VALIDATION OF CO_2 HARVESTER IN GREENHOUSE FROM PHOTOCATALYTIC DECOMPOSITION OF AGRICULTURAL WASTES

MEL JOHN V. SUMAIT

An Undergraduate Thesis Submitted to the Faculty of the Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines
in Partial Fulfillment of the Requirements
for the Degree of

BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING
(AB Machinery and Power Engineering)

JULY 2024

ACCEPTANCE SHEET

This undergraduate thesis entitled **"VALIDATION OF CO2 HARVESTER IN GREENHOUSE FROM PHOTOCATALYTIC DECOMPOSITION OF AGRICULTURAL WASTES,"** prepared and submitted by ***MEL JOHN V. SUMAIT***, in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB MACHINERY AND POWER ENGINEERING),** is hereby accepted:

JOHN VINCENT A. NATE, M.Sc.
Member, Advisory Committee

6/14/24
Date Signed

DANILA S. PARAGAS, Ph.D.
Member, Advisory Committee

6/19/2024
Date Signed

ROLDAN T. QUITOS, M.Sc.
Chair, Advisory Committee

6/14/24
Date Signed

Accepted as partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB MACHINERY AND POWER ENGINEERING)**:

JOHN PAULO C. SACDALAN, Ph.D.
Head, Department of Agricultural and Biosystems Engineering

6/14/24
Date Signed

ROY SEARCA JOSE P. DELACRUZ, Ph.D.
Acting Dean, College of Engineering

6/14/24
Date Signed

BIOGRAPHICAL SKETCH

The author, Mel John Velasco Sumait, was born on March 21, 2001, in Urdaneta City, Pangasinan, and raised in a small barangay in the Municipality of Maria Aurora, Aurora, where he currently lives. He is the third child of Mr. Melecio Rabina Sumait and Mrs. Gina Velasco Sumait. He grew up with a simple way of life, having a farmer father and a mother who ran a small sari-sari store.

He completed his primary education as an honor student at Kadayacan Elementary School in 2013. He obtained his junior high school diploma with honors at Bayanihan National High School and graduated in 2017. He continued his senior high school at Wesleyan University Philippines—Aurora Campus, taking science, technology, engineering, and mathematics, and then graduated with high honors in 2019. He then pursued his tertiary education in 2019 and took up a Bachelor of Science in Agricultural and Biosystems Engineering major in AB Machinery and Power Engineering at Central Luzon State University with the support of his family and friends, who helped him financially and continued to believe in him until the very end.

ACKNOWLEDGEMENT

The researcher would like to extend his sincere gratitude and appreciation to all the multiple individuals who provided their invaluable support, words of wisdom, and resources for the completion of this study. To them, the author is forever profoundly grateful.

To his thesis adviser, **Engr. Roldan T. Quitos**, whose profound expertise, patience, guidance, and unwavering support were instrumental throughout the research process from beginning until the end,

To his thesis committees, **Dr. Danila S. Paragas** and **Engr. John Vincent A. Nate**, for their valuable insights and constructive feedback that significantly improve the quality of the study,

The researcher extends his deepest appreciation to **Dr. Luzviminda S. Quitos**, for sharing her knowledge and for providing support and suggestions to make this study possible,

To his classmates, for being the reason for making this college bearable, their unwavering support and guidance are truly incomparable,

To his friends, **Eloisa**, **Lian Dhei**, **Shalemar**, **Lavern Josh**, **Rochelle**, and to those who failed to mention, for their assistance and continued support, who encourages the researcher to continue and finished the study,

To his best friend, **Jomel I. Pueblos** for his assistance and for providing a helping hand in time of need. For his kind heart that always encourages the researcher to continue. His love, support, and effort accompany him throughout the study. The appreciation was

extended to his family, Mama **Emy Pueblos**, for her unending help and guidance, the researcher is forever indebted to them,

To **Ms. Catherine Bianca Siapno**, for her support and endless words of encouragement, her generosity for lending print materials to the researcher all throughout the study.

To his family, especially his mom **Gina V. Sumait**, for their unending love and unwavering support and words of encouragement, throughout this academic pursuit. Their steadfast belief in the researchers' abilities has been a constant source of inspiration and motivation,

To his late dad, **Melecio R. Sumait**, for being an endless source of strength and determination. The researcher dedicates this success to him.

To his brother, **Mac Jayson V. Sumait**, and his uncle **Armando Velasco** for financially supporting the researcher in all the expenses his been through. The researcher is always and forever thankful to them,

Above all, to The **Almighty God**, all the researcher's success was because of Him. No words can define how thankful he is.

