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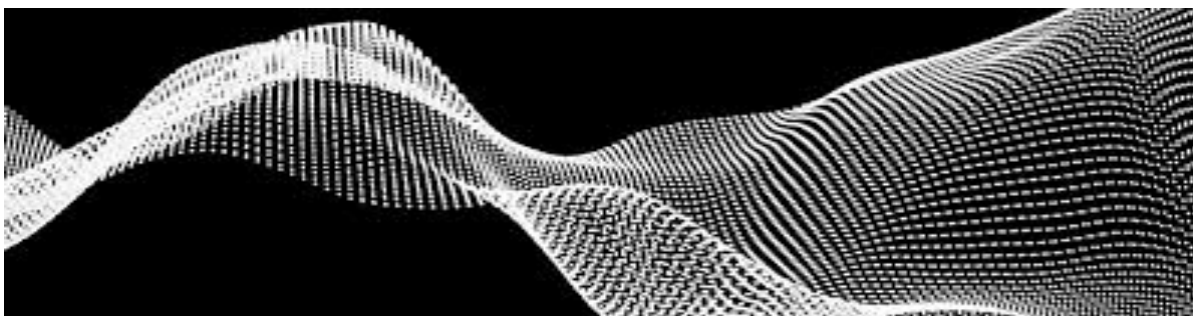
[HIT 300 (Design & Innovation) compendium of abstracts]

The document captures the abstracts of HIT 300 Projects done by students in the School of Industrial Sciences & Technology and School of Engineering & Technology for the academic year 2017-2018



School of Engineering & Technology

DEPARTMENT OF CHEMICAL AND PROCESS SYSTEMS ENGINEERING

DESIGN OF A PROCESS TO PRODUCE 20TPD OF HYDROGEN USING SYNGAS FROM THE GASIFICATION OF SAWDUST

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The purpose of this project was to come up with an alternative process for the production of hydrogen using sawdust as a raw material. This project was carried out at Harare institute of technology. Two major experiments, gasification and the water-gas shift reaction were done using MATLAB software to determine the most appropriate operating parameters for the process. For the gasification process, parameters were varied in order to investigate their impact on conversion efficiency of the gasification process to produce syngas. The overall best operating temperature was found to be 454.33°C (732.48K). Parameterized models of the enthalpy, entropy and heat capacity were used to compute the equilibrium constant and the equilibrium conversion for the water gas shift reaction in the temperature range of 500K to 1000K. At a lower temperature there would be a much higher yield of the desired product hydrogen (H2). For example, at 550K the equilibrium constant is about 58, and the pressure of H2 is 4.4 atm due to a much higher equilibrium conversion of 0.88. Some of the results obtained led to the design of a downdraft gasifier. Process control and HAZOP were done on the designed equipment to ensure safe operations. A detailed economic feasibility of the project was done. The project has a payback period of 2.7years and a return on investment of 36.8% which are acceptable financial indicators. It was concluded that it is possible to design an economically viable and

environmentally friendly hydrogen manufacturing plant. Further optimization of the process to examine the use of other fuels like charcoal briquettes as a source of heat for the gasification is being done process. Alternative uses of sawdust should be found to completely eradicate the problem that it is causing as a source of pollution.

Keywords: *Gasification Water-Gas Shift Reaction Sawdust MATLAB Syngas Hydrogen Downdraft-Gasifier*

DESIGN OF A PROCESS THAT PRODUCES A TONNE OF BIO-ETHANOL PER DAY FROM WASTEPAPER USING THE SIMULTANEOUS SACCHARIFICATION AND FERMENTATION METHOD.

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Among the problems faced in developing and developed countries in the 21st century waste disposal and an increasing fuel demand and crisis. Environmentalists and industrialists have come together in bid to counter these problems and from this a number of solutions. One of which is extraction of valuable material from waste material such as what this project focuses on. This project is aimed at the production of a tonne of bio-ethanol from waste paper. Due to the mandatory law of fuel blending, the increasing demand of fuel becomes directly proportional to the demand of ethanol for blending. To produce bio-ethanol from the waste paper, various experiments were carried out. The amount of cellulose in different types of paper was determined from literature and from this; a pre-treatment step at 60oC was done to achieve efficient conversion of lignocellulosic biomass to soluble sugars. Enzymatic hydrolysis and subsequent fermentation of the glucose yielded 0.4/1g of bio-ethanol. The products from the SSF Tank are then distilled to produce 95% ethanol. An SSF Tank was designed so as to give quality products since they are at the points where quality determination of the products is done. The size and design considerations of the equipment were based on the experimental work and the mass balance results. The HAZOP study on the designed equipment was done to ensure equipment operability and safety of the SSF Tank. The project has a payback period of 3.03 years, a return on investment of 33% at a breakeven point of 1 098 900 units which tallies to $840 000. It was concluded that it is possible to design the plant and Zimbabwe's economy would benefit immensely from the project.

Keywords: *Bio-ethanol, lignocellulose, cellulose, fermentation, waste paper.*

DESIGN OF A FERMENTER TO PRODUCE 5 TPD OF BUTANOL FROM CANE MOLASSES.

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Production of butanol biofuel from cane molasses was developed using a jacketed batch fermenter. Parameters affecting the biocatalyst during the reaction were determined to be the pH of molasses, water and bacteria culture and the concentrations of molasses culture. The maximum yields in the reactor were 78.9% and 80% of theoretical yield, respectively. The best conditions for butanol production obtained from the experiments were at 370C temperature and a pH of 6. The obtained results were scaled up to design the fermenter. Environmental impact assessment was carried out for the fermenter from inception, construction and operation and was found to be safe using the HAZOP analysis on the fermenter. A return on investment of 58.7% and a payback period of 1.808 years showed high returns. It was concluded that it is possible to design the fermenter. Zimbabwe being on fuel crisis would benefit immensely from the project.

