

ENGINEERING SCIENCE AND TECHNOLOGY

ESTD No. 1

DEVELOPING ENVIRONMENTAL MANAGEMENT ZONES USING GIS TECHNOLOGY

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An environmental management plan (EMP) was prepared for the province of Lanao del Sur with focus on the Lake Lanao watershed. This study was conducted with support from The Netherlands and implemented through collaborative efforts among different agencies like FAO, UNDP, ARMM and other stakeholders.

The scope of the EMP is extensive in terms of geographic coverage and purpose considering the state of human welfare and environmental condition in the area. While Lake Lanao Watershed reportedly provides 70% of the power needs of Mindanao, ironically, the Meranaos have not sufficiently benefited from being stewards of this vital resource. The preparation of the EMP was guided by this fact including the roles and responsibilities that must be played and shared in order to ensure the success of the Plan and thus sustain the benefits which can be derived from the watershed.

The planning exercise revealed important insights into the process of plan preparation: (1) The development of baseline information (e.g. basemaps in digital (GIS) format) is an important advantage for Lanao del Sur. The necessary next step is to provide a mechanism for the operationalization of the EMP and the implementation of the identified proposals contained in the plan. Thus, the zones were expressed according to the distribution in each local government unit (LGU) to allow them (the LGUs) to make comparisons and integrate these with their own respective land use plans. (2) It is crucial that the EMP be validated on the ground and integrated into the individual management plans of the municipalities of Lanao del Sur. (3) DENR-ARMM should consider this dataset as an important reference material in designing land use interventions in the province. However, validation and its continued and regular updating should be pursued as part of the monitoring and evaluation activities of the province.

Keywords: environmental management plan; geographic information system; management zones

ESTD No. 2

**IDENTIFICATION OF EROSION-PRONE AREAS IN
THE PROVINCE OF AKLAN USING
GEOGRAPHIC INFORMATION SYSTEM**

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This study used the Universal Soil Loss Equation (USLE) model to compute the rate of soil erosion in the 17 municipalities of the province of Aklan, Philippines. About half of the land area in this 181,790-hectare province is allotted to agriculture, thus, proper management of its land resources is of great importance.

The erosion factors in the USLE model (rainfall erosivity, soil erodibility, slope length and steepness and land cover and management) were computed from data gathered from various agencies and institutions. Data on vegetation cover were interpreted from a Landsat 7 image acquired on July 30, 2001. Geographic Information System was then used to integrate these factors to come up with the erosion potential map in terms of mass of soil loss per area of land. Digitizing of paper maps was done through Arcview v8.3 while interpolation and overlaying of values were done using IDRISI v14. The results of the study show that the average soil loss in the province was 5.8 ton/ha/yr, a bit higher than the national average of 2.69 ton/ha/yr. The erosion map was further classified into five different classes of erosion intensity. Results further showed that 82% of the province had a low soil loss rate (less than 7.4 ton/ha/yr). Areas with severe erosion rate (>37 ton/ha/yr) comprised 2.5% and were located on steep (>30% slope) hills and mountains, and on grassy areas. Thirty-nine percent of these areas are found in the municipalities of Madalag and Libacao. In terms of vegetation cover, grasslands had the highest average soil loss of 19.8 ton/ha/yr. This study concluded that, for Aklan province, the slope length and steepness factor had the highest correlation with soil loss.

Keywords: geographic information system, erosion, soil, remote sensing, USLE

ESTD No. 3

COMPARISON OF TECHNIQUES FOR BIODIVERSITY ASSESSMENT

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A study of land use necessitates a careful consideration of the factors that determine its appropriateness and sustainability. The key then is to assess the state and identify areas that are susceptible to agents of land degradation. The analysis of land capability is implemented by comparing an estimate of land degradation with a tolerance limit. The tolerance limit prescribes the threshold for agricultural productivity above which necessitates leaving the area for forest-use purposes. To operationalize the analytical procedure, a system for geodatabaseing the general characteristics of the land for assessment, monitoring and evaluation was developed. The description of the landscape is carried out using the vector approach – a new method for comprehensively describing all aspects about the landscape. The vector approach enriches the description of the landscape through the various levels of the GAME model – GIS-based assessment, monitoring and evaluation. The geodatabase component of GAME allows a comprehensive description of geographic phenomena. The mapping component, on the other hand, enables visualization of the landscape using GIS. Thus, the status of natural resources (e.g. forest cover) can be readily assessed; the progress of relevant projects (e.g. forest renewal) can be monitored; and the quality of natural resources and the impact of interventions (e.g. forest conversion) can be evaluated.

As a technique for biodiversity assessment, the GAME Model was compared with the line plot and strip methods using actual census data from a 16-ha permanent plot in Palanan, Isabela. The results of the study show that species abundance is dependent on the sampling intensity used in a particular inventory technique. Among the three inventory techniques, the GAME Model proved the most economical and practical.

Keywords: geographic information system; biodiversity; geodatabase

ESTD No. 4

**IMAGE ANALYSIS OF LEAF SHAPE VARIATIONS IN ENDEMIC,
INDIGENOUS AND NEW SPECIES OF HOYAS FROM THE PHILIPPINES
USING ELLIPTIC FOURIER SHAPE DESCRIPTORS**

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Applying technological advances in image analysis have contributed much in the advancement of understanding sources of variations not only in non-living objects but also in living organisms. Modeling shapes and understanding developing organisms including their relationships have already been possible by combining image analysis of the geometry of shapes coupled with appropriate statistical tools have increased our knowledge in understanding complexities in living organisms. In this study, we studied leaf shape variations in eleven (11) endemic, two (2) indigenous and three (3) new species of Philippine Hoyas by leaf contours summarized as increments of x and y coordinates extracted from scanned images (600 dpi) of leaves using image analysis and processing software. Elliptic Fourier (EFA) shapes descriptors, which are the cosine and sine components of the x and y increments along the leaf outline for the first ten harmonics were then computed. These descriptors were then normalized to avoid variations related to size, rotation and starting point of the contour traces. This procedure has allowed for the analysis of leaf shape variations only. Then, the leaf outlines were reconstructed using all ten harmonics. The information contained in the coefficients of the EFA descriptors were summarized through principal component analysis based on a variance-covariance matrix of the coefficients. The scores of the components were used in the subsequent analysis of leaf shape characteristics. Results showed variations in leaf shapes among the different species of Hoyas. Also, the first few components accounted for the total leaf variation and were good measures of the ratio of the length to width, the position of the centroid, and the curvature of the leaf wing size. It is very interesting to report that this methodology is very effective in illustrating graphically and statistically the variations in leaf shapes among the different species of Hoyas and can also be applicable in analyzing not only other biological shapes but also images of inanimate objects.

