

**ENGINEERING SCIENCES
AND TECHNOLOGY**

EST - 01

YIELD POTENTIAL OF RAIN TREE FRUIT (*Samanea saman* Merr.) AS FEEDSTOCK FOR BIOFUEL PRODUCTION

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This study was conducted to determine the ethanol yield potential of rain tree fruit and to evaluate its potentials as a feedstock for biofuel production.

Ripe rain tree fruits were fermented using baker's yeast (*Saccharomyces cerevisiae*) with the following treatments with three (3) replications each: Treatment 1 (T_1)- fermentation of the whole fruit pods; Treatment 2 (T_2) –fermentation of the fruit with the seeds removed and Treatment 3 (T_3) – fermentation of the filtered mixture only (solid particles consisting of pulp, bark and seeds were removed). One (1) kg of pounded and blended fruit was used for each replication and was fermented for 10 days in a six-gallon water container.

Result of this study reveals that using the basis that fifty percent (50%) of the measured sugar level is converted into ethanol, T_1 obtained the highest yield potential of 210 ml/kg. Based on the alcohol content analysis of the fermented solution the highest ethanol yield was obtained by T_1 (180 ml/kg), followed by T_2 (177 ml/kg) while T_3 (162 ml/kg) obtained the lowest ethanol yield among the treatments. Moreover, based on the alcohol analysis of the distillate, T_1 (117.03 ml/kg) obtained the highest average ethanol yield followed by T_2 (116.40 ml/kg) while T_3 (90.23 ml/kg) obtained the lowest. Analysis of variance reveals that there is a significant difference among the treatments at 5 percent level of significance.

This study found out that rain tree fruit has a yield potential of 210 ml/kg (210 liters/ton). Comparison of the yield potential of rain tree fruit with other feedstock reveals that the rain tree fruit is a very good feedstock for biofuel production. It is recommended that optimization studies should be conducted in all aspects of fruit processing, from particle size reduction to fermentation and distillation, for optimum bio-ethanol production.

Keywords: rain tree fruit, ethanol yield, biofuel feedstock, biofuel production, fermentation

EST - 02

PROPERTIES AND PERFORMANCE OF MMSU HYDROUS BIOFUEL

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Modified fermentation techniques at ambient temperature and simplified reflux distillation protocols were developed to produce the *MMSU 95 hBE* bioethanol and the *MMSU hBE-20* gasohol fuel blend.

The 95% fuel-grade hydrous ethanol, *MMSU 95 hBE*, was produced from sweet sorghum and sugarcane and was subsequently used to formulate a unique hydrous gasohol blend: the *MMSU hBE-20*. Unlike other hydrous ethanol fuel blends formulated in other countries, our formulation does not need a dispersant, nor a co-solvent and uses the commercially available anhydrous E-10 gasohol blend. The *MMSU hBE 20* was stable at ambient temperature and did not show phase separation even at refrigerated conditions. Preliminary tests of the gasohol, when used in stationary 4-stroke engines, motorcycles and motor vehicles, revealed no discernible problems. The performance of a 6.5 HP engine when fueled with *MMSU hBE-20* was comparable with the commercial E-10. Under different engine load of 4, 6, and 8 kg, the fuel consumption (L/hr), brake horsepower (BHP), brake fuel rate (L/BHP-hr), heat value (Btu/lb), and brake thermal efficiency of the same engine fueled with *MMSU hBE 20* did not vary significantly with the E-10-fed engine. Further tests indicate the *MMSU 95 hBE* can also be used up to E-85, indicating the possibility that it can be suitable for use in modern Flex Fuel Vehicles (FFV) when they become available in the Philippines.

The *MMSU hBE 20* is a promising fuel for gas powered engines and vehicles that is more economical and environmentally sustainable than blends using anhydrous ethanol. More important, these technologies are scale-adaptable and easily adoptable at the village level to create an enterprise that is economically viable. Current forecast indicate an average production cost of PHP 30 using feedstocks from sugarcane and sweet sorghum which, when compared to the prevailing cost of gasoline, can result in a profit margin of about 67%.