Keywords: *Butanol, molasses, biofuel*

DESIGN OF A DISC BOWL CENTRIFUGE FOR THE PRODUCTION OF 900KG/ DAY OF TAPIOCA STARCH FROM CASSAVA (*MANIHOT ESCULENTA)*

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Approximately 60% of the Zimbabwean population relies on agriculture for food and employment and the agricultural sector accounts for 11-14% of the Growth Domestic Product of the country (Department of Agriculltural Research for Development, 2009). The same author states that the main staple food of the country is maize and it continues to be an important crop. However, production of other food crops such as sorghum, millet, groundnuts, soybeans, sweet potatoes and cassava is being encouraged particularly in the areas that are marginal for maize production. Zimbabwe used to be self-sufficient in terms of food production and in surplus years even used to export to neighbouring countries. However, for several reasons, the country has failed to produce enough food to feed its people for the last eight years. Starch, which was once abundant in the country, is being imported from other countries, increasing Zimbabwe's import bills. The aim of this project is to assess the possibility of producing tapioca starch from locally available cassava. Experiments that were carried out, which include determination of ash content, moisture content and gelatinisation temperature, proved that tapioca starch produced at lab scale had the same properties as that of the starch on the market. It is possible to produce 900kg/day of tapioca

starch using the wet milling process and centrifugation is employed for efficient and effective separation. A disc bowl centrifuge of 900kg/day capacity was designed and a HAZOP analysis and process control was carried out on this equipment. A detailed economic balance was done giving a payback period of 2.98years and a return on investment of 33.5%

Keywords*: tapioca starch, cassava*

DESIGN OF A PROCESS FOR THE REMOVAL OF METHYLENE BLUE FROM ITS AQEOUS SOLUTION USING ZEOLITE SYNTHESIZED FROM FLY ASH

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This study addresses the need to remove methylene blue from textile waste water using zeolite synthesised from fly ash as an adsorbent. Methylene blue is one of the common dye used in textile industry and it damages the environment if it is released in lage quantities. In this project, a zeolite was synthesised from Zimbabwean fly ash as the main raw material Sulphuric acid and sodium hydroxide pellets were also used to synthesise the zeolite.. The zeolite was used as an adsorbent in removal of methylene blue from its aqeous solution.A maximun removal efficiency of methylene blue using zeolite as an adsorbent was found to be 79% and it was also observed that the zeolite can be regenerated at high temperaturesof 520oC. The regenerated zeolite also manged to remove methylene blue and its efficiency was 69 %. The adsorption data managed to fit Freundlich isotherm and failed to fit Langmuir isotherm. The break through time was found to be 8.2 hrs. From the results that were obtained it was observed that methylene blue can be adsorbed by zeolites synthesised from fly ash. The design of the adsorption column a major equipment was also done, its height was found to be 7.7 m and a diameter of 1.10m. A HAZOP analysis was done for the adsorption column for its safe operation. Also an economic analysis was aslo carried out, and it was found that the project has a payback period of 2.3 years and a return on investment of 43%.

Key words: *Adsorption, methylene blue, zeolite*

THE DESIGN OF A 20TONE/HOUR GOLD RECOVERY PLANT FROM GOLD COPPER OXIDE ORES (A CASE STUDY OF SANYATI.

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Kadoma, Sanyati, area in Zimbabwe consists of gold ore reserves that contain a high copper content amount. The head grade for the gold is 3.342g/t whereas that for copper is 1.93%, therefore it is evident that there is high amount of copper. A higher copper content in the ore would mean higher production costs due to higher reagent consumption during processing and also lower gold recoveries due to the coexistence of the gold with the base metal. The work conducted by the author has presented novel formulations for the design of a gold recovery plant from gold copper oxide ores. The recovery of gold from gold copper oxide ores by using sulphuric acid leaching pre-treatment is a viable alternative for solving the current problems faced by Sanyati ores. This yielded laboratory recoveries of 81.2% up from recoveries of 42% at optimum NaCN concentration of 1000ppm and H2SO4 concentration of 2.5M. The aims and objectives of designing a copper recovery plant were met. A recovery plant was designed and a detailed piping and instrumentation diagram was produced. The gold recovery project is technically and be economically feasible with a payback period of 3.3years and a return on investment of 30.27%. There is need to carry out field-based test works and engineering services which will form the basis of discussions for the built up of a full scale copper recovery plant.

Key words: *Assaying; Recovery; leaching reactor; Cyanidation; ROI*

DESIGN OF A FIVE TONNE PER HOUR CAPACITY PRE-TREATMENT REACTOR THAT REMOVES THE EFFECT OF STIBNITE GOLD ASSOCIATED ORE

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The proposed design utilizes 5 tonne per hour gold processing plant .A pretreatment reactor will be designed to oxidize the stibnite (Antimony sulphides). The rate of oxidation stibnite increases in alkaline conditions resulting in the formation Thioanimonites which retard dissolution by being adsorbed at the surface of the gold making gold inert as a result of partial oxidation. These sulphur anions are thermodynamically unstable towards oxidation with dissolved oxygen in alkaline solutions .The rate of oxidation is remarkably low. The Aeration in alkaline solution and also use of peroxide prior to cyanidation increases dissolution and also increases recovery. From results obtained an oxygen level of 20ppm during pre-aeration resulted in increased recovery of upto 84%.The efficiency of sulphur

removal of the designed pre-aeration reactor was 96%.The design has a payback period of upto one year six months and a return of investment of 62.42 %.The rector volume and size were calculated using lenvensipel principle of determining reactor volume and size obtained was 96.79m

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DESIGN OF A PROCESS THAT SYNTHESIZES 5000KG PERDAY OF CELLULOSE NANOCRYSTALS FROM PLANT RESIDUE-WHEAT NSTALK

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As we move forward in the twenty first century, an explosion in demand of raw materials, energy, food and water is mostly driven by growing world's population. The supply of raw materials building blocks as we go day by day is becoming insufficient. There is need to revisit materials from agricultural based resources as major sources of materials for products. The demand for higher quality food types will require enhanced packaging materials to minimize losses in food supply chain and also a need of clean water supply in food and pharmaceutical industries is of importance. This research paper aims to produce cellulose nanoparticles from renewable nature of agro-residues using nanotechnology so as to develop novel and superior industrial products with enhanced performance attributes. It entails the problem statement, aim of the project, justification of the study and the objectives of the study. The production process starts from drying wheat stalk followed by acid hydrolysis, dissolution of cellulose in alkali solvent, conversion of microcellulose nanoparticles to nanocellulose crystals, separating solid sediment from liquid by centrifugation, sonication and lastly drying at a considerable temperature to produce crystals. The results from the experiments were used in the mass and energy balances and these were then used to design the process and equipment. The results obtained shows a yield percentage of 96%. The project focus was on the design of batch reactor for the acid hydrolysis of bulk cellulose to nanocellulose. The control of the reactor was done and feedback control method was used to control variables like temperature, pressure and feed forward control for flow rate. The necessary instruments for the control process were also determined. The HAZOP analysis was carried out to ensure safety during the operation of the plant with safety measures and procedures also put up. The economic analysis was carried out to ensure the economic feasibility of the plant. The project requires a total capital investment of $ 1408625. The selling price of cellulose nanocrystals was calculated to be $ 3.25/kg and $3250/ton respectively. The project had a break-even point of 3071 units in tonnes, payback period of 2.6 years and return on investment of 38%. Key words: Lignocellulose, dissolution, acid hydrolysis, nanoparticles, rheology, cellulose nanocrystals, environmental friendly.