Keywords: image analysis, leaf variations, Hoyas, Elliptic Fourier Analysis

ESTD No. 5

**ODOR EMISSION REDUCTION FROM ENCLOSED
GROWING-FINISHING PIG HOUSE
USING DIFFERENT BIOFILTER MEDIA**

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This study was conducted to determine the odor reduction efficiency of a biofilter design using different filter materials. The summary of results are as follows: (1) The airflow penetration rate of the different filter materials namely; rice straw, woodchips, rice hulls and sawdust were 0.72 m/s, 0.64 m/s, 0.48 m/s and 0.17 m/s, respectively. (2) Compared to a pig barn with no biofilter, NH₃ emission was reduced by 77% using a biofilter media of sawdust and wood chip followed by rice hull and rice straw with a removal efficiency of 69% and 46%, respectively. Based on a two bi-weekly monitoring of NH₃ emission, wood chip as a biofilter media proved to be the most superior and consistent in reducing this gas due to removal efficiencies of 76%, 55% and 76% for days 7, 14 and 36, respectively. On the other hand, rice hull was the most effective among biofilter media in reducing H₂S with a 5.76% removal efficiency. The above findings indicated that NH₃ can be easily trapped/absorbed effectively by all the biofilter media than H₂S. Finally, the airflow penetration rate of the different biofilter media tended to be related to odor elimination efficiency with sawdust having the slowest penetration rate of 0.17m/s.

Keywords: biofilters, odor reduction efficiency.

ESTD No. 6

POTENTIAL OF LIGNOCELLULOSIC MATS FILTER FOR INDUSTRIAL WASTE WATER

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The study was conducted primarily to develop a lignocellulosic mat from waste banana trunks for use as filter for industrial waste water effluent from a secondary fiber-based paper industry. The banana fibers were prepared by retting the material in four different retting times: 1, 2, 3 and 4 weeks. Activated carbon and unretted banana fibers were used as controls. The different treatments were fitted separately in an improvised water column for the run through trials. The filtration capacity of the lignocellulosic mats including the controls were used twice in 48 hours to evaluate their re-usabilities.

Retting time affected significantly the removal of extractives without considerably affecting the other biomass components of the material. The significant removal of extractives with prolonged retting time correspondingly favored defibrillation of the individual banana fibers for a much improved mat formation. In effect, the freeness (flow of water, mL/sec) of the mat decreased, favoring the filtration efficiency of the lignocellulosic mat.

The filtration performance of the banana fiber lignocellulosic mat (BCFM) is generally comparable with that of the activated carbon and even showed better filtration capacity than the latter during the second time run through trials. Data analysis using the orthogonal polynomial contrast showed that prolonged retting time had a direct effect on the ability of the BCFM to reduce or remove the water pollutants. Except for the microbial load, all the other pollution indicators: Total dissolved solid (TSS); Total suspended solids, (TSS); biological oxygen demand (BOD); chemical oxygen demand; Calcium and calcium carbonate were reduced significantly by the BCFM filter.

Key words : lignocellulosic mat, filter, waste water effluent, banana fiber

ESTD No. 7

**STUDIES ON THE PREPARATION OF BANANA PULP
FOR VULCANIZED FIBER**

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Banana pulps were prepared by soda, soda AQ and retting process with two stage bleaching processes following the TAPPI standard procedures with some modifications to suit the fiber material. The pulps produced showed superior properties even before bleaching and beating. However, only those prepared by retting process met the criteria for vulcanization; e.g. low air permeability (40.70 sec/100ml) and superior strength properties. Hence, only those sheets prepared from retted pulp were used for the vulcanization trials.

Sufficient number of sheets at two different basis weights: 90 and 120 gsm were prepared and conditioned for the vulcanization. Two-ply sheet vulcanization was done by placing the two sheets on top of the other and passed them together in the vulcanization series. Their adjacent surfaces penetrated by the $ZnCl_2$ swelled and gelatinized making the two sheets to fuse homogeneously. The same process was done for the one-ply sheet. Percent (%) $ZnCl_2$ absorption by the sheets was found higher in the 90 gsm- than the 120 gsm-sheets for both the one- and two-ply samples. Correspondingly, the plybond strength of the two-ply sheets was remarkable with the 90 gsm sheet giving higher strength (3.33 lb/inch²) than the 120 gsm (2.86 lb/inch²). The values obtained were within the ranges obtained in previous studies using other materials like tobacco, kenaf, commercial softwood unbleached and bleached kraft pulps (Agrupis, 2000).

The physical appearance of the banana vulcanized fiber sheets closely resemble those of the commercial grade vulcanized fiber, but obviously showed the need to further improve the quality. Vulcanized fiber is a high grade cellulosic sheet, which is water- and heat-resistant. It is used in many industrial applications like electrical washers, heat insulators and the like.

Keywords : Vulcanized fiber, TAPPI(Technological Asso. of Pulp and Paper Industries) AQ (Anthraquinone), banana fiber

ESTD No. 8

**CHARACTERIZATION AND CEMENTITIOUS SOLIDIFICATION/
STABILIZATION OF A SLUDGE GENERATED BY A METAL
COATING/PLATING PLANT USING RICE HULL ASH AS ADDITIVE**

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The semiconductor industry is the top exporting industry in the Philippines. Sludges containing heavy metals from semi-conductor and metal coating/plating plants pose a grave threat to the environment that need to be given attention.

A treatability study was conducted to determine the feasibility of employing solidification/stabilization (S/S) technology to treat a heavy metal-contaminated sludge generated by the wastewater treatment facility of a metal coating/plating plant and evaluated the performance by conducting the Toxicity Characteristic Leaching Procedure (TCLP), compression and durability tests. The use of rice hull ash (RHA) as partial substitute to ordinary Portland cement (OPC) that will act as the S/S binder or reagent was also investigated.

Seven treatments of OPC, RHA and sludge were designed for the relative amounts of mixture components. Seven duplicate concrete blocks were molded and cured for 28 days. Three blocks were tested for unconfined compressive strength (UCS) using the universal testing machine (UTM). Two blocks were subjected to wetting and drying cycles to test the durability. TCLP was employed to determine the percent reduction in the nickel that leached after extraction.

The results of the study clearly show that the mobility of heavy metals can be effectively reduced by the S/S process. Leaching of nickel can be minimized or retarded to meet standards by blending the waste with siliceous materials such as Portland cement and rice hull ash. Immobilization is more effective when the OPC is available at higher amounts as in higher formulations.

