

ENGINEERING SCIENCES AND TECHNOLOGY

ESTD No. 1

**DEVELOPMENT OF COMPUTER-BASED MATHEMATICAL
MODELS FOR ESTIMATING GROUNDWATER
RECHARGE IN SHALLOW AQUIFERS**

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Increased reliance on groundwater necessitates improved aquifer management. Quantification of the rate of groundwater recharge is an important step for efficient and sustainable groundwater resource management. This study was carried out to develop mathematical models for estimating groundwater recharge based on the concept of a leaking bucket and groundwater level fluctuation and to evaluate the applicability of these two models in simulating groundwater recharge. The mathematical formulations of the two models were programmed in Visual Basic to provide a user-friendly platform of the two models. The two models were calibrated and validated using years with adequate groundwater data from shallow aquifer.

Simulation results showed that both models exhibit adequate capability to simulate groundwater recharge in shallow aquifers. During the four-year simulation period, the leaking bucket model adequately replicated the observed groundwater level data in the area with an overall coefficient of model efficiency of 77%. Groundwater recharge estimates ranged from 426 mm to 668 mm and 234 mm to 400 mm using the leaking bucket and groundwater level fluctuation model, respectively, constituting approximately 23% to 41% and 14% to 26% of the annual rainfall in the area, respectively. The groundwater recharge estimates of the two models were significantly different ($p < 0.001^{**}$) but they were significantly correlated ($r = 0.972^*$), indicating consistency in results.

Keywords: Groundwater level fluctuation model, groundwater recharge, leaking bucket model, modeling, shallow aquifer

ESTD No. 2

**DEVELOPMENT OF LOW-FIRE PARIAN PORCELAIN
USING ILOCOS NORTE RAW MATERIALS**

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Parian porcelain is a vitrified whiteware characterized by extreme translucency giving the appearance of marble. Its principal raw material is feldspar constituting up to 90% of the batch and it has no silica quartz.

A binary formulation study using Pasuquin feldspar and Pasaleng white clay was conducted to develop Parian porcelain. Pasuquin feldspar was beneficiated through magnetic separation while Pasaleng white clay was elutriated to remove unwanted impurities. Chemical analysis of the beneficiated raw materials was done.

The test specimens were formed by slip casting and were oven dried at 110 °C. The dried specimens were bisque fired at 900 °C. A borosilicate glaze was applied to the bisque specimen through dipping and then glost fired at 1000-1200 °C.

Physical analysis, particularly castability, shrinkage, water absorption, porosity, modulus of rupture, degree of vitrification, translucency, and color showed that a body formulation consisting of a mixture of 75% Pasuquin feldspar, 21% Pasaleng white clay, 4% Calcium carbonate and 0.1% Cobalt sulfate glost fired at 1150 °C results in properties comparable to that of an ideal soft porcelain.

Bench scale production was conducted to validate the results of the development study. Results showed that the developed technology to produce Parian porcelain can be replicated as the product exhibit consistently the same physical properties.

Keywords: porcelain, Parian, low-fire, beneficiation, ceramics, Ilocos raw materials, glaze, slip casting

ESTD No. 3

**REGENERATION OF USED TRANSFORMER OIL
BY ADSORPTION USING ACTIVATED CARBON**

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The performance of transformer oil as insulator is greatly affected by relatively small amounts of impurities. Replacement with fresh oil is necessary even though degradation of the oil is minimal. In the Philippines, prolonged storage is the only option for disposal of used transformer oil. In South Luzon alone, estimated amount of 3750 cu meters of used transformer oil is being disposed annually. Recycling of transformer oil is therefore a good option because the waste oil is still in good quality.

The effectiveness of activated carbon as an adsorbent for the regeneration of used transformer oil was investigated. The effects of agitation rates (100, 150, and 200 rpm) and temperatures (30°C, 40°C, and 50°C) on the reduction of coloring matter and carboxylic acids were determined. Insulating property (dielectric breakdown voltage) of the treated used-transformer oil and untreated oil was analyzed.