CO-PYROLYSIS OF 10 TONNES PER DAY OF WASTE TIRES AND WASTE LUBRICANT OIL WITH ACTIVATED CARBON USING MICROWAVE HEATING TO PRODUCE D-LIMONENE

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The disposal of waste tires and waste lubricant oil is increasingly posing a problem to the globe (Cheung et al., 2011)**.** According to Altayeb 2015, one of the very common and outstanding solid wastes is scrap tire. On average 2 600 000 tires are disposed per annum and approximately 20% from Harare. Along Willowvale road approximately 100 tires are burnt in a week. The burning of tires leads to the emission of harmful compounds like black smoke and noxious gases including carcinogens which are hazardous to humans. This therefore calls for the conversion of these waste tires to a more valuable means through pyrolysis and further purification. Pyrolysis using microwave heating was opted for due to its energy efficiency and high heat transfer. Carbon black, pyrolysis oil and syngas were yielded from the experimental work. Pyrolysis oil was further purified by distillation to give d-limonene. Particle separation of carbon black was carried out and the particle distribution determined for the design of the cyclone separator to be used in the process. A process control mechanism was designed so as to monitor the operation of the plant. A feed forward control system for pressure was conducted for the cyclone separator. An economic analysis was done to assess the feasibility of the project economically. The project proved to be viable as it has a return on investment of 30% with a payback period of 3.65 years for a unit cost of $1.18 per kilogram on an average investment of three million dollars. Hence, this project proves to be beneficial and economically feasible as it also supports the Zim- ASSET Agenda in adding value to waste materials to benefit the nation. Key words: pyrolysis, cyclone separator, carbon black, d-limonene

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PRODUCTION OF PROPYLENE FROM SUGARCANE BAGASSE

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Propylene is one of the major building blocks in any successful chemical industry. Propylene is a major raw material of petrochemical and plastic manufacturing industries. The increase in human population has also driven the rise in demand of Propylene. Propylene can be produced using various methods which include for example steam cracking of naphtha or other light fractions of petroleum, Fluid Catalytic cracking and Propane dehydrogenation. This process route is a very energy consuming process and consumes non-renewable feedstock and will thus not be sustainable in the long run. Environmental pollution has become a major threat confronting the world therefore there is need to replace methods like steam cracking that produce high volume so fcarbon dioxide into the atmosphere with biomass. Research on replacing fossil feedstocks with

biomass has been increasing recently. Sugarcane bagasse is a cheap raw material and is always available all year round hence it can be used in non-oil producing nations. Propylene was produced from sugarcane bagasse in this project. Sugarcane bagasse was dried inorder to a moisture content of 12wt% inorder to create perfect conditions for gasification. Sugarcane bagasse was first gasified to produce syngas which was later converted to methanol. The methanol was placed in a fluidized bed reactor in the presence of a zeolite catalyst impregnated with sulphuric acid in order to form propylene. The project focuses on the design of a fluidized bed reactor with a production capacity of 100 tonnes per day. Experiments carried out include determining the effect of moisture content, bulk density, temperature, ash content and the heating values on the yield of propylene were investigated. The optimum conditions to obtain the maximum yield of 38.7% were found to be a temperature of 415^0C and a pressure of 2 bars. The piece of equipment which was designed for this project is a fluidized bed reactor. A process control was done on the fluidized bed reactor, flow rate and temperature were controlled for the fluidized bed reactor. A detailed HAZOP analysis was done for the plant and also for the fluidized bed reactor inorder to find out hazards that can occur in the plant. A detailed economic analysis was carried out to assess the economic feasibility of the project. The project has a payback period of 3.48 years and a return on investment of 28.7% which are acceptable financial indicators. It was concluded that it is feasible to design an economically viable and environmentally friendly process for producing propylene from biomass.

Key words. *Biomass, Fluidized bed reactor, Propylene, Steam cracking, Sugarcane bagasse, Fluid Catalytic Cracking , Gasification*

DESIGN OF A PROCESS TO PRODUCE 750KG PER DAY OF MAGNESIA-SILICAALUMINA NANOCOMPOSITE

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Developing countries and even developed countries are continuing to develop. Over the past few years, the construction activities have been increasing significantly and they will continue to increase as the world around us develops. A lot of developing countries are relying more and more on their mining activities as a major source of income from their exports and as this happens, there will be a need of more mining accessories. This document reviews the synthesis a nanocomposite that composes of magnesium oxide, aluminum oxide and silicon dioxide. The magnesium oxide, aluminum oxide and silica nanocomposite is a ceramic nanocomposite that was formed using a modified sol-gel synthesis. It was formed using conventional silica form a mine, magnesium oxide and aluminum oxide. Nanocomposites can be synthesized using a number of various ways but for this project, the sol-gel method was used for its convenience and simplicity in the laboratory. During the experimental procedure, silica reacted with sodium hydroxide at around 400°C in a muffle furnace to form sodium silicate. The sodium silicate solution then reacted with hydrochloric acid to form silicon tetra-hydroxide gel (silicic acid) and

sodium chloride crystals, the sodium chloride crystals were dissolved in water and the gel remained. Magnesium oxide an aluminum oxide was reacted with nitric acid and the resulting products were mixed with the gel, the resulting gel contained the magnesium and aluminum ions. The gel was dried and calcined at 600°C for about 2 hours to yield the nanocomposite. The control variables for the reactor were temperature and flow rate into the reactor, it encompassed use of control valves and measuring instruments to measure these variables and alter them. The HAZOP analysis was done for the batch reactor o identify the hazards and ensure process safety during its operation. The economic analysis for the project was carried out to see the viability of this project and analysis on the profitability of the project. In conclusion, the costs of starting this project and expecting a reasonable amount of profit was low and the project has a short period of rate of return. Recommendations were made on the project in order to fully implement this project on a larger scale which identified areas of improvement and other factors to consider.

SYNTHESIS OF AN ALUMINUM DOPED CELLULOSE ACETATE MEMBRANE FOR THE REGENERATION OF USED LUBRICATING OIL

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With the advancement in technology in Zimbabwe there is also a high level of mechanization. Machinery with moving parts are lubricated with oil from petroleum but after a certain period it is nothing but just a waste to pollute the environment. This research work focuses on the regeneration of used lubrication oil with a plant to operate at 5687kg of used oil refining per batch per day. A semi ceramic Aluminium doped Cellulose Acetate membrane was synthesized to improve the efficiency of the filtration process. The regeneration process of the oil is done in main stages which are acid attack with concentrated sulphuric acid, bleaching with activated carbon, neutralising with lime and sedimentation after each stage to finally go to the filtration unit and a complete base oil is formed. A batch reactor for the acid attack was designed, a HAZOP analysis was carried out on the equipment and control measures suggested. The work also proved that membrane filtration does not only deal with solid particulate matter in oil but also improves the quality from 53.16cP unfiltered 40.41cP. The doping of a cellulose acetate membrane proved to be a success as there was a significant change in the tensile strength of the membranes. The higher the amount of doping applied has a negative effect on the permeability of oil retarding the process speed. Operability studies where carried out on the running of the plant an Acid Attack batch reactor was designed with a volume capacity of 8.25m3 and a capacity to process 5874kg of oil per batch. The main dimensions of the reactor are a height of 3m and an internal diameter of 2m, a jacket being the heating system of the reactor.