The researcher recognizes that completing this thesis represents not only a personal achievement but also a collective endeavor marked by the contributions and support of countless individuals. Their collective wisdom, guidance, and encouragement have been instrumental in pursuing knowledge and academic excellence. Without them, this study would not be possible.

MEL JOHN V. SUMAIT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF APPENDIX TABLES

LIST OF APPENDIX FIGURES

LIST OF EQUATIONS

ABSTRACT

SUMAIT, MEL JOHN VELASCO., Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz Nueva Ecija, Philippines, **June 2024. VALIDATION OF CO_2 HARVESTER IN GREENHOUSE FROM PHOTOCATALYTIC DECOMPOSITION OF AGRICULTURAL WASTE.**

Adviser: ENGR. ROLDAN T. QUITOS, M.Sc.

Agricultural waste, including Corn cobs, rice straw, and chicken manure, are common agricultural waste in the Philippines. In this study, it was used as a bioresource material for photocatalysis. The mixture of agricultural waste with titanium dioxide was put inside the 1000L capacity IBC tank for decomposition and production of concentrated carbon dioxide. It was placed under direct sunlight for faster decomposition and UV light was installed for a continuous process at night.

The optimum performance of CO_2 harvester was evaluated at different parameters, which includes, temperature, daily CO_2 produced, volume of CO_2 produced, and flowrate. For validation, the CO_2 Harvester were installed in the greenhouse and the CO_2 injected were evaluated based on the carbon dioxide condition after injection. A CO_2 sensor were used to monitor the amount of CO_2 concentration inside the greenhouse.

As a result, the total volume of carbon dioxide collected was 195L, 178 liters under sunlight conditions while 17 liters under UV light conditions. Which concludes that the production under UV light conditions is not as effective compared to sunlight. The CO_2 collected was then injected inside the greenhouse trough drip irrigation for 3 minutes at 6:00 AM. A CO_2 sensor were used to monitor the amount of CO_2 concentration inside the greenhouse. The highest collected data of concentration was 537 ppm and the lowest is 400

ppm. The study shows that the used of CO_2 harvester inside the greenhouse can boost carbon dioxide that helps the production and growth of plants through photosynthesis.

Keywords: CO_2 Harvester; carbon dioxide; CO_2 sensors; photocatalysis; greenhouse

LITERATURE CITED

Abebe, A., Pathak, H., Singh, S.D., Bhatia, A., Harit, R.C., & Kumar, V. (2016). Agriculture, Ecosystems & Environment, Growth, yield and quality of maize with elevated atmospheric carbon dioxide and temperature in north–west India,Volume 218 (0167-8809), Pages 66-72, https://doi.org/10.1016/j.agee.2015.11.014.

Agamuthu, P. (2009, November). Challenges and opportunities in agro-waste management: An Asian perspective. In Inaugural meeting of first regional 3R forum in Asia (pp. 11-12).

Aminuzzaman, M., Kei, L. M., & Liang, W. H. (2017, April). Green synthesis of copper oxide (CuO) nanoparticles using banana peel extract and their photocatalytic activities. In AIP Conference Proceedings (Vol. 1828, No. 1, p. 020016). AIP Publishing LLC.

Anjum, M., Al-Talhi, H. A., Mohamed, S. A., Kumar, R., & Barakat, M. A. (2018). Visible light photocatalytic disintegration of waste activated sludge for enhancing biogas production. Journal of environmental management, 216, 120-127.

Ashworth, G., Azevedo., (2009) Study on Agricultural Waste. Nova Science Publishers Inc. 1-306.

Ayyildiz, M., Erdal, G. (2021) The relationship between carbon dioxide emission and crop and livestock production indexes: a dynamic common correlated effects approach. Environ Sci Pollut Res 28, 597–610, https://doi.org/10.1007/s11356-020-10409-8.

Benedix, R., Dehn, F., Quaas, J., & Orgass, M. (2000). Application of titanium dioxide photocatalysis to create self-cleaning building materials. Lacer, 5, 157-168.

Boerjan, W., Ralph, J., & Baucher, M. (2003, February). Lignin Biosynthesis. Annual review of plant biology. 54. 519-46. 10.1146/annurev.arplant.54.031902.134938.

Byrne, C., Subramanian, G., & Pillai, S. C. (2018). Recent advances in photocatalysis for environmental applications. Journal of Environmental Chemical Engineering, 6(3), 3531-3555.

CureBasilAcock, Jennifer D. Agricultural and Forest Meteorology. Volume 38, Issues 1–3, October 1986, Pages 127-145 https://doi.org/10.1016/0168-1923(86)90054-7.