From the general comparison made on the seven mixture formulations, OPC-RHA-SLU ratio of 0.3/0.35/0.35 was rated the most outstanding composition after passing the leachability, compression, and durability test, having the highest OPC substitution with RHA hence highest binder cost reduction, and highest amount of sludge treated.

Keywords: metal coating-plating plants, nickel, heavy metals, solidification/stabilization technology, sludge, rice hull ash

ESTD No. 9

**RHEOLOGICAL AND CASTING PROPERTIES OF SANITARY WARE
SLIPS WITH RICE HULL ASH**

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The manufacture of ceramic sanitary ware utilizes white clay, feldspar and quartz and these are usually imported. Rice hull ash is high grade amorphous silica when subjected to heat. We evaluated the progressive replacement of quartz by active silica obtained from rice hull ash for ceramic casting slips to determine the level of substitution to be used without affecting its rheological property.

Calcined rice hull ash was used to gradually replace the quartz content of the slip at 3%, 6%, 9%, 12% and 15%. Sodium silicate (Na_2SiO_3) as the electrolyte and deflocculant was added at a varying rate of 1.3%, 1.6% and 1.9%. Rheological properties such as viscosity, specific gravity and casting rate were determined.

Results of the experiments indicate that the addition of rice hull ash significantly increased the viscosity (decrease in fluidity). Using 1.9% deflocculant, all the formulations flowed while with 1.3% of deflocculant, only up to 6% quartz substitution was possible. Deflocculation level above 1.3% resulted in high viscosity that resisted flow. Increased percentage of rice hull ash also increased the thickness of the hollow cast specimen. However, increasing the percentages of deflocculant decreased the cast rate for all formulations.

Furthermore, results of the study revealed that the utilization of the calcined rice hull ash could be utilized for ceramic manufacturing particularly for slip casting but should not to exceed 3% to maintain an acceptable rheological characteristics and proper degree of deflocculation for ceramic sanitary ware casting slips.

Keywords: calcined rice hull, ceramic, deflocculant, feldspar, quartz, rheological properties, specific gravity, sodium silicate, viscosity, white clay

Producing No. 10
ESTD No. 10

**REMOVAL OF LEAD FROM ELECTROPLATING WASTEWATER USING
PHOSPHONOMETHYLATED POLYETHYLENEIMINE (PPEI)- Ca^{2+}**

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Lead contamination in the environment has long been recognized as a serious health problem. Lead, despite its toxic effect, is still being used by industries. This study aimed to evaluate the performance of phosphonomethylated polyethyleneimine (PPEI) as a chelating flocculant for the removal of lead from an actual electroplating wastewater. The effect of equilibrium pH conditions and the amount of PPEI used on lead flocculation using PPEI-Ca²⁺ as chelating flocculant was studied. The regenerative property of the PPEI polymer was tested and an absorption isotherm was established for Pb²⁺.

Even at a low equilibrium pH condition (pH 3), the polymer was able to remove 66.93% of the initial 2.06 ppm Pb²⁺ concentration. At high equilibrium pH (pH 8, 9, and 10), almost 100% removal was obtained. The results showed that increasing equilibrium pH condition increased lead removal. This may be due to the improved affinity between PPEI and Pb²⁺ at high pH, where less hydronium ions would be available to compete with Pb²⁺ and Ca²⁺. The same trend was observed at increasing PPEI amounts. At equilibrium pH 10, even a small amount of 0.05 mL of PPEI can already remove more than half (59.08%) of Pb²⁺ in a 40 mL electroplating wastewater and 0.50 mL PPEI can already remove almost 100% of Pb²⁺ in the solution.

This study showed that in lead flocculation using PPEI as chelating flocculant, the PPEI can be used up to the second cycle with an 85.99% regeneration and would still show satisfying results. It also showed that Pb²⁺ follows the Freundlich absorption isotherm with a 36.69037 mg/g absorptive capacity and 1.95413 L/mg stability constant. Therefore, lead flocculation using PPEI-Ca²⁺ as chelating flocculant is a good method for lead removal in wastewater.

Key words: lead, PPEI-Ca²⁺, phosphonomethylated polyethyleneimine, flocculation

ESTD No. 11

**BIOMASS RESOURCE RECOVERY SYSTEMS FOR
SUSTAINABLE AGRICULTURE**

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Through effective and practical conversion or transformation of wastes into resources such as biomass residues that contain abundant organic matter, nutrients and other components can be recycled beneficially into the soil as amendments or nutrient sources.

A close loop rice resource recovery system or 3RS in the agricultural production that considered turning waste into resource was developed. Stopgap technology using a carbonizer with smokestack can convert 182 kg rice husk into 119 kg carbonized rice hull (CRH) in 3 to 4 h with 65% conversion efficiency. On the other hand, fermentation-decomposition pathway using effective microorganism or EM Technology reduced decomposition of biomass in 2 to 4 weeks.

The 3Rs technology was introduced to more than 10,000 farmers nationwide wherein 7 People's Organization engaged in the production and marketing of CRH and organic fertilizer. These resulted in additional profit and income of about 30%. Likewise, the utilization of organic fertilizers reduced the farm input cost of about 30 to 40%.

The technologies are simple and appropriate and can encourage the general public to increase the utilization of biomass to a level that would equal to less generation of wastes.

Keywords: Biomass, conversion, resource recovery system, carbonizer, EM technology

ESTD No. 12

**DEVELOPMENT OF TRANSPARENT LEADLESS GLAZE FOR
LOW-FIRED CERAMIC WARE UTILIZING LOCAL RAW MATERIALS
IN ILOCOS NORTE**

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The ceramic industry in the Ilocos Region relies on glazes that are prepared by a company specializing in supplying industry. For this reason, potters are investing on expensive commercial (imported) glazes, since glazes are at one and the same time the area of most fascination and most difficult for the potters. Additionally, the producers do not usually have access to raw materials and its chemical analysis at reasonable prices.

The study focused on the development of transparent leadless glaze for low firing ceramic products utilizing local raw materials such as Solsona white clay, Ventura feldspar and red silica with the addition of commercial carbonates and boron compounds (borax). The compatibility of such materials as alternative replacement for commercial glaze materials was determined.

Raw materials were subjected to preliminary drying, grinding and screening to achieve even particle size of the glaze materials. The prepared slip glaze batched was applied on both red clay and earthenware (white ware) bodies made from slabbing and fired in gas fired (LPG) kiln at 1050°C based on the recording pyrometer of the kiln.