Percentage removal of carboxylic acids increased from 43.44% to 93.14% with increase in agitation rates from 100 rpm, to 200 rpm. Adsorption rate constants (hr^{-1}) were found to be higher at faster agitation rates with 0.0533, 0.0981, and 0.986 at agitation rates of 100 rpm, 150 rpm and 200 rpm, respectively. Pore diffusion constants at agitation rates of 100 rpm, 150 rpm and 200 rpm were 0.00137, 0.002658, and 0.006767, respectively.

Increase in temperature does not favor the adsorption of carboxylic acids and coloring matter. A decrease in the removal of carboxylic acid from 69.05% at 30°C to 37.5% at 50°C was observed. The rate of adsorption also decreased with increase in temperature from 30°C to 50°C.

The insulating capacity of used transformer oil was greatly enhanced after treatment with activated carbon. Percentage increase in dielectric breakdown voltage reached up to 66.12% and 81.4% at temperatures of 30 °C and 50 °C, respectively.

Keywords: transformer oil, oil, activated carbon, carboxylic acids

ESTD No. 4

**ORGANIC BUILDER: A JAVA PROGRAM THAT DISPLAYS
THE 3-D MOLECULAR STRUCTURE OF AN ORGANIC
COMPOUND GIVEN ITS I.U.P.A.C. NAME**

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Nomenclature is one of the difficult topics to understand in organic chemistry. To help students understand this better, OrganicBuilder was developed to aid them. This was developed using the Java programming language. It uses a deterministic finite automaton (D.F.A.) in determining whether the organic compound name input is a valid International Union of Pure and Applied Chemistry (I.U.P.A.C.) name. At the same time the name is being checked, information is also being gathered about the compound such as whether it is an alkane, alkene or alkyne, the number of carbon present and the type of bond present between two atoms. After all the required information has been gathered, the ball-and-stick model of the organic compound input is displayed and all the relevant information such as the bond length and bond angle is also incorporated into the model. The user is free to rotate and move the model so he can clearly visualize the molecular structure from any angle. The module for displaying the molecular model was developed with the Java 3D Application Programming Interface (A.P.I.). With this software, the students can understand nomenclature better by showing the model of a particular organic compound from just its I.U.P.A.C. name input.

Keywords: nomenclature, model, ball-and-stick model, D.F.A., Java, Java 3D API

ESTD No. 5

**A COMPARATIVE STUDY OF SELECTED
COMMERCIAL STRUCTURAL CLAY BRICKS IN
VIGAN CITY, ILOCOS SUR AND IN SAN NICOLAS,
AND PAOAY, ILOCOS NORTE USING S. E. M.**

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Ilocos Sur and Ilocos Norte are among the provinces in Northern Philippines known for time-honored manufacturing of structural clay bricks.

Locally manufactured commercial structural clay bricks (CSCB) were collected from selected local manufacturers in Vigan City, Ilocos Sur and in San Nicolas, and Paoay, Ilocos Norte.

The CSCB samples were broken along their traverse flat surfaces. The freshly fractured surfaces and the microstructure were then examined using JSM-35C Scanning Electron Microscope (SEM) with setting at 20 to 25 KV and the spot magnification of 1000X mag. SEM photomicrographs were taken and evaluated.

Results show that the CSCB of Vigan City, Ilocos Sur have evidences of open pores, microcracks and compact granulated particles at varying locations. In comparison, the CSCB of San Nicolas, and Paoay, Ilocos Norte photomicrographs reveal nodular, varnish-like surfaces, clayey masses and conchoidal to uneven or earthy fractures. The different microstructures captured by SEM were attributed to the types of raw materials used, methods of forming and firing.

Keywords: structural clay bricks, microstructures

ESTD No. 6

**FORMULATION OF CERAMIC GLAZES USING INDIGENOUS CERAMIC
RAW MATERIALS FOUND IN ILOCOS REGION**

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Glazes were formulated using tri-axial diagram based on ideal glaze formulation with 15% Clay (Lubbock, Batac Clay), 30% Flint (Pasuquin Red Silica, Calacal Asbestine and Lahar), 55% Fluxes (Tumedtedted, Batac limestone, banana leaves ash, wood ash, BaCO₃, ZnO and red lead) by weight, and varies into 14 different glaze formulations.