Dessai, D. D., Gonsalves, G. B., Luis, M. R., & Samantha, M. (2017). Dark detector system for paper waste detection. International Journal for Scientific Research & Development 5(1), 873–875.

Diaz, L. F., Golueke, C. G., Savage, G. M., & Eggerth, L. L. (2020). Composting and recycling municipal solid waste. CRC Press.

Dibble, L. A., & Raupp, G. B. (1992). Fluidized-bed photocatalytic oxidation of trichloroethylene in contaminated air streams. Environmental Science & Technology, 26(3), 492-495.

D'Oliveira, J. C., Al-Sayyed, G., & Pichat, P. (1990). Photodegradation of 2-and 3-chlorophenol in titanium dioxide aqueous suspensions. Environmental science & technology, 24(7), 990-996.

Elfving, J., Bajamundi, C., & Kauppinen, J. (2017). Characterization and performance of direct air capture sorbent. Energy Procedia, 6087-6089.

Ferrara, G., Lanzini, A., Leone, P., Ho, M. T., & Wiley, D. E. (2017). Exergetic and exergoeconomic analysis of post-combustion CO2 capture using MEA-solvent chemical absorption. Energy, 130, 113-128.

Fujishima, A., & Honda, K. (1972). Electrochemical photolysis of water at a semiconductor electrode. nature, 238(5358), 37-38.

García-Marco, S., Ravella, S. R., Chadwick, D., Vallejo, A., Gregory, A. S., & Cárdenas, L. M. (2014). Ranking factors affecting emissions of GHG from incubated agricultural soils. European journal of soil science, 65(4), 573-583.

Gentzis, T. (2000). Subsurface sequestration of carbon dioxide — an overview from an Alberta (Canada) perspective, International Journal of Coal Geology, Volume 43, Issues 1–4, Pages 287-305, ISSN 0166-5162, https://doi.org/10.1016/S0166-5162(99)00064-6.

Herrmann, J. M., & Guillard, C. (2000). Photocatalytic degradation of pesticides in agricultural used waters. Comptes Rendus de l'Académie des Sciences-Series IIC-Chemistry, 3(6), 417-422.

Hobbs, P. R., Sayre, K., & Gupta, R. (2008). The role of conservation agriculture in sustainable agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1491), 543-555.

Huang, D. D., Cao, G. J., Geng, Y. H., Wang, L. C., Chen, X. W., & Liang, A. Z. (2019). Impact of agricultural waste return on soil greenhouse gas emissions. Applied Ecology and Environmental Research, 17(1), 1321-1335.

Jandoc, R., (2023) Development of CO2 Harvester from the photocatalytic decomposition of agricultural waste. An Undergraduate Thesis. Central Luzon State University, Science City of Munoz Nueva Ecija, Philippines.

Janusz, G., Pawlik, A., Sulej, J., Świderska-Burek, U., Jarosz-Wilkołazka, A., & Paszczyński, A. (2017). Lignin degradation: microorganisms, enzymes involved, genomes analysis and evolution. FEMS microbiology reviews, 41(6), 941-962.

Jo, W. K., & Kim, J. T. (2009). Application of visible-light photocatalysis with nitrogen-doped or unmodified titanium dioxide for control of indoor-level volatile organic compounds. Journal of Hazardous Materials, 164(1), 360-366.

Kargbo, F. R., Xing, J., & Zhang, Y. (2009). Pretreatment for energy use of rice straw: A review. African Journal of Agricultural Research, 4(11), 1560-1565.

Kieatiwong, S., Nguyen, L. V., Hebert, V. R., Hackett, M., Miller, G. C., Miille, M. J., & Mitzel, R. (1990). Photolysis of chlorinated dioxins in organic solvents and on soils. Environmental science & technology, 24(10), 1575-1580.

Konaka, R., Kasahara, E., Dunlap, W. C., Yamamoto, Y., Chien, K. C., & Inoue, M. (1999). Irradiation of titanium dioxide generates both singlet oxygen and superoxide anion. Free Radical Biology and Medicine, 27(3-4), 294-300.

Kormann, C., Bahnemann, D. W., & Hoffmann, M. R. (1988). Preparation and characterization of quantum-size titanium dioxide. The Journal of Physical Chemistry, 92(18), 5196-5201.

Kushniarou, A., Garrido, I., Fenoll, J., Vela, N., Flores, P., Navarro, G., ... & Navarro, S. (2019). Solar photocatalytic reclamation of agro-waste water polluted with twelve pesticides for agricultural reuse. Chemosphere, 214, 839-845.