Results obtained from the formulated glaze show a clear transparent glassy surface appearance in the test ceramic clay bodies. The clay bodies and glaze formulation were found to be acceptable with some minor defect such as pin holes but these gave a unique artistic surface appearance especially for decorative artwares.

Keywords: transparent leadless glaze, slip glaze, red clay, earthenware, gas fired, recording pyrometer, slabbing.

ESTD No. 13

**PRODUCTION OF HYDROGEN FROM ETHANOL THROUGH STEAM
REFORMING USING A FABRICATED CATALYTIC REACTOR**

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Developmental work on renewable energy source is imperative in the face of the threatening energy crisis. Hydrogen is a clean and good substitute to fossil-based fuel. This study focused on producing hydrogen from ethanol using a fabricated catalytic reactor with $\text{CuO}/\text{ZnO}/\text{Al}_2\text{O}_3$ catalyst. The effect of reaction temperature and reaction time on percent recovery of hydrogen were also tested. The catalyst used was prepared by first precipitating oxides of copper, zinc and aluminum. The precipitated oxides were then filtered, dried in an oven and calcined in a furnace at 400°C . The calcined precipitate was granulated after which a binder (graphite) was added and lastly it was pelletized.

During the ethanol reforming experiment, the catalyst packed in the reactor was divided into half to ensure good surface area of contact. An ethanol to steam mole ratio of 1:45.5 mole were passed-on to the reactor at certain set of reaction temperature and reaction time. At each set of reaction temperature and reaction time, samples were collected by water displacement method. The samples were collected at reaction time at 200°C and 400°C . At each reaction temperature, reaction times were set at 10 seconds and 30 seconds. The samples collected were analyzed for its components by gas chromatography (GC).

Results of the GC analysis showed that the highest percent volume and percent recovery of hydrogen were obtained in the sample collected at reaction temperature of 400°C and reaction time of 10 seconds. The said sample contained 66.09% volume hydrogen giving a 34.30% recovery of hydrogen. The sample taken at 400°C too, but at longer reaction time, set at 30 seconds, had a lower percent recovery of 27.06%. Those samples gathered at a lower temperature of 200°C had a lower percent recovery of 16.40% and 4.48%. Percent recovery was calculated on the assumption that all the hydrogen in the ethanol prepared was totally recovered.

It was observed that the production of hydrogen was directly related to reaction temperature and inversely related to reaction time. Further, as the reaction temperature increased, percent recovery of hydrogen also increased. ZnO (an

active agent of the catalyst used) activity at a higher temperature predominated because of its redox property, which promoted the steam reforming reaction, thus producing more hydrogen. On the other hand, percent recovery of hydrogen was observed to decrease as reaction time increased. At a longer reaction time, H_2 was given a chance to react with CO_2 via the reverse water gas shift reaction that resulted in the production of CO and H_2O ; thus the recovery of hydrogen became smaller.

Keywords: hydrogen gas production, catalytic reactor,

ESTD No. 14

FABRICATION AND PHYSICAL PROPERTIES OF PROTOTYPE CERAMIC WATER FILTER ELEMENT PREPARED FROM MIXTURES OF RICE HULL ASH, KAOLINITE CLAY, AND PULVERIZED CHARCOAL

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Fabrication of prototype ceramic water filter element was conducted utilizing calcined rice hull ash, kaolinite clay from Solsqna, Ilocos Norte, pulverized charcoal and organic binder. Five different mixtures (F1, F2, F3, F4, and F5) were formulated based on the batch composition of 8.65% clay material, 67.31% calcined rice hull ash, 19.23% combustible material and 4.81% starch as organic binder. Solid cylindrical test specimens with a dimension of 9.19 cm long and 3.18 cm diameter were fabricated from the formulated mixtures using semi-plastic pressing process in a steel mold. The forming process was done by manual pressing operation using Nagasaki NSP-5 hydraulic press with a pressure load of approximately 150kg/cm² and holding time interval of 3-5 minutes per test specimen. The formed test specimens were subjected to both natural drying for 24 h and oven drying for 8 h at 110°C. The test specimens were sintered at temperature of 1100°C with varying sintering time of 2, 3, and 4 h respectively, under oxidizing condition.

Physical properties of the sintered test specimens like apparent porosity, bulk density, linear shrinkage, water absorption, and water permeability were determined and compared with the properties of commercial ceramic water filter element in order to evaluate if the fabricated element will pass the acceptable standards.

Results show that test specimen of F1, F3, and F4 sintered at 1100°C for 3 and 4 h with an apparent porosity of 70.59%, 69.49% and 69.30% respectively, were acceptable based on the requirements for the commercial water filter element with a minimum value of 68.84%. The bulk densities of all test specimens from the five mixtures were within the range of 0.60–0.67 g/cc which were also acceptable compared with the minimum value of 0.63 g/cc in the commercial. All mixtures have an acceptable result of good filterability within the range of 94–95 % efficiency based on their water absorption and water permeability test.

Keywords: ceramic water filter element, semi plastic pressing, and physical properties

ESTD No. 15

**ALPHA-PSO: DEVELOPING A SWARM OPTIMIZER
AND ITS APPLICATION IN PROCESS INTEGRATION**

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Due to rapid industrialization, water use has increased six-fold over the last century. Freshwater resources have been rising in cost and end-of-pipe wastewater treatments have become expensive too. Process Integration aims to optimize interrelationships of the different units in a plant to meet performance criteria in plants, such as maximum profit or minimum cost, energy efficiency or good operability. Evolutionary-based algorithms have been the subject of extensive researches to approach these types of problems and particle swarm optimization (PSO) is the most recent development in this field. Several variations have been introduced since PSO was presented in 1995. ALPHA-PSO was developed to enhance the search performance of the basic PSO and is based on the concept of having a leader in a group. The leader is called the alpha-particle. Only the leader knows the best performing follower in his swarm. On the other hand, the follower particles have no global vision. Thus, they can only access g_{best} indirectly through the alpha-particle. A set of ten benchmark functions was used to compare its computational efficiency against five other PSO variants. Statistical tests were done and showed significant improvement over them.