The mixtures were ground and mixed with sufficient amount of water in 1:1 water: glaze composition ratio and aged for several days. The formulated glaze slip was applied to earthenware bodies (70% Lubbock, Batac Clay and 30% Lahar), both mono and fired bodies.

The Limberg Blue electric furnace was used with settings at 24.21°C/min ramping rate (r_1) until 456°C and dwelling time (d_1) of 120min. The firing temperatures were 1000°C, 1050°C and 1100°C respectively with 8.99°C/min ramping rate (r_2) and dwelling time (d_2) of 90 min.

Results show that a firing temperature at 1000°C produced underfired and pre-matured glazes. The presence of pin holes, bursting and crawling was evident. On the other hand, glazes fired at 1050°C and 1100°C yielded satisfactory results basically for those glaze formulations with 30% lahar and produced glossy, bright and transparent glazes with minimal glaze defects.

Keywords: ceramic glazes, indigenous, tri-axial diagram, firing

ESTD No. 7

**BIOAUGMENTATION OF TRICKLING FILTER FOR DOMESTIC
WASTEWATER TREATMENT**

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Biological treatment is widely used to remove biologically degradable substances in wastewater. It also partially or completely stabilizes such substances. Trickling filter is a biological waste treatment process which is considered as a secondary treatment facility mainly used to remove organic matter present in wastewater. On the other hand, bioaugmentation, that is, applying selectively adopted microbial cultures tailored to a specific contaminant, in an existing biological system, has been one of the progressive developments in wastewater engineering.

Three bioaugmentation applications were conducted by applying the inoculant on the filter media. The amount of inoculant was about 102g (2% of the bed contact volume). Corresponding percent COD removals were determined every four hours for the first 12 hours and every 12 hours there after. When the removal approached the efficiency observed (~55%) at conventional operation, the inoculant was reapplied

For all applications, a maximum treatment efficiency of at least 70% was established within 4 to 8 hours after the inoculant has been applied and has reached about 55% after 36-48 hours of application. After 24 hours, removal of almost 60% was observed indicating that the inoculant still had a considerable effect on the treatment efficiency. The optimum-dosing interval was therefore taken after 36 hours of application and that beyond this period it was necessary to reapply the inoculant to achieve the maximum treatment efficiency of at least 70%.

Varying COD removals of at least 50% for a range of COD loading rate of 1.56 to 1.81 kg/m³h were observed for conventional operation subjected at nearly the same volumetric flowrate. Likewise, the bioaugmented process achieved treatment efficiencies of at least 70% fluctuating at the COD loading rate range of 1.39 to 1.79kg/m³h. The experimental data available provided insufficient evidence that for a particular range of COD loading rate for both the

conventional and bioaugmented trickling filter processes, the increase in organic load significantly dictated the change in treatment efficiency. The data were then pooled to arrive at a maximum 54.19% COD removal achieved by the conventional operation regardless of the differences in organic load, provided however that this load does not exceed 2.00 kg/m³h. Given the same condition, this efficiency was improved to 71.93% when bioaugmentation was applied. When the COD loading rate was increased beyond 2.00 kg/m³h, both processes exhibited decreasing efficiencies until the facility approached equilibrium COD that was the minimum percentage or fraction of the influent COD the filter could treat. The minimum fractional COD removal established by conventional operation at 0.22 was improved by bioaugmentation to 0.28. This entails that with the application of the inoculant, the facility could handle higher organic load or stronger wastewater strength.

Keywords: bioaugmentation, trickling filter, biological treatment, wastewater

ESTD No. 8

**DEVELOPMENT OF CONTROLLED RELEASE
FERTILIZERS FOR THE LAHAR AFFECTED AREAS
AND COARSE TEXTURED SOILS**

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The lahar-affected area in Central Luzon requires heavy application of chemical fertilizers in order to regain its productivity. Heavy application of fertilizers is necessary to overcome the heavy losses due to leaching. Therefore, a controlled-release fertilizer (CRF) is an excellent alternative for conventional and soluble fertilizers.