Commercialization of these technologies will open opportunities for village level ethanol production and would be a significant contribution towards the implementation of several Republic Acts: the RA 9637- the Philippine Biofuels Act, RA 9003- Philippines' Ecological Solid Waste Management Act, RA 9513- The Philippines Renewable Energy Act, and the RA 8749- The Philippine Air Act.

Keywords: village-scale ethanol production, *MMSU 95 hBE*, *MMSU hBE-20*, hydrous ethanol, reflux distillation, biofuel

EST - 03

EFFECTS OF ANTIOXIDANTS EXTRACTED FROM LEAVES OF “BANABA” (*Lagerstroemia speciosa*, L.), MANGOSTEEN (*Garcinia mangostana*, L) AND “TSAANG GUBAT” (*Ehretia microphylla* L.) ON THE OXIDATION STABILITY OF BIODIESEL FROM *Jatropha curcas*, L.

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The stability of biodiesel is relatively inferior to petrodiesel due to its unsaturated fatty acids which may lead to the formation of gums. In the presence of air or oxygen, alcohol and acid may be produced which can reduce the flash point and increase the total acid number, thus causing damage to the engines. The effects of the antioxidant extract from “banaba” (*Lagerstroemia speciosa*, L.), mangosteen (*Garcinia mangostana*, L) and “tsaang gubat” (*Ehretia microphylla* L.) on the oxidative stability of biodiesel from *Jatropha curcas*, L. were determined based on the induction period (IP) of the samples using the Rancimat method of oil stability index. The data obtained for the “banaba”, mangosteen and “tsaang gubat” extracts had regression coefficients (R^2) of 0.687, 0.804 and 0.886, respectively, indicating a linear positive correlation between the loading rates (mg total polyphenol in the extracts /L biodiesel; ppm) and the IP (hours). To meet the European standard of 6-hour IP, the loading rates (g antioxidants per 100 L biodiesel) were found to be: 983.4, 110.9, 1124.9, and 206.3 for “banaba”, mangosteen, “tsaang gubat” and the commercial antioxidant, respectively. The antioxidant extract from mangosteen leaves had actual loading rate of 260.4 g/100L, with induction period of 17.52 hours, greatly exceeding the American, European and Japanese standards.

Keywords: Antioxidant, “banaba”, mangosteen, “Tsaang Gubat”, biodiesel, *Jatropha curcas*

EST - 04

**MICROEMULSIFIED HYBRID FUEL FROM
JATROPHA AND COCONUT OILS**

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A microemulsified hybrid fuel from *jatropha* and coconut oils was developed through the process of microemulsification. This was done by mixing the oils with surfactant, co-surfactant and water. The resulting product was evaluated in terms of phase behavior and physicochemical properties. Application tests were done in high powered lantern (petromax) for lighting and gas stove for cooking. Results of the study showed that microemulsions of *Jatropha* oil and coconut oil and its blend are thermodynamically stable, have low viscosities and stable against oxidation. Application tests showed that microemulsified *jatropha* oil, microemulsified blend of *jatropha* and coconut and blends with kerosene have better lux range and less fuel consumption than using kerosene in petromax. In gas stove, results showed that blends of microemulsified *jatropha* and coconut oil with kerosene, exhibited less fuel consumption, high thermal and combustion efficiency, reduced CO and CO₂ emission. Results of the analysis of physicochemical properties, smoke emission test and vehicle performance showed its potential as alternative fuel for transport. Application test of microemulsified hybrid fuel in diesel genset showed reduced fuel rate consumption, liter per hour of about 53.0% to 76.5%.

The process of microemulsion is simple with no residual waste product to be disposed or treated. Microemulsion fuels are generally cleaner fuel. Microemulsion fuels provide a method for increasing the use of *jatropha* and coconut oil as fuel. It has the ability to significantly reduce petroleum consumption as well as lower harmful and particulate emissions.