Keywords: swarm intelligence, process integration

ESTD No. 16

**OPTIMIZATION OF BIOFUEL LIFE CYCLE GREENHOUSE GAS EMISSIONS
USING PARTICLE SWARM COMPUTATION**

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Coconut methyl ester or CME is one of the promising fuel alternatives used in the Philippines. It is derived from coconut oil by transesterification. The use of CME in the Philippines was supported when the national government in 2004 issued an order directing all government departments to incorporate the use of one percent (1%) CME in their diesel-fueled vehicles. Along with the production of CME, during farming, considerable amount of coconut residues are produced and disposed. In fact, according to the report of the Philippine Department of Energy, in 1997 the total available shell and husk are 1.79 and 4 million metric tons, respectively. In connection with this supply, the United Nations Development Program and the World Bank estimated a total of 20 MW potential power source based from these residues alone. Furthermore, during the pressing of the coconut oil from coconut meat or copra, substantial amount of copra meal is generated. Total life cycle greenhouse gas (GHG) emissions from four different biofuels: methanol, ethanol, coconut methyl ester and coconut ethyl ester were quantified. Life cycle assessment or LCA is a process to evaluate the environmental burdens associated with a product system, or activity by identifying and quantitatively describing the energy and materials used, and wastes released to the environment, and to assess the impacts of those energy and material uses and releases to the environment. Different fuel pathways were considered to form the biofuels superstructure. This consists of options for cogeneration and cofiring using agricultural wastes and coconut meals as well as utilization of agricultural wastes to produce raw materials such as ethanol and methanol. The minimum life cycle GHG emissions were computed based on the optimum fuel paths using swarm intelligence for the optimization. Particle swarm optimization (PSO) is an algorithm developed by Kennedy and Eberhart in 1995, which is based on the social behavior of animals. PSO was first applied in unconstrained optimization problems with continuous variables. This study explores the different pathways on how these agricultural wastes can be utilized to obtain the minimum total GHG emissions on a life cycle basis. Convergence characteristics of the different variants of the algorithm were studied.

Keywords: greenhouse gas, life cycle and particle swarm optimization

ESTD No. 17

**SYNTHESIS OF OPTIMAL TOPOLOGICALLY-CONSTRAINED
WATER REUSE NETWORK USING SWARM INTELLIGENCE**

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Industries are finding ways to minimize the water costs and to reduce the water pollution through efficient use of water supplies. Process water integration achieves minimum water usage was by establishing the reuse scheme, or interconnections, from the sources to feed the demands in an industrial plant. A procedure for designing reuse networks with topological, network complexity and stream matching constraints has been developed. The procedure uses particle swarm optimization (PSO) which is an evolutionary algorithm based on the behavior of social animals developed by Kennedy and Eberhart in 1995. In this study, a prototype software coded using Visual Basic was developed. The case study of the acrylonitrile plant from El-Halwagi (1997) was used to demonstrate the algorithm. A 60% reduction of freshwater consumption was achieved for just one recycle stream, while the result by linear programming gave about 70% reduction with two recycle streams. This methodology thus provides flexibility to plant designers to balance the freshwater usage and the retrofitting capital cost.

Keywords: Process water integration, interconnection, particle swarm optimization

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ESTD No. 18

APPLYING ARTIFICIAL NEURAL NETWORK FOR VAPOR LIQUID EQUILIBRIUM PREDICTION

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Most solvents used in the semiconductor industry are toxic and costly. Thus, the solvents should be recovered for re-use in these processes by distillation methods, and vapor liquid equilibrium (VLE) data are necessary for the design and operation distillation columns. VLE data can be estimated using thermodynamic models (Wilson and Tan-Wilson) based on calculation activity coefficients. In this work, artificial neural networks (ANNs) developed using Matlab[®] software were applied to predict and estimate VLE data for ternary systems saturated salts. The databases taken from Tan et al. (2004 and 2005) were split into training, validating and testing data and the best architecture was 8-7-5-4 network. The mean deviations were 0.01279, 0.009336 and 0.499 K for vapor mole fraction of ethanol, 1-propanol and bubble points, respectively. The ANNs showed better agreement with published experimental data than the thermodynamic models.

Key words: ANNs, VLE, ternary system, salts.

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ESTD No. 19

DETERMINATION OF THE FUEL OIL (BUNKER) PROPERTIES OF 1,2 BENZENEDICARBOXYLIC ACID, DIISOCTYL ESTER FROM THE ETHYL ACETATE EXTRACT OF *Euphorbia tirucalli* L. (POBRENG KAHOY)

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This study was conducted to determine the bunker fuel properties of *pobreng-kahoy* crude extract using the standard test methods used in bunker fuel oil and identify the presence of 1,2 benzenedicarboxylic acid, diisooctyl ester by instrumentation analysis.

Ground stems of *pobreng kahoy* were percolated with ethyl acetate as solvent and the extract was concentrated in vacuum using a rotary evaporator. The crude extract was purified using column chromatography. Fractions A₆ to A₇ were recolumned and fractions B₂ and B₃ analyzed using gas chromatography-mass spectrometry. The gc-mass spectrum of the compound showed the presence of 1,2 benzenedicarboxylic acid, diisooctyl ester in the retention time of 24.40 and 24.40 and its mass spectrum showed the fragmentation peaks m/z at 149 as its base peak and m/z at 279 as its molecular ion peaks of the said compound. Fractions A₈ to A₉ were used for the infrared and ultraviolet spectroscopy. The infrared spectrum showed C-H stretch, C=O stretch, C-C stretch, aromatic ring and C-O as the functional groups present. The ultraviolet spectrum gave a λ_{max} at 283 nm.

The *pobreng kahoy* crude extract gave 9,928 BTU/lb for gross heating value, specific gravity of 0.927, 0.03% sulfur, kinematic viscosity at 40°C. These values were compared to the standard limits for the said fuel. The study of the bunker fuel oil properties of *pobreng kahoy* to determine an acceptable fuel-source will be of great help to lessen the economic problem regarding the increasing crude oil demand of the country.

Keywords: fuel, bunker fuel, gross heating value, kinematic viscosity, flash point

ESTD No. 20

**NON-CHLOROFLUOROCARBON (CFC) REFRIGERANT
HEAT PUMP DRYER**

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Drying is one of the major aspects of agricultural whether at the farm or in the industrial level. It is an energy intensive operation and it is estimated to be between 20 to 30% of the total energy required before the product reaches the consumers. A heat pump dryer was developed to ensure a relatively clean drying atmosphere for fruits and vegetables. The heat pump is an air-conditioning machine using non-chlorofluorocarbons (non-CFC) as refrigerant that extracts heat from one environment and discharge it to the other. It will collect heat from the condenser and discharges it to the air handler and with the help of the expansion valve, the flow of the refrigerant moves in the opposite direction and heat is extracted from the air handler and discharged to the drying chamber.

The heat pump was observed to have a thermal efficiency of 97% and dehumidifying efficiency of 67%. It can be used to dry mango, pine apple, papaya, banana, onions and other fruits and vegetables.