Key words: *semi ceramic, HAZOP, Cellulose Acetate*

DESIGN OF A PROCESS FOR THE TREATMENT OF EXHAUST GASES FROM A GOLD DIGESTION PROCESS.

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The elution of gold is a method that is used to obtain gold from its complex. The gold will readily desorb from the carbon into solution. Gold has an affinity to adhere or load on activated carbon. It is this process of elution that produces poisonous gases such as SO2 and NO2. Nitrogen oxides and sulphur oxides are poisonous gases that should not be emitted to the environment. The aim of this project is to design a process for the treatment of the exhaust gas from the gold digestion process. Gas Scrubbers work by dissolving or absorbing the pollutant into the scrubbing liquid. To achieve the aim of the project experiments were done. An experiment was done to react the gas with the scrubber liquid. A conversion of 90% and 95% was obtained for both NO2 and SO2 respectively. Experiments were also done to determine the effect of varying scrubber liquid concentration, issue of resident time and pressure. A detailed process design was carried together with an economic analysis to assess the economic feasibility of the project. It was concluded that it is possible to design a system of treating exhaust gases from a gold digestion process with a net profit of $25 000 and a payback period of 6.6years. A detailed design of the equipment that is of the scrubber was done as well.

Keywords *Elution, desorb, scrubbers*

DESIGN OF A TWIN-SCREW EXTRUDER FOR THE PRODUCTION OF 750 KG PER DAY OF BIODEGRADABLE THERMOPLASTIC RESINS FROM WASTE CHICKEN FEATHERS.

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Thermoplastic resins are used to make thermoplastic materials with the use of a twin-screw extruder to replace non-biodegradable packaging material. The main objective of this project is to compare the properties of keratin based plastic to petroleum based plastic as well as to come up with the most cost-effective production of thermoplastics. Several experiments were conducted

and from the extrusion process, plasticizer to quill ratio was at 3:7, water absorption of the extruded plastic resins was approximately 15% with a 15% thickness swelling. Mechanical tests were done as well to compare the elastic moduli, tensile strength and elongation at break of the quill plastic to polystyrene and corn-starch. Experimental results from the conducted experiments showed that the production of thermoplastic resins from chicken feathers is not only possible but also produces a plastic with desirable properties. These results lead to the design of a twin-screw extruder. A HAZOP analysis was done on the extruder. A detailed economic analysis was also done to access the economic feasibility of the project. The project has a payback period of 3.1 years and a return on investment of 32.26% which are acceptable financial indicators. It is feasible to design an economically viable and environmentally friendly process for thermoplastic extrusion.

Keywords: *Keratin, Extruder, Chicken feathers, Thermoplastic Resin, Biodegradable, plasticizer*

DESIGN OF A BATCH REACTOR THAT SYNTHESIZES ZEOLITE 4A FROM KAOLIN CLAY

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The process for the production of Zeolite 4A using Kaolin and sodium hydroxide as raw materials is a new process and is thermodynamically and economically feasible.Experiments in this study project were carried out which include the calcination of kaolin , where it was exposed to a high temperature of about 550 0C for about 1.5 h where its structure is distorted and any undesired volatile matter was removed and converted to a metakaolinite, a material, which readily accepts and exchanges sodium. The produced metakaolin was then reacted with sodium hydroxide so as to insert sodium ions forming a zeolite complex ,which was then washed, filtrated , dried and calcinated forming zeolite 4A.A design of the process was done for the production of Zeolite 4A from the abundant raw material kaolin which is locally available. A design of the major equipment for the process was done and the equipment was a stirred batch reactor. A HAZOP analysis was carried out on the major equipment. The process control for the reactor was carried out for the process. The economic analysis for the project was carried, payback period, rate of return, production cost and other expenses were carried out. The payback period for the project after calculation was found to be 2years 6 months and the rate of return was found to be 39.6%. The break-even for the products was also calculated and found to be 46 727.66units in terms of mass (kg). The project is economically viable since its utilizing Kaolin which is an abundant raw material, to making something of use, adding value to the country.

Keywords: *Zeolite, metakaolin, calcination, kaolin, payback period, rate of return.*

DESIGN OF A PROCESS FOR PRODUCTION OF SOY BASED WOOD ADHESIVES FROM SOY MEAL

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Adhesive bonding of wood plays an increasing role in the forest products industry and is a key factor for efficiently utilizing timber and other lignocellulosic resources in Zimbabwe. The diverse and various forms of wood utilization highlight an abundance and diverse market for wood adhesives. Adhesives play a prominent role in a wide array of industrial fields including construction, aerospace, automobile manufacturing, packaging, wood products, and many more. Currently synthetic adhesives are widely used include petrochemical-based and formaldehyde-based adhesives such as, phenol formaldehyde resin and urea-formaldehyde resins in the preparation of wood composites. The purpose of this design and innovation project was to come up with an alternative way of producing wood adhesives from renewable raw material (soy meal). Soy flour is denatured in alkaline conditions so as to activate functional groups which aid in adhesive binding properties. However, despite the need to completely eradicate use of phenol and formaldehyde, denatured soy flour resin cannot meet all the standard adhesive properties. Soy meal/ phenol- formaldehyde matrix can meet the required standards. Experiments were carried out to determine the effect of addition of phenol and formaldehyde to a sample of denatured soy flour and a sample of only denatured soy flour resin was used as a control. Three samples were prepared, sample A which consisted of a denatured soy flour resin only, sample B which consisted of denatured soy flour and formaldehyde which acted as a stabilizer from further denaturation, and finally sample C, a resin which consisted of denatured soy flour, phenol and formaldehyde. From experimental results sample C showed the best adhesive properties with shear bond strength of 0.6133Kpa and solids percentage of 36.5%, comparatively to a sample A of denatured resin with shear bond strength of 0.2267Kpa and solids content of 30.2%. high solids content prevents adhesives from penetrating wood sample which results in high shear strength of adhesive, hence an important parameter. An economic assessment was done on the project to find out if it is economically feasible to produce wood adhesives from soy meal. A payback period of 2.6 and rate of investment of 38.5% were obtained.