Controlled release fertilizers (CRF) developed are coated urea, coated di-ammonium phosphate (DAP), coated potassium chloride (KCl) and coated complete or nitrogen (N), phosphorus (P), potassium (K). Coated Urea contains 37-38% N; Coated KCl contains 42-55% K₂O; Coated DAP contains 14% N and 30% P₂O₅ and Coated complete fertilizer contains 15% N, 13% P₂O₅ and 18% K₂O.

The sources of major nutrients are conventional fertilizers such as urea, muriate of potash and di-ammonium phosphate. Conventional fertilizers were granulated with soil conditioner and binder. The pre-coated granules were coated with used "strofoam" materials" by the bottom spray coating fluidized bed apparatus.

The study on coating process explores appropriate operating conditions, different coating solutions, concentration and amount of coating solutions. The operating conditions such as flow rate of coating solution, the velocity of fluidizing air, coating temperature, drying time and coating technique had been established.

Coated products were subjected to dissolution tests at different temperatures to determine the duration of nutrient release. The release period attained at ambient temperature (30-37°C) ranged from 90 to 100 days and faster nutrient release rate were observed at temperatures 50° and 70°C.

A cheaper controlled release fertilizer that costs about P30-52/kg was developed compared to the commercial CRF that costs P176-192/kg.

The initial result of efficacy test of the CRF products in lahar affected areas planted to rice, tomato and onion reveals a 77-92% fertilizer efficiency and increased crop yield.

Keywords: controlled-release fertilizer, conventional fertilizer, bottom spray coating fluidized bed, dissolution test, efficacy test

ESTD No. 9

**COLOR REMOVAL OF DISTILLERY BIODIGESTER
EFFLUENT BY FLOCCULATION USING MALUNGGAY
(*Moringa oleifera*) SEED EXTRACT**

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Distillery biodigester effluent is a pollution problem in the Philippines today because of its extremely high BOD content and dark color. The residual brownish color is attributed to polymeric pigments, collectively known as melanoidin. Existing methods of coagulation, flocculation, and sedimentation

with the aid of inorganic coagulants such as aluminum sulfate and ferric salts to decolorize the effluent may be inappropriate for our local distilleries because of their high cost in addition to the inherent sludge-handling problem. In this work therefore, the ability of an inexpensive substitute coagulant derived from malunggay seeds (*Moringa oleifera*) for treatment was evaluated. The malunggay seeds contain water-soluble proteins with an overall positive charge that make it act similarly to inorganic coagulants in coagulating negatively charged melanoidin polymers by the mechanism of charge neutralization.

Coagulant solutions were prepared by mixing a measured amount of dried and pulverized malunggay seeds with distilled water and then allowing the mixture to stand for 30 minutes. The resulting mixture was then filtered and the filtrate was collected and used for coagulation experiments. Results showed that addition of malunggay seed extract in the distillery slops resulted in the formation of brownish flocs and the subsequent decolorization of the filtrate. The coagulant dosage and initial pH of the distillery slops affected the decolorization efficiency. In general, the pH determines the charge speciation of both melanoidin and the coagulating proteins in malunggay extract, thus, affecting treatment performance. At the existing pH of the distillery slops (pH 8) and a coagulant dosage of approximately 2.5% (w/v malunggay seeds), decolorization was found to be 83%. This result is comparable with that of existing treatment processes utilizing inorganic coagulants but at a much lower cost. Furthermore, flocs formed by this method are more safe to handle due to their purely organic content, which allows for their possible use as feeds and fertilizer components.

Keywords: distillery slops, *Moringa oleifera*, coagulation, wastewater treatment

ESTD No. 10

VIRTUAL CLASSROOM IN GENERAL CHEMISTRY

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The traditional mode of learning characterized by a typical classroom setting wherein the teacher explains in front of students who, at the same time, take down notes, is an effective way of imparting knowledge to students. However, with the advancement in information technology (IT), learning can be greatly improved. Incorporation of IT in the classroom can make learning of difficult subjects such as General Chemistry more interactive and enjoyable. Thus, at the College of Arts and Sciences, University of the Philippines Manila, two units from the Department of Physical Sciences and Mathematics (DPSM), namely, the Mathematics and Computing Sciences Unit, and the Chemistry Unit, collaborated in order to create a working online lecture guide in General Chemistry. This project was entitled Virtual Classroom in General Chemistry.