The heat pump has the advantage of drying agricultural products and at the same time cooling perishable fruits and vegetables.

The heat pump can be manufactured in modules or designed and installed on-site depending upon the drying requirements.

Keywords: dryer, heat pump, Drying, refrigerant, non-chlorofluorocarbon, fruits, vegetables

ESTD No. 21

**ONLINE MEDICAL TRAINING SYSTEM FOR SIMULATED
CATARACT SURGERY**

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Majority of the eyes used in the laboratory for the training of medical students for cataract surgery often lacks the diseased state necessary for surgical training. As such, the Online Medical Training System for Simulated Cataract Surgery was developed to provide training for students on cataract surgery. The system was developed using Java and Java 3D API. The surgical procedure training provided by this system includes incision in the junction of clear and white outer parts of the eye, suction of the damaged lens, and insertion of an intraocular lens (I.O.L.) in place of the damaged lens. Aside from the surgical procedures training provided, it also evaluates and grades the performance of the medical student in cataract surgery. This system will be able to help the medical student to have a more realistic look at a cataract eye for their cataract surgery training and will allow the students to undergo cataract surgery for a number of times without using a lot of eyes from the eye bank.

Keywords: medical training system, simulation, eye surgery, cataract

ESTD No. 22

**SURVEILLANCE SYSTEM OF HOSPITAL-ACQUIRED INFECTION
IN THE PHILIPPINES**

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The Surveillance of Hospital-Acquired Infection in the Philippines (SHIP) was established in 1999 with an aim to create a national database of nosocomial infections and improve surveillance methods of hospitals in the Philippines.

Nosocomial or hospital-acquired infections are defined as those that were neither present nor incubating at the time the patient came for care.

The Surveillance System of Hospital-Acquired Infection in the Philippines (SSHIP) is a web-based computer program that would aid infection control doctors and nurses on the data collection and retrieval of important nosocomial infection information. SSHIP has the capability to allow infection control nurses to update the Infection Worksheet, Laboratory Data Form and the ICU Monthly Report Form; and to permit infection control doctors and nurses to generate rates and graphs of the ICU Monthly Report Form. It also has the interface to permit online users to submit online SHIP Application Forms, and sent via email of notification of application to Philippine hospitals who submitted their online SHIP Application Forms.

Keywords: surveillance system, hospital-acquired infections in the Philippines, nosocomial infections in the Philippines, SHIP, Philippine surveillance system

ESTD No. 24

PEDIGREE AND CANINE MANAGEMENT SYSTEM

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The Pedigree and Canine Management System (PCMS) manages the data used by the Philippine Canine Club (PCCI) and generates pedigree of 3rd to 5th generation of each registered dog. PCCI was formed for the protection and advancement of pure-bred dogs. PCCI implements standardized regulations administering dog competitions and field trials; safeguard its members from fraud information; and to further improve the study, breeding, exhibiting, administration and maintenance of the breed veracity of pure-bred dogs.

PCMS has a user-friendly interface to let the PCCI members view requested dog information, search and submit dog activities and advertisement and view summary reports on dog mortality. Additionally, the system is capable of notifying the member with dog activities through short messaging services (SMS). Furthermore, the system is able to allow online guests to view summary reports on dog mortality, dog advertisements and post dog competition information. Lastly, a

module was created for the PCCI administrator to manage the system with his/her ability to update dog information and PCMS user's profile.

Keywords: *dogs, PCCI, pedigree, dog information management system

ESTD No. 25

TRAUMAP: A GEOGRAPHIC INFORMATION SYSTEM

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Traumap is a decision-support tool that allows medical practitioners to graphically track trauma-related cases by showing them reported occurrences alongside a scalable (zoomable) view of the cityscape, which contains street-level detail.

Traumap is a Geographical Information System (GIS) based on the Scalable Vector Graphics standard. The system allows users to report and view trauma cases directly on the maps through a point-and-click interface. The following features were implemented: entering, editing, and querying information, generating reports with regard to the cases, locating streets in the map using regular-expression search, and additional controls to easily navigate the vector map.

Keywords: geographic information systems, Scalable Vector Graphics (SVG), decision support systems, trauma

ESTD No. 26

ONLINE TRAINING SYSTEM FOR PIT AND FISSURE DENTAL CARIES

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The Online Training System for Pit and Fissure Dental Caries (OTSPFDC) is a web-based application that allows student/users to view a variety of learning materials. They are also allowed to assess their knowledge online through the system's evaluation tools.

Through OTSPFDC, student/users are able to view online lectures about pit and fissure dental caries in plain text or in different file formats such as word documents or powerpoint files. They are also able to view animations about amalgam dental restoration for pit and fissure dental caries. The student/users are presented with step-by-step procedure on amalgam restoration. Objective type quizzes give student/users a good way to test their knowledge about the online lectures on pit and fissures. A special feature of this system is the simulation exam on amalgam restoration for pit and fissure dental caries. The simulation exam offers the student/user a more challenging test as they are administered via 'hands-on' practical exam type. Additionally, error messages regarding the hands-on exam are displayed whenever a user makes a mistake. The dental expert acting as system administrator modifies the database entries enabling him to update necessary lecture files and lessons. He is allowed to add, edit or delete lectures, files and objective-type quizzes.

OTSPFDC is a tool that addresses the need to reinforce the objective of dentistry – which is to restore teeth as much as possible. This tool helps students to further improve their knowledge regarding the topic and provides them with lessons in restorative techniques which can be repeatedly viewed for better understanding.

Keywords: training system, pit and fissure dental caries, simulation

ESTD No. 27

**THE MAKINGS OF AN INTERNET-BASED RICE INFORMATION SERVICE
(IRIS): PILOTING IN THE PHILIPPINES**

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A collaborative activity involving a private consortium, an international and a national rice research institution was conducted to validate the design of an internet-based information system that would provide more timely and objective data on rice area and production. This system consists of two components that make use of geospatial tools including remote sensing, GIS and GPS technologies. The remote sensing component comprises a largely automated protocol using multi-date SAR imagery for mapping and estimating rice area and planting dates. These outputs are fed into a production estimation component comprising a crop growth model that predicts harvest dates and crop yield using meteorological data. Rice area and yield estimates are summarized by administrative boundaries and are offered through a web-based service to subscribers.