Kumar, S., Negi, Y. S., & Upadhyaya, J. S. (2010). Studies on characterization of corncob based Nanoparticles. Advanced Matterials Letters, 1(3), 246-253.

Lim, J. S., Manan, Z. A., Alwi, S. R. W., & Hashim, H. (2012). A review on utilisation of biomass from rice industry as a source of renewable energy. Renewable and sustainable energy reviews, 16(5), 3084-3094.

Lipman, T. E., & Delucchi, M. A. (2002). Emissions of nitrous oxide and methane from conventional and alternative fuel motor vehicles. Climatic Change, 53(4), 477-516.

Liu, T. (2019). Biogas production from lignocellulosic agricultural residues: microbial approaches for enhanced efficiency. Acta Universitatis Agriculturae Sueciae, 2019:5. https://publications.slu.se/?file=publ/show&id=10423.

Louis, L. (2018). Working principle of arduino and using it as a tool for study and working principle of arduino and using it. International Journal of Control, Automation, Communication and Systems 1(2), 21-29. https://doi.org/10.5121/ijcacs.2016.1203.

Majlessi, M., Eslami, A., Saleh, H. N., Mirshafieean, S., & Babaii, S. (2012). Vermicomposting of food waste: assessing the stability and maturity. Iranian journal of environmental health science & engineering, 9(1), 25.

Molchanova, N. P., Morosova, S. V., Kondakov, K. S., Zhelezovskaya, G. I., & Bobyleva, G. A. (2022). Assessment of carbon dioxide effect on agricultural crops productivity by

the method of dispersion analysis. IOP Conference Series: Earth and Environmental Science, 979(1), 012078. https://doi.org/10.1088/1755-1315/979/1/012078.

Muñoz, C., Paulino, L., Monreal, C., & Zagal, E. (2010). Greenhouse gas (CO2 and N2O) emissions from soils: a review. Chilean journal of agricultural research, 70(3), 485-497.

Mvondo, D. N., Navarro-González, R., McKay, C. P., Coll, P., & Raulin, F. (2001). Production of nitrogen oxides by lightning and coronae discharges in simulated early Earth, Venus and Mars environments. Advances in Space Research, 27(2), 217-223.

Oak Ridge National Library. US Department of Energy (Bioenergy Technologies Office). (2011). Crop residues and agricultural wastes. Retrieved from https://www1.eere.energy.gov.

Ocampo, D. M., & Cotter, J. (nd). White Corn in the Philippines: Contaminated with Genetically Modified Corn Varieties. Greenpeace.org, 1-26.

Ollis, D. F., Pelizzetti, E., & Serpone, N. (1991). Photocatalyzed destruction of water contaminants. Environmental Science & Technology, 25(9), 1522-1529.

Omid, M. (2004). A Computer-Based Monitoring System to Maintain Optimum Air Temperature and Relative Humidity in Greenhouses. International Journal of Agricult

Paragas, D. S., J.R. Salazar, J.L. Abalos and E.V. Salapare,1999. Pesticide Decomposition Through Photocatalysis, R & D Highlights 1998-1999. Published by the Research, Extension and Training, Central Luzon State University.

Paragas, D. S. and Ordonez, I.DS. (2003). Chlordane Degradation by Ultraviolet Irradiation of Semiconductor Powders, LSC Journal, Vol. 2, No. 1. June 2003.

the method of dispersion analysis. IOP Conference Series: Earth and Environmental Science, 979(1), 012078. https://doi.org/10.1088/1755-1315/979/1/012078.

Muñoz, C., Paulino, L., Monreal, C., & Zagal, E. (2010). Greenhouse gas (CO2 and N2O) emissions from soils: a review. Chilean journal of agricultural research, 70(3), 485-497.

Mvondo, D. N., Navarro-González, R., McKay, C. P., Coll, P., & Raulin, F. (2001). Production of nitrogen oxides by lightning and coronae discharges in simulated early Earth, Venus and Mars environments. Advances in Space Research, 27(2), 217-223.

Oak Ridge National Library. US Department of Energy (Bioenergy Technologies Office). (2011). Crop residues and agricultural wastes. Retrieved from https://www1.eere.energy.gov.

Ocampo, D. M., & Cotter, J. (nd). White Corn in the Philippines: Contaminated with Genetically Modified Corn Varieties. Greenpeace.org, 1-26.

Ollis, D. F., Pelizzetti, E., & Serpone, N. (1991). Photocatalyzed destruction of water contaminants. Environmental Science & Technology, 25(9), 1522-1529.