Virtual Classroom in General Chemistry was intended not to replace but only to supplement the traditional mode of learning. It is already a working system whose contents are authored by a General Chemistry teacher from the DPSM Chemistry Unit. Its syllabus is based on the current Chemistry Module of the Natural Sciences I (NAT SCI I) subject offered at the University of the Philippines Manila hence contains a comprehensive set of topics that should be included in any General Chemistry course. It features a table of contents, introduction to each topic, subtopics, and associated illustrations and animations. Any General Chemistry teacher who is subscribed to the system can adopt the syllabus provided by the author and expound on the concepts by allowing him to upload additional supplementary learning files and exam questions especially made for his set of students. It also has an email feature to help sustain student-teacher communication even outside the classroom. Students can likewise browse and download lectures, and assess their understanding by allowing them to take exams then view their exam scores online.

The project's website is at <http://csdev.cas.upm.edu.ph/virtual>.

Keywords: distance learning, virtual classroom

ESTD No. 11

**FLOCCULATION OF COPPER(II) FROM WASTEWATER
BY POLYELECTROLYTE COMPLEX FORMATION
OF *Rhizobium sp.* EXOPOLYSACCHARIDE (EPS)
AND MALUNGGAY SEED EXTRACT**

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Accumulation of toxic heavy metals in the environment greatly threatens public health. Conventional heavy metal removal techniques are greatly expensive and potentially risky due to hazardous by-products generation.

In this work, the potential of *Rhizobium sp.* (BJVR-12) exopolysaccharide (EPS) in combination with cationic polyelectrolytes derived from malunggay (*Moringa oleifera*) seed extract for Cu²⁺ removal by polyelectrolyte complex formation was investigated. Qualitative evaluation of the process revealed that malunggay seed extract enhanced the flocculation of EPS-heavy metal complex. Results showed that heavy metal removal was influenced by the EPS/malunggay extract ratio and pH. Copper removal was most significant at pH 5. For synthetic wastewater, maximum Cu²⁺ removal efficiency was 0.417 mg EPS/mg malunggay seed extract. Likewise, maximum Cu²⁺ sequestration was 0.556 mg EPS/mg malunggay seed extract for actual wastewater sample. At optimum EPS/malunggay seed extract mass ratio, the COD of the filtrate was found minimum.

Using these operating parameters, close to 100% Cu²⁺ removal was achieved for both synthetic and actual wastewaters with increasing EPS concentration. Effluent regulatory standards for pH and residual copper concentration were met. Furthermore, flocs were firm and the supernatant was clear and easily filterable. The maximum adsorption capacity (Langmuir approximation) for EPS on synthetic wastewater was 48.3 mg Cu²⁺/g EPS and 62.5 mg Cu²⁺/g EPS for actual wastewater with stability constants of 0.42 and 0.36 L/mg for synthetic and actual wastewater, respectively.

Keywords: Copper(II); exopolysaccharide (EPS); flocculation; polyelectrolyte; wastewater treatment

ESTD No. 12

**MINERAL IDENTIFICATION OF SELECTED ILOCOS NORTE
CERAMIC RAW MATERIAL DEPOSITS USING THEIR
INTERNAL MICROSTRUCTURE**

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The vast deposits of non-metallic minerals in Ilocos Norte like clay and feldspar are potential raw materials for the production of good quality ceramic products. To enhance the utilization of these clay and feldspar deposits, their mineralogical component should be identified.