Pilot testing of the data generation component of the system was carried out in 81 municipalities covering Nueva Ecija, Isabela and Pangasinan for the dry season rice crop of 2003-2004. Acquisition of RADARSAT and ENVISAT ASAR data at various dates throughout the rice-growing season permitted evaluation of the capacity of the automated SAR processing system to handle multi-platform data. Investigations were made on the minimum number of acquisition dates that would provide reliable rice area estimates. A field campaign was conducted covering 68 municipalities and 667 geo-referenced survey points to collect ground truth information. Daily weather data were collected from 5 surrounding weather stations for at least the past 10 years; data for the 2003-2004 season were available for 3 stations. Processing of the SAR data provided rice area and planting date estimates, which were fed together with the weather data into the crop model. The predicted yields and rice area are reported by municipality. The implications of operationalizing

such an information system for rice is discussed based on the experience from this pilot study.

Keywords: IRIS, rice monitoring, crop growth model, rice area mapping

ESTD No. 28

**EVALUATION OF PARTIALLY PURIFIED PROTEIN FROM MALUNGGAY
(*Moringa oleifera*) SEED EXTRACT AS A CATIONIC POLYMERIC
FLOCCULANT FOR THE DECOLORIZATION OF DISTILLERY
BIODIGESTER EFFLUENT**

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The ability of partially purified protein from malunggay (*Moringa oleifera*) seed extract as a cationic polymeric flocculant for the decolorization of distillery biodigester effluent was experimentally evaluated. Screening and selection of the most appropriate partial protein purification method (ammonium sulfate precipitation, ethanol precipitation, and acetone precipitation) based on the amount of protein precipitated, cost of salt/solvent used per gram of protein precipitated, and percent decolorization was also done. The optimum initial pH of the distillery effluent and optimum dosage of malunggay protein for decolorization were determined. Ammonium sulfate precipitation was found to be the most appropriate partial protein purification method in terms of protein recovery (34.7%), cost (Php 1.11 per gram protein precipitated), and decolorization efficiency (81.6%). Addition of partially purified malunggay protein solution in the distillery effluent resulted in a dramatic change in color of the effluent along with the formation of brownish flocs. At the optimum pH of the effluent (pH 8), 88.2% decolorization was achieved at an optimum dosage of 2.707 mg/ml malunggay protein. The addition of EPS improved the ability of the flocs to settle.

The color removal efficiency of partially purified proteins from malunggay seed extract was found to be similar to crude malunggay seed extract. The main advantage of using the former flocculant was the reduction in the COD concentration of the treated effluents by as much as 40% (relative to the COD

concentration of the treated effluents using crude MOSE). However, further treatment may be necessary to reduce the COD of the treated decolorized effluents to conform with DENR effluent standards.

Keywords: *Moringa oleifera*, *Rhizobium*, exopolysaccharide, color removal, flocculation

ESTD No. 29

**PARTIALLY PURIFIED PROTEIN FROM MALUNGGAY (*Moringa oleifera*)
SEED EXTRACT FOR USE AS SECONDARY CATIONIC POLYMERIC
FLOCCULANT FOR COPPER REMOVAL FROM WASTEWATER
EFFLUENTS**

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The efficiency of the partially isolated/purified *Moringa oleifera* seed extract as a secondary cationic polymeric flocculant to *Rhizobium sp.* BJVr12 EPS for copper removal in simulated wastewater was investigated. Selection of the best purification process by precipitation (ammonium sulfate precipitation, acetone precipitation, and ethanol precipitation) in terms of protein yield, cost of precipitant and percent copper removal was also done. The role of pH and the mass ratio of the EPS to the protein isolates were determined. Moreover, evaluation of the capacity of the EPS-partially isolated/purified *Moringa oleifera* seed extracts flocculation system and the recovery of the copper from the flocs formed after treatment were made. Ammonium sulfate precipitation was taken as the recommended protein purification method with a protein yield of 8.15 mg/ml, a raw material cost of Php 0.24/ g protein produced, and had the highest percent mean percent copper removal among the three methods. At the optimum workable pH of 6, the percent copper removal had a mean average of 90.86% along with the formation of firm flocs, clear and easily filterable supernatant after each treatment. Optimum EPS-ammonium sulfate protein isolates mass ratio was at 0.767 with a mean copper removal efficiency of 93.30%. Decreasing copper removal capacity of

the EPS-partially isolated/purified *Moringa oleifera* flocculation system was observed with increasing amounts of EPS and ammonium sulfate protein isolates employed during treatment.

The EPS-*Moringa oleifera* flocculant system which utilized the $(\text{NH}_4)_2\text{SO}_4$ precipitated seed extract performed better than the crude (unprecipitated) one. Copper removal efficiency was 88.7% or a final copper concentration of 1.10 ppm which approximates the allowable copper concentration in wastewater effluents set by the DAO 35. COD was reduced by 75.8 % (relative to the COD of effluents treated using EPS-crude *Moringa oleifera* seed extract flocculation system).

Keywords: *Moringa oleifera*, *Rhizobium* exopolysaccharide, protein purification, copper removal, flocculation

ESTD No. 30

EVALUATION OF THERMO-TOLERANT YEAST ISOLATES FOR ETHANOL PRODUCTION IN FLASK AND BIOREACTOR FERMENTATIONS.

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Ten yeast strains which were isolated locally from various sites around the Philippines were screened for their ability to ferment sugarcane molasses at high temperatures. From among the strains used, the most promising strain was selected and was used in the bioreactor experiments.

All strains were found capable of fermentation up to 50 °C although no apparent cell growth was seen at the end of 24 hr at 50 °C; only six strains were able to remain viable up to 47 °C. The maximum ethanol concentration for all strains was reached at 45°C for which five strains produced about 5% (v/v) or more. Based on the amount of ethanol produced as well as on cell viability, strain 2015 was selected as the best strain from among the strains used. The performance of the selected strain was studied in a worst-case scenario of fermentation under uncontrolled as well as under controlled (30 °C) temperature condition. This strain was able to produce a maximum ethanol concentration of 8.73% (v/v) after 20 hr under

uncontrolled temperature condition and 9.83% (v/v) after 31 hr under controlled temperature condition.

Strain 2015 was found to be comparable with other strains used in industries which under controlled temperature conditions, usually yield about 8 to 10% (v/v) ethanol. Furthermore, fermentation under uncontrolled temperature condition using this strain was comparable with fermentation under controlled (30 °C) temperature condition. Thus, strain 2015 has a potential for use in industries having the advantage of maintaining high ethanol production while decreasing energy costs for cooling.