Keywords: Microemulsification; *Jatropha* Oil; Coconut Oil; Hybrid Fuel

EST - 05

**ASSESSMENT OF RENEWABLE ENERGY RESOURCE
POTENTIAL AND APPLICATION FOR DECENTRALIZED
RURAL ELECTRIFICATION USING GEOGRAPHIC
INFORMATION SYSTEM (GIS)**

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One consequence of massive economic development across the globe since the industrial revolution is the depletion of fossil fuel and global climate change. Countries increase its energy demand to sustain their economic growth. However, this relationship between energy demand and economic growth greatly affects our environment. It is already a given fact that fossil fuels will eventually run out, thus the move towards alternative sources of energy which are renewable and at the same time eco-friendly.

This study evaluates solar and biomass energy sources in Bukidnon, a province located at the southern part of Philippines, by means of analyzing the theoretical and the technical potential of these renewable sources of energy using geographic information system (GIS).

Various scenario analyses were also carried out to show the effects of different financial parameters (initial costs, operations and maintenance costs and electricity export rate) to the renewable energy systems financial viability using RETScreen software.

Results showed that Bukidnon has an estimated technical solar energy potential of 55 MW power plant capacities that could be added to the grid and 69 MW of installed capacity power plant can be set-up from the technical potential of agricultural crops.

In conclusion, the study was able to provide a GIS-based support system for the government in the formulation of policies and strategies with regards to finding interested investors that could develop a suitable site for renewable energy system in the province and thus, could help avert future energy crisis and at the same time reduce GHG emissions.

Keywords: Renewable Energy Resources, Solar Energy, Biomass Resource, RETScreen, GIS

EST - 06

**A BI-LEVEL MULTI-PERIOD OPTIMIZATION MODEL FOR
MULTIPLE FEEDSTOCK BIOENERGY SUPPLY CHAINS**

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This paper presents a bi-level optimization model for bioenergy supply chains that integrates a multiple-feedstock, multi-period framework for determining the best trajectories of such systems with time. The resulting model gives a more accurate interpretation of the different scenarios that could face real world energy systems. The upper level decision maker, the government, seeks to maximize the total amount of bioenergy that is produced by setting the appropriate desired range of production; whereas the lower level decision maker, the bioenergy producers, strives to maximize its profit, while subject to the economic and environmental limits imposed by the government. This interaction results in a Stackelberg game which is equivalent to a bi-level programming problem. Inclusion of a multi-period approach allows the growth and development of the different bioenergy sources to be specified for a fixed time horizon from the perspective of multiple decision makers. This approach can pave the way to obtain a rational prediction and allow for the optimization of resources being consumed, which can increase public awareness and assist decision makers in choosing the best path to choose. A numerical case study are used to assess the effects of key system parameters on the growth trajectories of the bioenergy systems and key policy implications of the results are discussed.

Keywords: energy planning; bi-level optimization; sustainability; importation; bioenergy system; Stackelberg game

EST - 07

**LACTIC ACID FERMENTATION FROM *Jatropha curcas* L.
PRESS CAKE AND RAW CASSAVA STARCH
USING *Rhizopus oryzae* NRRL-395**

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The utilization of *Jatropha curcas* L. for biodiesel production, produces significant amount of press cake as by-product. Toxic compounds render the cake unsuitable for animal feed. Thus other uses, such as substrate for fermentation should be explored. Its use for lactic acid production was tried in this study.

Dilute-acid hydrolysis of *Jatropha* press cake substrate was initially optimized, specifically pH conditions and duration of autoclaving. The highest value of reducing sugars recorded was 86.6 g/L obtained by hydrolyzing the samples at pH 1.0 for 30 minutes. Upon fermentation with *Rhizopus oryzae* NRRL-395, starch-supplemented hydrolyzed *Jatropha* press cake produced 3.67 g/L lactic acid in one day at pH 5.0. On the other hand, unhydrolyzed press cake took four days to ferment, but attained the highest value of 11.93 g/L lactic acid. Hydrolyzed samples could have produced sugars that are not utilizable by *Rhizopus oryzae*.

The use of *Jatropha* press cake as protein supplement for the fermentation of raw cassava starch into lactic acid was feasible. This would probably provide a good alternative to reduce the fermentation costs due to chemical supplements. Further optimization is still needed for it to be suitable for large scale production

Keywords: lactic acid fermentation, *Jatropha curcas*, cassava starch, *Rhizopus oryzae*.