Key words: *Defatted Soy Flour(DSF), Soy-Protein, Phenol, Formaldehyde, Resin*

MICROALGAL BIODIESEL PRODUCTION BY HYDROTHERMAL LIQUEFACTION

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Finding new energy resources to compensate the decrease of the world petroleum reserves is an important challenge. Fossil fuel dependency, mainly in the transportation sector, has encouraged research on biofuels. Given these circumstances, searching for other renewable forms of energy sources is reasonable. Algae refer to a group of microorganisms which are aquatic. These microorganisms produce a lot of lipids up to 60% of their total weight. This project seeks to utilize the vast quantities of oil in these organisms and use them in the hydrothermal liquefaction process in order to produce biodiesel. Studies were carried out in the literature review so as to gather a lot of information concerning the production of oil from algae and the catalytic hydrotreating process for the production of biodiesel process. Experiments were also carried out to determine the cultivability of algae, methods of algae harvesting and the extraction of the oil itself. The production of algae oil can be done in a number of ways but for this particular project work the hydrothermal liquefaction method was used. The oil upon extraction was then characterized and then used in the catalytic hydrotreating process using hydrogen as a reactant and molybdenum as a catalyst. The resulting biodiesel was then obtained and its properties determined. The experimental results were recorded and they showed that the best method for obtaining higher yield of wet algae was hydrothermal liquefaction as there is need for drying wet algae. Algae was heated to 90oC with n-hexane in the presence of HCl catalyst. The amount of oil obtained after hydrothermal liquefaction was 39%. A temperature of 120oC was responsible for a 39% oil yield. This meant that the relative oil composition of algae is higher than other oil sources like corn, peanuts etc. The emulsion test was done to confirm the presence of fats in the presumed oil and it yielded positive results characterized by a milk emulsion. Algae oil obtained by hydrothermal liquefaction was reacted with hydrogen in the presence of molybdenum catalyst and biodiesel was produced. Biodiesel was characterized and its flash and pour point were determined. The equipment designed for this particular project was a batch reactor. The control of the reactor was also done and it will be using the cascade control method to control variables like temperature, pressure and flow rate. The necessary instruments for the control process were also determined. The HAZOP analysis was carried out to ensure safety during the operation of the plant with safety measures and procedures also put up. The economic analysis was carried out to ensure the economic feasibility of the plant. The conclusion was then determined and it was deducted that the project was feasible.

Keywords*: algae oil, hydrothermal liquefaction, biodiesel, catalytic hydrotreating*

DESIGN OF A PROCESS THAT PRODUCES 2780KG/DAY OF FLOUR USING SWEET POTATO AS A RAW MATERIAL

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This project aims to enhance the socio economic, agronomic potential for production of flour from sweet potatoes. The utilization of sweet potatoes, better controls of spoilage of the material to be processed, during process, conversion rate, were the technical problems that required solutions before marketable flour could be manufactured. The objectives of this project involved to process sweet potato tubers into fine powder (flour)that can suite for gluten intolerable people, to evaluate the proximate nutritive composition and the color of the processed sweet potato flour during storage. This project mainly determined the design of 2780kg per day off lour using sweet potato as a raw material. Washing, slicing, drying, crushing and packaging are the main stages in the designed process. Drying was done using solar powered dryer at a range of temperature of 500C to 600C. The sweet potato flour was found to contain proximate values of moisture content, ash content, fat content, protein content, fiber content, carbohydrate content, with no significant changes during storage. The equipment design was done and the equipment designed was a solar powered tray dryer. The Hazop analysis was done to check for the deviations that may be encountered in the flour manufacturing plant. Economic analysis for the design was done. The project indicated to be economically feasible having a payback period of 2 years. The return on investment was calculated to be 62.7%. .From both the process design and equipment design, it can be deduced that there possibility of producing 2780kg per day of flour using sweet potato material as raw material.

Keywords: sweet potato, processing, nutritive, flour, proximate.

DESIGN OF A PROCESS THAT PRODUCES 1000KG OF HYDROGEN BY DARK FERMENTATION USING LIGNOCELLULOSIC FEEDSTOCK FROM SUGARCANE WASTE

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Current worldwide energy consumption is rapidly increasing, leading to a reduction in fossilfuel reserves. When combusted, fossil fuels release by products such as greenhouse gas which have been recognized as causing global pollution and possible climate changes. Growing concerns over greenhouse gas emissions from the combustion of fossil fuels, as well as the need for a clean high-energy fuel have prompted interest in the production of hydrogen from bio-renewable sources, also known as “bio hydrogen”. In the search for an alternative fuel, special consideration has been put on a fuel that not only supplies the world’s energy demands, but is also a cleaner option to the fossil fuels used today. Along with finding an alternative fuel that supplies the

growing energy demands these alternative fuels must also curb the environmental effects of burning fossil fuels. The mainly used currently available process for the hydrogen production is by water electrolysis. The generable biological-based process being developed in this project provides an alternate to water electrolysis. Laboratory studies were conducted to investigate the dark fermentation of the fermentable sugars present in bagasse. The dark fermentation reaction is feasible in the temperature range of 32ºC to 35ºC. Microbial production of hydrogen using yeast was investigated and the factors affecting production were optimized. The initial pH of the culture medium significantly affects the total gas evolved and the hydrogen contribution content in it. A suitable bagasse extract concentration level is essential to get high hydrogen production; however, excessively high or excessively low concentrations of bagasse extract level affect the growth of organism resulting in reduced production. Temperature is another important factor and it also affects the growth of the microorganism. The optimum values were found to be: Time- 48 h, initial pH - 7.0, Temperature - 320C, and Bagasse Extract - 1.0% (v/v). At these optimized condition the maximum hydrogen production was found to be 0.23 mol H2 /mol substrate respectively. From these results, it can be concluded that the use of Bagasse Extract for Hydrogen production increases the yield. The equipment chosen for this project work is the batch reactor as it was considered the main and also the biggest piece of equipment that is involved in the manufacture of hydrogen from the fermentable sugar hydrolysates obtained from sugarcane bagasse by dark fermentation. A payback period of two years and five months resulted. A return on investment was 41, 7%.

