, USA.

(9) Lehmann J., 2007. A handful of carbon. Nature 447:143–144 https://doi.org/10.1038/447143a. Cited January 15, 2020.

(10) Lehmann J, and Joseph S., 2015. **Biochar for Environmental Management**: **Science, Technology and Implementation.** 2nd edition. Routledge, London, pp 1–1214.

(11) Lennard, J., 1932. Processes of adsorption and diffusion on solid surfaces', **Transactions of the Faraday Society**. Volume 28, 1932. pp. 333-359.

(12) Sichula, J., Makasa, M., Nkonde, G., Kefi, S., & Katongco, C., 2011. Removal of Ammonia from Aquaculture Water Using Activated Carbon. ISSN: 1997-0455

6. POTENTIAL IMPACT

By utilizing biodegrable materials as biochar, it can have significant positive impacts on reducing the waste management of the university, soil health, agriculture, and economic opportunities promising a solution for promoting a more sustainable and resilient community.

7. LOGICAL FRAMEWORK

OBJECTIVES	TARGET ACTIVITIES	TARGET ACCOMPLISHMENTS	Y1			
			Q1	Q2	Q3	Q4
1.Fabricate a multi-purpose carbonizer for biodegradable waste biochar production.	• Procurement of materials • Fabrication • Pre-testing and evaluation	• Fabrication multi-purpose carbonizer				
2.Evaluate the performance of the multi-purpose carbonizer using biodegradable materials.	• Performance evaluation of multi-purpose carbonizer.	• Performance of multi-purpose carbonizer.				
3.Characterize the biochar produced from biodegradable materials using proximate analysis.	• Proximate analysis of the biochar samples	• Characteristics of biochar produced in terms of its composition (carbon, ash, volatile matter, etc.)				
4.Perform a simple cost analysis of using biochar prior to application as soil amendment.	• Simple viability/cost analysis	• Viability of processing biodegradable wastes into biochar.				
	• Terminal Report writing • Publication of the project output • Presentation of the results of the project in coferences.	•				

8. MILESTONE

Publication:

To publish 1 technical paper

Patent:

People Service:

Place and Partnerships:

Extension of Technologies for adaptation

Policy:

9. IPR/ RESEARCH OUTPUTS

Type of IPR	Nature	Name of Technology
☑ Utility Model ☑ Patent ☐ Copyright	☑ Process ☑ Equipment ☐ Others (Please specify): ____________________	

10. RESEARCH ETHICS CONSIDERATION

Classification	Applied for Certificate of Ethics Clearance?	Remarks
☑ Human ☐ IACUC ☑ Plant Use ☐ Micro and Biotech Use	☑ Yes ☐ No	

10 BUDGETARY REQUIREMENT

A.

Unit	Item Description	Quantity	Unit Cost	Total Cost
unit	Multi-purpose carbonizer	3	3,000	9,000.00
pcs	Proximate analysis of biochar samples	4	1,990	7,960.00
Sub-Total				**16,960.00**

B. Maintenance and Other Operating Expenses (MOOE)

Unit	Item Description	Quantity	Unit Cost	Total Cost
ream	A4 bond paper	5	220.00	1,100.00
bottle	Epson L3110 ink (Black)	3	330.00	990.00
bottle	Epson L3110 ink (Yellow)	1	330.00	330.00
bottle	Epson L3110 ink (Magenta)	1	330.00	330.00
bottle	Epson L3110 ink (Cyan)	1	330.00	330.00
Sub-Total				**3,080.00**

C. Capital Outlay (CO)

Unit	Item Description	Quantity	Unit	Total Cost

DEPARTMENT OF RESEARCH AND DEVELOPMENT

			Cost	
Sub-Total				
D. Equipment Outlay (EO)				
Unit	Item Description	Quantity	Unit Cost	Total Cost
Sub-Total				
Total Budgetary Requirement (A+B+C+D):				**20,040.00**

CERTIFICATION

I hereby certify that the information given are true and correct and the research being conducted is authentic. I further signify my commitment to revise the paper as per evaluation results, submit all the documentary requirements, including monthly accomplishment report on time, secure research clearance certificate, complete the research within the specified timeframe, and present the research during the Annual Agency In-House Review.

Note: Documentary requirements to be submitted before and after the completion of the research:

- ☑ Research Clearance Certificate
- ☑ Research Status Monitoring Form
- ☑ Terminal Report with photodocs (soft & hard copy)

Note: Failure to submit the documentary requirements on a specified time may mean reimbursement of the grant in full or may affect the research rating performance on the untimely submission of report.

Date signed: __3/21/24

CATHERINE DR. PUEYO, Ph.D.
Lead Researcher
(Signature over Printed Name)

Date signed: ___________________	Date signed: ___________________
ENGR. BENJIE M. DELA VEGA *Co-Researcher* *(Signature over Printed Name)*	**ENGR. BENNIDICT P. PUEYO** *Co-Researcher* *(Signature over Printed Name)*

Note: Add signatories as needed

ENDORSEMENT

Date signed: ___________________	Date signed: ___________________
ENGR. CHELSIE C. PAGATPATAN *College Research Coordinator*	**LEONELL P. LIJAUCO, Ph.D.** *College Dean/ Head of the Office*

DEPARTMENT OF RESEARCH AND DEVELOPMENT

<table>
<tr><td colspan="2">(Signature over Printed Name)</td><td colspan="2">(Signature over Printed Name)</td></tr>
<tr><th colspan="4">PRE-EVALUATION</th></tr>
<tr><th rowspan="2" colspan="2">Criteria</th><th colspan="2">Decision</th></tr>
<tr><th>Qualified</th><th>Not Qualified</th></tr>
<tr><td colspan="2">Alignment to the Research Agenda of the University</td><td>☐</td><td>☐</td></tr>
<tr><td colspan="2">Has Potential significance/ impact to the community</td><td>☐</td><td>☐</td></tr>
<tr><td colspan="2">Alignment of proponents specialization to the proposal</td><td>☐</td><td>☐</td></tr>
<tr><td colspan="4">Recommended Evaluators: ____

Date signed: ___________________

MARIA ELENA T. CAGUIOA, PhD.
Director for Research & Development
(Signature over Printed Name)</td></tr>
<tr><th colspan="4">ACKNOWLEDGING RECEIPT</th></tr>
<tr><td colspan="4">Processed by:

____
R&D Staff
(Signature over Printed Name)</td></tr>
<tr><td>Date Received:</td><td colspan="2">Proposal No:</td><td>Document No:</td></tr>
</table>