EST - 08

GREENHOUSE GAS EMISSIONS OF TOBACCO FLUE-CURING PROCESS IN THE PHILIPPINES

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The production of flue-cured tobacco is one of the major agricultural production systems in the Philippines specifically in Northwestern Luzon. It is considered high value cash crop that could offset the cost of production of food crops. The production of the crop is energy intensive especially in the flue-curing process which is done in natural convection flue-curing barns made of different materials like concrete and galvanized iron sheets in various configurations with fuelwood as the primary source of energy.

The annual production of flue-cured tobacco for the past five decades is fluctuating between 45,000 to 75,000 tons. The amount of fuelwood to cure this volume of tobacco was determined by statistical models developed and it ranges from 157,500 to 262,500 tons per year. This volume of fuelwood was estimated to be equivalent to trees grown in 6,750 to 7,500 hectares of woodland depending on growth density.

Mathematical models were developed utilizing previous research data in establishing the greenhouse gas emission levels in relation to the different tobacco flue-curing barn configurations. The amount of carbon dioxide (CO₂) and carbon monoxide (CO) emitted were obtained in the mathematical models developed at different conditions. The range of annual CO₂ and CO emission computed using the mathematical model are, 55,460 to 83,460 tons and 4,560 to 6,970 tons.

Keywords: carbon dioxide, carbon monoxide, emissions, energy, flue-curing, fuelwood, greenhouse gases, tobacco

EST - 09

**INVESTIGATION OF ARSENATE UPTAKE BY
HYDROTALCITE AT HYPERALKALINE AND ELEVATED
TEMPERATURE CONDITIONS**

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Hydrotalcite is known to retain large amounts of anionic species due to its positive charge characteristics. Hence, investigating its role for the retention of long-lived dissolved anionic nuclides during an intrusion scenario in radioactive disposal facilities is necessary.

This study examined the Mg-Al type hydrotalcite ($Mg_6Al_2(CO_3)(OH)_{16} \cdot 4(H_2O)$) (Mg/Al ratio = 2) as possible sorbent of anionic nuclide using arsenate as an analogue. The sorption experiments were carried out at alkaline pH condition (pH 11) and elevated temperature of 75°C to simulate the intrusion scenario at radioactive waste repositories. Arsenate sorption was conducted during and after hydrotalcite formation.

The results showed that hydrotalcite was able to remove more than 90 and 70% of arsenate during and after mineral formation, respectively even in the presence of competing anions. The co-precipitated arsenic was more resistant to release and showed a significant irreversible fraction of sorbed arsenate of more than 30%, which could be attributed to the inner-sphere complexation with the Mg or Al in the octahedral sheets by displacing their coordinated hydroxyl group and stronger interlayer fixation.

Overall, the immobilization of arsenate by hydrotalcite could possibly ensure the long-term immobilization anionic nuclides. Hence, controlling the pore water chemistry of cement to ensure the significant precipitation of hydrotalcite during hydration must be considered in cementitious systems used in geological waste repositories.

Keywords: Hydrotalcite, arsenate, sorption, radioactive waste repositories, cementitious systems

EST - 10

**EFFECT OF FUNCTIONAL IRON OXIDE NANOCRYSTALS
ON THE ARSENIC LEVEL IN DRINKING WATER**

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Arsenic is a semi-metal element in the periodic table and a naturally occurring element in the earth's crust. It enters drinking water supplies from natural deposits in the earth or from the agricultural and industrial practices. It has created serious contamination of the environment, causing many mass poisonings throughout the world. This study was designed to prepare functional iron oxide nanocrystals (a nanomagnet) and be used in the treatment of water contaminated with arsenic.

The synthesis of functional iron oxide nanocrystals was divided into three parts: soap making process, extraction of oleic acid from soap with commercial vinegar, and preparation of magnetite or functional iron oxide nanocrystals from rust and fatty acids.