Keywords: *bio hydrogen, dark fermentation, bagasse, generable and green house*

DESIGN OF 51 000 000 UNITS PER ANNUM OF GRAIN AND CEREAL PROTECTANT TREATED PAPER LAMINATED POLY-PROPYLENE 50 KILOGRAM STORAGE SACKS

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Despite losses of grain due to problems encountered during harvesting, threshing and cleaning, drying, transportation and milling, major losses are encountered during short-term and long-term storage of grain and cereal crops as a result of lack of knowledge, inadequate technology and poor storage infrastructure in developing countries, particularly in Zimbabwe. Insect attack constitutes a major cause of damage and losses on calorific basis of stored grain in the tropics where cereals and grains such as rice, maize, wheat, soya beans, sugar beans and dried cassava constitute a large portion of developing countries staple diet. Improvising safe storage technics and strategic grain reserves is a key pre-requisite to ensure security of stored grain and crops. The use and application of protectant treated laminated polypropylene 50 kilogram storage sacks effectively and significantly protects stored grain and food crops from pests and insects that

may infest the food reserves and as well allow expansion of storage time and preserving quality and nutritional levels of the stored food crops. Effective repellant, hermetic and effects have been achieved by the implementation of protectant treated laminated polypropylene 50 kilogram storage sacks. This has proved economically efficient and optimum quantities of protectants are used per specific quantities of grain and cereal for storage through technical means without contaminating food, which could result in direct poisoning or through synergism. The machine design to retrieve unused protectant solids allows effective application rates and is economic since all materials used are fully utilised. A detailed financial analysis was carried out and the project proved to be economically feasible. The method is comparatively cheaper as compared to the mechanical protectant treatment application methods which is labour intensive and involves use of other unsatisfactory storage infrastructure and techniques, as well as posing a potential threat such as poisoning to both human and animal life if the protectants are not carefully applied or administered.

DESIGN OF PROCESS THAT PRODUCES 42 TONNES/DAY OF PAPER USING GRASS CLIPPING

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Grass is the green plant that one sees lining most streets across the country and possibly the most durable of all flora. Grass is grown from a seed. It has a root, a crown, and a leaf. It is 70% water. It is a completely naturally occurring substance, therefore 100% organic. It is made up of basic elements, carbon, oxygen, nitrogen, and phosphorus. Basically, grass is commonly use for animal feeding and the rest is disregarded us a waste. Zimbabwe has about 8.56tons/ha (Rhodes Grass Breeding, June 27,2015) and base on this, the researcher embarked on the full utilization of the grass, as source of raw material for paper production. The main intend purpose of the project was to eradicate environmental pollution, to reduce dependence of wood as source of raw material and to add monetary value to grass. Several experiments where conducted on the feasibility of the Kraft process using the grass clippings, all the experiment came out successfully. With an assumption of allocation of 3% of grass clipping for paper production a process capacity of 42tons/day was established base on calculated mass balance and energy balances. The project resulted in a design of a conveyor dryer. Control strategies on the dryer where done resolving in a feedforward strategy. It is further recommended that optimization approaches be in-cooperated in further study and a prototype be developed.

DESIGN OF A PROCESSS TO PRODUCE 5 TONNES PER DAY OF NANOPOLYMERIC CHITOSAN COATED FERTILIZER COMPOSITE

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Zimbabwe is a country that is heavily dependent on the agriculture sector as its economic backbone. Agriculture makes up of >18% of the country's GDP. Almost half of the country's exports are derived from agriculture especially cotton, tobacco, maize and horticultural products. The major crops grown are tobacco, wheat, maize, tomatoes and other horticultural products. The application of chitosan coated nano fertilizer with zinc oxide nanocomposite will result in increasing agricultural output and reduction in the damage that is done to the environment by the large scale application of regular fertilizers. This composite will also reduce the impact of the use of harmful pesticides on the environment. The product was characterized using FTIR and UV VIS Spectroscopy. A phosphate test was done to test the slow releasing effect of the nano polymeric fertilizer compared to the regular fertilizer. Based on the results obtained the nano polymeric fertilizer clearly showed the slow release of phosphate from the encapsulated fertilizer whilst the regular fertilizer showed that the phosphate content was released early on from the start and was quickly exhausted. The nano polymeric fertilizer exhibited high slow releasing capabilities and it can be seen as an effective product. From the economic analysis it has been concluded that it is possible to produce 5 tonnes of nano polymeric chitosan fertilizer composite. The minimum selling price of the fertilizer should be $56.04. The payback period is 3.4 years and it has a return on investment of 29.72%. All these factors can be noted as favourable for the production of this product.

Keywords: *Agriculture, Nanotechnology, Slow Release Fertilizer, Productivity*

DESIGN OF A PROCESS FOR MAKING MOLDED PULP FROM WASTE PAPER SLUDGE

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A detailed research was carried out to come up with a method to manufacture molded pulp from waste paper sludge. Experiments done include qualitative analysis, moisture content analysis, additives required and product testing. The proposed process involves waste paper sludge dewatering, mixing with additives, molding, drying then heat pressing. Process control and hazard operability studies (HAZOP) were done on the designed equipment to ensure safe operations. On completion of the project it was proved that it is possible to manufacture molded pulp from waste paper sludge. The economic analysis carried out showed that the project is viable with a payback period of 2.5 years and return on investment of 39.4%.

DESIGN OF A PROCESS TO TREAT TEXTILE EFFLUENT USING ELECTROCHEMICAL METHOD ENCHANCED BY NANO ZERO VALENT IRON DOSAGE.

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Despite efforts and awareness campaigns to stop the discharge of untreated or incompletely treated textile effluent by environmental watchdogs like the Environmental Management Agency (EMA) in Zimbabwe, textile industries remain a threat to the livelihoods of people surrounding these economic growth zones due to chromophore presence i.e. the –N=N- bond and trace metals such as Cr, As, Cu and Zn. Chemical and physical methods treating textile effluent are currently being employed to try and meet regulation standards but they have only achieved as such costing the industry heavy losses in income through fines and unending troubles to the society at large. Moreover chemical treatment is produces secondary pollution in the form of sludge and results in side reactions which render the process inactive. Hence as a solution advanced oxidation processes viz. electrocoagulation and nZVI were used to treat textile effluent using methylene blue as a model for all azo dyes. From experiments it was proven that a pH of 3 is optimum for both processes while a charge density of 30A/m2 was used. An initial dye concentration of 125mg/l showed to have the least absorbance peaks using UV/VIS. These results lead to the design of an ideal fixed bed catalytic reactor using a basis of 425m3 effluent discharge per day, using 97% efficiency .Aspects of temperature control, flow control was also done and HAZOP analysis was done on the packed bed. From the calculations, 8717.9 kg of catalyst would be required to produce 508 kmol of CO2 in a 42,05m3 FCBR. The specs of the reactor were broken down to a length of 7.54m and catalyst bed area of 5.65m2. The mechanical design of the reactor included internal pressure-stress relations, dead weight stress and strain analysis. A ROI of 34% was calculated in a 3 year payback period. Recommendations for future work include employing other reagents like activated carbon as support material so that it can make the processes' adsorption oxidation kinetics highly flexible and also evaluating plant performance and economics using a different type of reactor. It was concluded that the project is technically and economically feasible.