Mineral identification of some selected Ilocos Norte ceramic raw material deposits was conducted by taking photomicrographs of their internal microstructure using JEOL JSM-35C Scanning Electron Microscope (SEM). The samples investigated in this study were white clay (from Pagudpud and Solsona) and feldspar (from Pasuquin) deposits. Representative test specimens in the form of powder (passing 200 mesh screen) from the samples were prepared. Each specimen was mounted in an 8 mm diameter copper metal holder by scattering the powder on one side with double sided adhesive tape and was coated with gold-palladium by ion sputtering method. Photomicrographs obtained from the sample of each material were carefully evaluated as regard to their internal microstructure and compared with the standard reference data on mineralogy for the identification of their mineral constituents.

Based on the comparative evaluation study, the mineral constituent in the clay samples were identified to be mostly of kaolinite and halloysite type of clay mineral together with quartz as the impurity. For the feldspar sample, the abundant presence of albite and orthoclase type of feldspar mineral together with free quartz was determined. Thus, clay and feldspar samples were found to be suitable for use in the production of ceramic white ware and fireclay refractory.

Keywords: Scanning Electron Microscope (SEM), mineral constituent, photomicrograph, internal microstructure

ESTD No. 13

PHOSPHORIC ACID ACTIVATION OF CORNCOBS

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The purpose of this study was to determine if activated carbon from corncobs using phosphoric acid, has an acceptable quality that can be used in simple industrial processes.

The adsorption characteristics of untreated and chemically activated corncobs using 25% and 50% phosphoric acid at impregnation times of 2, 4 and 6 hours, were investigated. Electron micrographs of the raw, charred, untreated and chemically treated activated corncobs and their corresponding pore sizes and iodine number, were evaluated.

Micrographs showed that the activated corncobs treated with phosphoric acid produced larger pores. The treatment increased the adsorptive capacity of the activated corncobs. The iodine number of the untreated sample, activated corncobs treated with 25% and 50% phosphoric acid, were 373.64 mg/g, 557.22 mg/g and 664.51 mg/g, respectively. Increase in the impregnation time of activated corncobs soaked in 50% phosphoric acid also increased the iodine number with values of 572.49 mg/g, 620.02 mg/g and 664.51 mg/g for 2 hours, 4 hours and 6 hours, respectively.

The maximum adsorptive capacities of the activated corncobs for decolorizing basic methylene blue dye were also determined. The highest color removal occurred with the activated corncobs soaked for 6 hours in 50% H_3PO_4 , and the lowest for the untreated corncobs. As the treatment concentration and soaking time was increased, the activated corncobs produced became more efficient in removing colorants from the dye solution.

Keywords: activated charcoal, corncob, adsorptive capacities, basic methylene blue dye

ESTD No. 13

IMPACT AND COMPRESSION RESISTANCE OF YOUNG COCONUT

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Young coconut is consumed in many hotels and restaurants, and is being exported in minimally processed form. During processing, the green peel is removed and the exposed husk is carved to enhance its visual appeal. Mishandling can cause bruising of the husk, reducing the quality of the product and increasing rejects during processing. The study aimed to determine threshold levels for impact and compression stress of young coconut for different impact surfaces, drop heights and static loading patterns. Threshold values for two impact surfaces (compact soil and concrete) were determined for different drop heights (15 – 120 cm). Compression resistance of whole samples was determined by creep test using different static loads (75 – 225 kg) and compression times (3, 6, 9 hr). Drop tests on soil and concrete surfaces showed that drop height had the greatest effect on both bruise depth and volume. Bruising developed to a greater degree in samples dropped on concrete, with incidence of 100% regardless of height. Bruising incidence for samples dropped on soil increased with height. Setting the acceptable bruise depth to 1 cm, the allowable drop height for compact soil was 40 cm. Drop heights greater than 15 cm onto concrete produced bruises greater than 1 cm in depth. Bruise volume and depth were highly correlated with drop height for samples dropped on concrete ($r^2 > 0.93$). Correlation was lower ($r^2 > 0.54$) for samples dropped on soil, possibly due to variations in compaction. Permanent deformation was significantly related to static load and exposure time ($r^2 = 0.82$). The greatest deformation of 4 mm was observed after 9 hrs of exposure with a load of 225 kg. Impact stress produced deeper bruising compared to compression; hence greater care must be taken during harvesting and handling to reduce injury.

Keywords: impact, compression, threshold, bruising, young coconut