The functional iron oxide nanocrystals (0.5 g per liter of water) was placed in water contaminated with arsenic and stirred for 5 minutes. The formation of bubbles on the surface of nanocrystals was observed. The water samples before and after treatment was brought to the Natural Science Research Institute for the analysis of arsenic using THGA Graphite Furnace Atomic Absorption Spectroscopic method.

Results of the analysis showed that the functional iron oxide nanocrystals was able to remove 85.89% of arsenic. The removal of arsenic is through nanomagnetism. Further studies on the effect of different amounts of iron oxide nanocrystals and concentration of arsenic in water must be conducted.

Keywords: nanocrystal, arsenic, rust, oleic acid, nanomagnet

EST - 11

**GOOGLE EARTH: A TOOL FOR ELICITING SPATIAL
INFORMATION ABOUT FOREST DEGRADATION
FROM LOCAL PEOPLE**

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As a component of REDD or REDD+ (Reduced Emissions from Deforestation and Forest Degradation), detection and measurement of forest degradation has been widely reported in literature as technically difficult. This is because forest degradation is not easily detected and measured using satellite imageries, a situation that requires increased use of field data and information from local people. Hence, all available technology must be used including Google Earth that provides virtual landscape of localities on earth.

A high resolution Google Earth imagery was used to delineate watershed boundary; map streams, roads, trails, houses and other ground features; stratify forest vegetation according to carbon stock; and as input for interpreting Landsat ETM+ data. More importantly, the three dimensional virtual landscape enhanced collection of information about historical change in extent and composition of forest vegetation, proximate drivers of forest degradation, and risk of degradation based on historical trend. Using the virtual landscape as visual aid, key informant interview and workshop were conducted to elicit information. It was observed that, using an effective visual aid, local people can easily grasp such technical concepts as percent canopy cover, relationship between tree diameter and tree crown, appearance of canopy in the imagery according to species composition and tree density, and carbon stock decline as indicator of forest degradation. The information elicited from local people when combined with GIS ancillary data, Landsat ETM+ data, and field data resulted in reliable estimate of forest degradation in Maasin Watershed in Nueva Vizcaya.

Keywords: Google Earth imagery, forest degradation, REDD, local knowledge, participatory GIS

EST - 12

FERMENTATION KINETICS OF GELATIN-IMMOBILIZED *Lactobacillus plantarum* BS USING SKIM MILK AS SUBSTRATE

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Probiotics should at least have 10^7 CFU/ml count for more effective health benefits. However, a common problem with probiotic products is cell viability especially at ambient conditions. Cell entrapment or immobilization may promote viability.

A local lactic acid bacteria isolate, *Lactobacillus plantarum* BS, showed good probiotic properties in previous studies. Entrapment in gelatin was thought to enhance cell viability and create a different form of probiotic drink. The growth kinetics of gelatin-immobilized *L. plantarum* was investigated using 8, 10, and 12% (w/v) skim milk as substrates. Batch fermentation was done at 37°C and agitation speed of 100 rpm. Total sugar consumption, biomass production, titratable acidity, pH and viability of immobilized cells during storage were determined. Maximum growth of *Lb. plantarum* BS was observed at its logarithmic phase, which was 6.5×10^7 CFU/ml, 6.0×10^7 CFU/ml and 6.1×10^7 CFU/ml for 8, 10 and 12% (w/v) skim milk concentrations, respectively. Its stationary phase was observed after 6 h of fermentation. Highest rate of substrate consumption and biomass production were observed at 8% (w/v) skim milk concentration, suggesting substrate inhibition at higher concentrations.

Results also showed that through time, the pH of the substrate dropped while the total titratable acidity increased, suggesting an increase in the lactic acid production. The viability of the microbial cells during storage was also investigated and results showed that the viability of gelatin-immobilized cells was higher than that of the free cells during storage at refrigerated conditions. The growth of gelatin-immobilized *L. plantarum* was best described by the Moser Model yielding a μ_{max} value of 0.3556 hr⁻¹ and Ks value equal to $3.2E+7$ µg/mL.

Keywords: *Lactobacillus plantarum*, viability, probiotics, lactic acid bacteria, skim milk, kinetic study