Omid, M. (2004). A Computer-Based Monitoring System to Maintain Optimum Air Temperature and Relative Humidity in Greenhouses. International Journal of Agricult

Paragas, D. S., J.R. Salazar, J.L. Abalos and E.V. Salapare,1999. Pesticide Decomposition Through Photocatalysis, R & D Highlights 1998-1999. Published by the Research, Extension and Training, Central Luzon State University.

Paragas, D. S. and Ordonez, I.DS. (2003). Chlordane Degradation by Ultraviolet Irradiation of Semiconductor Powders, LSC Journal, Vol. 2, No. 1. June 2003.

Pareek, S., Sagar, N., Sharma, S., Kumar, V. (2017). Onion (Allium cepa L.): Chemistry and Human Health, 2nd Edition. 10.1002/9781119158042.ch58ure & Biology, 8530, 6–5. Retrieved from http://www.ijab.org

Pagal, D.G. (2008). Production of Organic Fertilizer through Photocatalytic Degradation pof Rice Straw using Titanoum (IV) Oxide. An Undergradate Thesis. Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines.

Paz, Y., Luo, Z., Rabenberg, L., & Heller, A. (1995). Photooxidative self-cleaning transparent titanium dioxide films on glass. Journal of Materials Research, 10(11), 2842-2848.

Peng, J., Wang, Y., Dan, L., Feng, J., Yang, F., Tang, X., et al. (2022). Overestimated terrestrial carbon uptake in the future owing to the lack of spatial variations CO_2 in an Earth system model. Earth's Future, 10, e2021EF002440. https://doi.org/10.1029/2021EF002440.

Pointner, M., Kuttner, P., Obrlik, T., Jager, A., & Kahr, H. (2014). Composition of corncobs as a substrate for fermentation of biofuels. Agronomy Research, 12(2), 391-396.

Rahimi, N., Pax, R. A., & Gray, E. M. (2016). Review of functional titanium oxides. I: TiO2 and its modifications. Progress in Solid State Chemistry, 44(3), 86-105.

Roy, R. K. (2001). Design of experiments using the Taguchi approach: 16 steps to product and process improvement. John Wiley & Sons.

Saad, R. (2019). A Review on Anaerobic Co-Digestion with a Focus on the Microbial Populations and the Effect of Multi-Stage Digester Configuration. Energies, 12(6), 1–25. https://ideas.repec.org/a/gam/jeners/v12y2019i6p1106-d216111.html.

Sabate, J., Anderson, M. A., Kikkawa, H., Edwards, M., & Hill Jr, C. G. (1991). A kinetic study of the photocatalytic degradation of 3-chlorosalicylic acid over TiO2 membranes supported on glass. Journal of catalysis, 127(1), 167-177.

Sheikh, A. Q., Skinder, B. M., Ashok, K. P., & Ganai, B. A. (2014). Terrestrial carbon sequestration as a climate change mitigation activity. Journal of Pollution Effects & Control, 1-8.

Spigarelli, B., Kawatra, SK. (2013). Journal of CO_2 Utilization, Opportunities and challenges in carbon dioxide capture, Volume 1 (2212-9820), Pages 69-87, https://doi.org/10.1016/j.jcou.2013.03.002.

Stewart, C., Moturi, P., Follet, R., & Halvorson, A. (2015). Lignin biochemistry and soil N determine crop residue decomposition and soil priming, 124:335–351, doi:10.1007/s10533-015-0101-8.

Terzian, R., Serpone, N., Minero, C., & Pelizzetti, E. (1991). Photocatalyzed mineralization of cresols in aqueous media with irradiated titania. Journal of Catalysis, 128(2), 352-365.

Tsai, W. T., Chang, C. Y., Wang, S. Y, Chang, C. F., Chien, S. F., & Sun, H. F. (2001). Utilization of Agricultural Waste Corn Cob for the Preparation of the Carbon Absorbent. Journal of Environmental Science and Health, 36(5), 677-686.

Velmurugan, P., Shim, J., Lee, K. J., Cho, M., Lim, S. S., Seo, S. K., Cho, K. M., Bang, K. S., & Oh, B. T. (2015). Extraction, characterization, and catalytic potential of amorphous silica from corncobs by sol-gel method. Journal of Industrial and Engineering Chemistry, 1-6.

Zhang, C., Zeng, G., Huang, D., Lai, C., Chen, M., Cheng, M., ... & Tan, X. (2019). Biochar for environmental management: Mitigating greenhouse gas emissions, contaminant treatment, and potential negative impacts. Chemical Engineering Journal, 373, 902-922.