Keywords*: textile, chromophore, electrocoagulation, nano zero valent iron, methylene blue, fixed bed catalytic reactor*

PRODUCTION OF 2 TONNES OF AMMONIA FROM CHICKEN MANURE

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This project aims to produce ammonia from chicken manure. Ammonia is a useful raw material in the fertilizer industry and other industries like the mining industry, refrigeration industry and others. The release of ammonia into the atmosphere from the agricultural industry has triggered the need to find ways to reduce these emissions into the atmosphere. Chicken manure contains a lot of nutrients amongst which ammonia has high quantities. Literature review carried out showed methods of obtaining ammonia from chicken manure. Membrane method, aerobic digestion of chicken manure and precipitation method were some of the methods investigated. Experiments carried out and optimum pH was found to be 8.8 for the release of ammonia, optimum temperature was found to be 71oC and the operating pressure was 1 atm. The key experiment carried out was the precipitation of struvite from chicken manure. This experiment is key as it provides our key compound(NH4+) which gave us the desired product which is ammonia. Mass and energy balances were carried out to ensure all the flow rates of the material and from these 197.813kg of ammonia was obtained. Process control and HAZOP analysis of the major pieces of equipment was done to ensure quality product, safety, and higher profit margin. The economic analysis was carried out and the bill of quantities for the equipment totalled $97156.88 and a total capital investment of $246918.35. The payback period of the project is 3.0 years and the selling price of the ammonia was determined as $0.36/kg thus, the return on investment is 33.18%. The production of ammonia from chicken manure is technically and economically feasible.

Key words: *chicken manure, emission, ammonia, precipitation, struvite*

DESIGN OF A PROCESS THAT MANUFACTURES 3.9TPD WATER PURIFICATION MEMBRANE FROM WASTE POLYSTYRENE (KAYLITES) DOPED WITH SILVER NANOPARTICLES.

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Water scarcity and plastic waste are two well-known, global problems. For plastic waste, an increase in recycling is necessary, which requires a perception change towards recycled plastics. For water scarcity, treatment and reuse of wastewater is the most promising option to decrease water consumption. Within this scope, membrane technology is an attractive method to

accomplish this in a cost-efficient manner. However, today membrane technology is not applied to its full potential in industry. This research will develop a new generation of cheaper, “green membranes”, by exploring the use of a new source for membrane materials for water purification and wastewater management, that is solid waste plastics (Expanded Polystyrene (EPS)). The conceptual design of this design and innovation project uses waste kaylites to produce a water filtration membrane via a Phase Inversion method.100grams EPS was washed in Methanol and dried followed by dissolving in a solution of100ml 98wt%Acetone and different membrane additives at varying proportion of Polyetheneglycol(PEG) ,Polyvinyl Acetate(PVA),Silver Nanoparticles were added to improve membrane properties like antimicrobial activity together with tensile and flexibility properties in the casting solution. Membrane with membrane composition of 10%PEG400, 25% PS, 50%Acetone and 15% colloidal solution of Silver nanoparticles was chosen as the best performing membrane. The addition of different concentration of PEG as additives in casting solution improve the viscosity, and influence the performance of water permeation rate. On the other hand, as concentration of PEG200 and PEG400 in the casting solution is increased, the flux is increased. Based on the specific plant configuration evaluated, the financial analysis projects a nearly 27.1% return on investment and a payback period of 3.7years. Recommendations were also suggested to improve certain areas relating to the project work like to employ other reagents like DOP should be used as an additive in the casting solution so that it can make the membrane highly flexible.

Keywords: *Expandable Polystyrene, Polyetheneglycol, Silver Nanoparticles, water permeation and water flux properties, Phase Inversion.*

DESIGN OF A PROCESS THAT PRODUCES 1110 TONNES OF LEVULINIC ACID USING MAIZE STOVER AS THE RAW MATERIAL.

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Corn is one of the leading agricultural commodity in Zimbabwe that is a low cost raw material important to food, chemical, and fuel applications. Most of these products made from corn are brought about as a result of the starch, oil and proteins contained in the corn kernel whereas the rest of corn residue (stover) is viewed as waste product following the harvest of the economically important plant part i.e. grain. However over the past years corn stover has proved to be a potential raw material for biochemical production. Among the chemicals that can be produced from maize stover include levulinic acid a platform chemical that can be used to produce a number of biobased products that can replace some products that are currently being sourced from fossil fuels. Currently, there is no commercial production of levulinic acid from biomass and reasons include processing issues associated with the presence of lignin, waste disposal caused by typical acid processes and equipment corrosion. The experimental work for production of levulinic acid from pretreated maize stover using aqueous HCl was conducted using both pretreated and unpretreated maize stover at 2200C for 60 minutes and a yield of 12.0% and 6.9%

were obtained respectively. The results obtained were used in the design of a continuous stirred tank reactor CSTR). Process instrumentation and control diagrams (P and ID) and hazard operability studies (HAZOP) were done on the designed equipment to ensure safe operations. A detailed economic analysis was done to assess the economic feasibility of the project. The estimated total capital investment for the whole project is about $2 136 579.98 with a payback period of 5.3 years and a return on investment of 19.0% which are acceptable financial indicators. From the experiments and economic analysis conducted and also from the information gathered it was concluded that it is possible to design a cost effective levulinic acid production plant that uses maize stover as the raw material.

Keywords: maize stover, levulinic acid, biomass, CSTR, HAZOP

DESIGN OF A 1500LITRES/DAY ETHANOL PRODUCTION PROCESS VIA CELL FREE ENZYME ENCAPSULATION USING WASTE BAGASSE FROM SUGAR MANUFACTURING.

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The ethanol production process from cellulosic feed stocks such as sugar cane bagasse via cell free enzyme encapsulation is a modern day technology that ensures the protection of enzymes or catalyst within a semi-permeable matrix (ideal for toxic substrate composition as toxins do not gain access to capsule contents) while at the same time allowing the entry of vital nutrients and substrate and exit of finished product. This process is ideal for use with cellulosic feed stocks due as they are characterised by toxic substrate compositions that destroy enzyme in the production process. This project was conducted in order to test the viability (both economically and mechanically) for producing ethanol using this process which may help in alleviating pressure from First generation feed stocks such maize grain. Production process employed involved a number of stages that ran sequentially to each other. Experimental work was done starting with size reduction, followed by chemical pre-treatment using dilute acid hydrolysis at a temperature range of (110-125)^{O}C, under atmospheric pressure ,solid-liquid ratio of (1-10) and a pH of 5.Products from experiments where then tested for the presents of reducible sugars by use of benedict's reagent and then fermentation was partaken using two different enzyme delivery systems under the same conditions in an incubator for 8 hours (35^{0}C,Atmospheric pressure). First batch comprised of free cells which were acting as a control to the encapsulated free cell culture .The fermentation products for both samples where then tested qualitatively for the ethanol produced via the tri-iodoform test and the results obtained are tabulated within this dissertation as well as the economic assessment of partaking the venture. Data obtained was then used in equipment design where a batch fermenter was designed and an economic analyses which yielded a pay-back period of 1.6 years and a return on investment of 66%.