Keywords: thermo-tolerant, yeast, ethanol, bioreactor

ESTD No. 31

DESIGN, FABRICATION AND TESTING OF A BENCH-SCALE AND CONTINUOUS FLOCCULATION SYSTEM USING A MICROBIAL EXOPOLYSACCHARIDE (EPS) BIOPOLYMER AND MALUNGGAY (*Moringa oleifera*) SEED EXTRACT FOR TREATMENT OF COPPER CONTAINING WASTEWATER

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A continuous bench scale flocculation system for the treatment of copper containing wastewater was designed, fabricated and tested. The flocculation system involved the use of an exopolysaccharide (EPS) as primary agent for copper sequestration, and Malunggay (*Moringa oleifera*) (MO) seed extract as secondary flocculant to separate the copper-EPS complex from the solution. Jar test experiments were also done to obtain a workable velocity gradient (G) to be used for design calculations of the flocculator.

Laboratory flocculation experiments to optimize the pH and flocculant dose conditions yielded the following results: an optimum initial pH of 5, a 0.01 ml EPS solution/mL of synthetic copper wastewater, and a ratio of 1.65 g EPS/g protein in the MO seed extract. Jar test experiments using these conditions obtained a workable velocity gradient (G) of 63.5/s which was used as a scale up factor of the setup.

The above process information was used to design, fabricate and test a continuous bench scale flocculation system consisting of a rapid mixing tank, flocculator and settler. At steady state, a copper removal efficiency of 80% was obtained, with an effluent copper content approaching the DENR effluent standard of 1 ppm. Although the performance was considered satisfactory, further improvements (such as optimization of the EPS and MO seed extract flowrates) were recommended to increase copper removal.

Keywords: flocculation, copper wastewater, exopolysaccharide (EPS), Malunggay

ESTD No. 32

**ELECTROLYTIC DESTRUCTION OF AZO-DISPERSE DYE IN
A MODEL SYSTEM**

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Decolorization, through electrolytic oxidation of azo-disperse dye (C.I. Disperse Red 1) was evaluated in a model-system-wastewater simulating the dye concentrations in textile effluent, and supplemented with sodium chloride. The electro-oxidation system involved the use of chlorine-based oxidants generated by the electrochemical oxidation of chloride ions in the wastewater. The objective was to obtain the best conditions of electrolyte (sodium chloride) supplementation and charge dose which would give the highest decolorization efficiency. The charge dose (in the units of coulombs/unit amount of pollutant removed) is an empirical factor which could be useful in the scale-up of an electrochemical process for wastewater treatment. Nuclear magnetic resonance (NMR) spectroscopy was also used to check molecular changes in the dye after electrolytic treatment.

Results showed that the initial rate of decolorization increased with operating current, up to a saturation value at constant level of NaCl. The same phenomenon was also observed when NaCl supplementation was increased at constant operating current. The saturation value was attributed to the limitation of oxidant formation imposed by the operating current or concentration of chloride ions. The following

optimum electrolytic conditions were obtained from experiments: a charge dose of 714.6 coulombs/Abs.L color removed, with a sodium chloride supplementation of 2 g/L. The maximum decolorization efficiency was 83%. The cost of electrical energy for electrolysis was computed to be PHP 14.76/m³ of 200 ppm C.I. Disperse Red 1. Significant changes in the specific signals in NMR spectra also confirmed partial oxidation of the dye molecule during electrolysis.

Keywords: electrooxidation, electrolysis, azo dye, charge dose

ESTD No. 33

**XRD AND SEM CHARACTERIZATION OF SINTERED CORDIERITE
PREPARED FROM MIXTURES OF KAOLIN CLAY, TALC AND
OTHER ADDITIVES**

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Stoichiometric composition of cordierite was prepared from the mixtures of kaolin clay, talc powder, and magnesium carbonate with a percentage composition of 72.06, 13.23, and 14.71 respectively via solid state sintering reaction. Test specimens in the form of pelletized circular disk of 20 mm diameter by 2.5 mm thickness were prepared from the mixtures by powder pressing in a metal mold using hydraulic press with a pressing load of 80-100 MPa. The sintering process was conducted using Linberg Blue M box furnace with four segment temperature control program. The sintering time was set to 2 and 3 hours respectively within the sintering temperature range of 1000°C-1100°C. The sintered cordierite test specimens were characterized using Philips PW 1830 x-ray diffractometer to determine the formation of crystalline phases and Leica S440 scanning electron microscope to determine the morphology and microstructures.

X-ray analysis revealed that at 1000°C sintering temperature within the sintering time of 2 and 3 hours, there were two types of cordierite phase that can be identified in the test specimen at almost equal amount based from the relative intensity of the x-ray diffraction pattern. The crystalline phases were identified as μ -cordierite and \bar{U} -cordierite. At 1100°C sintering temperature with the same sintering time, it was noticed that the formation of \bar{U} -cordierite was increasing while μ -cordierite phase was decreasing. This phenomenon was due to the polymorphic transformation reaction of μ -cordierite starting at 1050°C as described from earlier

study in the formation of cordierite.

SEM observation and analysis of the micrographs taken at magnifications of 1,000X, 5,000X, 10,000X and 15,000X of the test specimen sintered at 1000°C for 2 and 3 hours revealed a microstructures consisting mostly of euhedral and subhedral particles with sizes approximately in the range of 1-10 μm . As the sintering temperature increases to 1100°C of the same sintering time, the micrographs revealed a microstructures consisting of partially melted euhedral grain particles and was started to transform into spherical shape. Open pores between particles could also be observed in the micrographs. The presence of pores between particles can be concluded that the sintering reaction was not completely achieved at the sintering temperature range of 1000-1100°C and the individual particles did not formed a dense body.

Keywords: solid-state sintering, x-ray analysis, scanning electron microscopy, crystalline phases, and microstructures

HEALTH SCIENCES

HSD No. 1

MICROBIOLOGICAL ASSESSMENT OF DRINKING WATER QUALITY OF SELECTED BARANGAYS IN ILIGAN CITY

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Microbiological drinking water quality using Most Probable Number (MPN) Method and Heterotrophic Plate Count (HPC) was assessed from two water sources in each of three selected barangays of Iligan City from April to June 2005. Two pumping stations distribute treated water to these barangays: Pumping Station 1 for Barangays Palao and Hinaplanon, and Pumping Station 2 for Barangay San Miguel with a water source from a farther and higher elevation.

MPN test showed that 28% of 108 water samples yielded total coliforms and only 10% were confirmed to have faecal coliform. Abrupt increase in MPN coliform was observed in Sites A and B from Palao on the second of six samplings, and stresses the unpredictability of possible faecal contamination which might pose a potential health risk. Water samples from Sites C and D of San Miguel displayed irregular and varying MPN coliform levels which can be attributed to a probable