Key words: *First generation feed stocks, Second generation feed stocks, Lignocellulose, hydrolysis, pre-treatment, Encapsulation, Cell-free enzyme encapsulation, sugar cane bagasse*,

DESIGN OF A PROCESS TO SYNTHESIZE 3TPD NANOCELLULOSE FROM SUGARCANE BAGASSE.

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Due to the unavailability of a nanocellulose production plant in Zimbabwe, which causes high costs in nanocelluose and of products produced using nanocellulose as additive since it is being imported from other countries. This project focuses on the design of a process that extract 3000kg per day of nanocellulose from sugarcane bagasse and other plant sources using acid hydrolysis process. The design process has main stages which are alkalization I and alkalization II, acid hydrolysis process of nanocellulose synthesis, centrifugation of hydrolysed cellulose and sonication using a sonicator machine. Experiments were done to determine the effective and economical process between chemical, and mechanical process and also to determine the quality and yields of nanocellulose. These experiments were used in mass balance to determine the amount of raw materials needed and hence the size of equipment design. A detailed design was done for the major equipment; hydrolysis batch reactor which operate at 45^{o}C, pressure of 1 atmosphere. Hazard operability has been analysed in trying to monitor deviations that may rise in the process. An economic analysis for the project was carried out and the project proved to be economically viable with a payback period of 3.5 years. From the process and equipment design it can be concluded that it is possible to produce 3000kg/day of Nano cellulose.

Keywords*: Nano cellulose, acid hydrolysis, alkalisation, sugarcane bagasse, additives, synthesis, centrifugation, sonication.*

DESIGN OF A PROCESS FOR PRODUCTION OF 10 TONNES PER DAY OF HYDROGEN FROM METHANE CRACKING USING IRON OCHRE CATALYST SUPPORTED ON NICKEL.

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Due to lack of a hydrogen producing plant in Zimbabwe, the country has seen a major downfall in international trade due to large importation of fertilizer. This project focuses on the design of a 10ton per day Hydrogen plant that uses methane, which is abundant in the country in the form of

coal bed methane. The designed process has two main stages, which are preparation of the catalyst and the production of hydrogen gas from cracking methane. The steam is supplied by boilers and methane obtained from natural gas. I did experiments to determine the performance of the catalyst, the rate of its denaturation and its ability to crack the methane. I used these experiments in mass balances to determine the amount or raw material needed and hence the size of equipment designed. From the experiments it was determined that the using the catalyst, with mean diameter of 500µm and density 850kg/m3, gives a 50% yield of hydrogen from methane cracking. It was also determined that at temperature less than 550ºC, the rate of reaction is independent of the rate of catalyst denaturation. From the kinetics of the reaction, I experimentally found that 80 000kgs of Methane is required to produce 10tons per day of Hydrogen. I did a detailed design for the major equipment; packed bed reactor. Hazard operability has been analyzed in trying to monitor deviations that may rise in the plant. An economic analysis for the project was carried out and the project proved to be economically viable with a payback period of 3.5 years and a return on investment of 30%. From the process and equipment design, it can be concluded that it is possible to produce 10t/day of Hydrogen. The researcher recommends further optimization of the process to utilize iron carbon composites, which are produced by the process for water treatment, and investigate the formation of carbon nanotubes, which are partially formed.

DESIGN OF A PROCESS THAT PRODUCES 336M^3 /HR OF BIOMETHANE PER DAY FROM RAW WHEAT BRAN (USING ACTI-ZYME AS BIO-CATALYST)

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Anaerobic digestion is the process in which organic material decays in an oxygen free or low oxygen environment. The process releases heat and biogas, and the gases produced are methane, carbon dioxide and traces of other gases. Biogas generated from anaerobic digesters can be used for the generation of thermal or electrical energy, lighting and cooking. Biogas production can reduce the use of fossil fuel which is a non-renewable source of energy that contributes to environmental pollution. Carbon-di-oxide is the main product of fossil fuels which leads to global warming. Renewable energy helps in energy security, environmental pollution abatement and social upliftment. This project focused of the production of biogas from wheat bran and further upgrading the biogass into biomethane. Wheat bran is a cheap and available raw materials. Zimbabwe has a monthly wheat bran production of about 30 000MT, of which 9000MT is being used for stock feeds leaving about 21 000MT lying idle. Wheat bran is first subjected to a number of pretreatment methods to condition it for biogas production. Actizymes are used for the fermentation of wheat bran. From the experiments an optimum residence period of 22 days was obtained. 1kg of wheat bran produced 10L of biogas which was then upgraded to biomethane using a water scrubber. From the water scrubber 7L of biomethane was produced.

By upgrading the biogas, the calorific value of biogas was increased from 23MJ/Nm^3 to 39.8MJ/Nm^3. Also covered in this project was the major equipment design (absorption column). The absorption column uses water as the solvent and iron wool as the scrubbing agent. A HAZOP analysis was done to evaluate all the potential hazards which are associated with the designed plant. The project has been proved to be economically feasible, since, by injecting $ 782 227 as the total investment cost, a rate of return of 47.5% is achieved, and the payback period of 2.1 years.

DESIGN OF A LEACHING REACTOR THAT PROCESSES 300 TPD BITUMINOUS COAL TO PRODUCE HYPER COAL: CASE STUDY-MUNYATI POWER STATION.

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With regard to the environmental aspects, the oxides of sulphur created when coals are burnt have long been recognised as a real threat to both the ecosystem and human health. In this design and innovation project, the researcher produced hyper coal which can be used in coal fired powerplants to reduce high sulphur dioxide emissions and to reduce the ash content in coal so as to prevent ash induced fan blockages of the FD and ID fans. The researcher designed a low cost leaching reactor which effectively remove sulphur and ash from bituminous coals so reduce unplanned plant shutdowns and to lower emission penalties from the Environmental Management Agency. This project mainly focuses on the design of a low cost leaching reactor. Experiments were done to determine the effects of particle size, concentration of leaching solvent and leaching time on the production of hyper coal. The average conversion of 83% was obtained. These results led to the design of a continuously stirred leaching reactor. Aspects of flow control was done and HAZOP analysis was done on the leaching reactor. A cost benefit analysis was also be done so as to assess the monetary social cost and benefits of capital investment on the project. The project has a payback period of 1.009 years and a return on investment of 52.6% which are acceptable financial indicators. It is concluded that it is feasible to design a leaching reactor for increased plant availability and for reducing EMA penalties

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THE DESIGN OF A PROCESS FOR THE EXTRATION OF OIL FROM POWDERED AVOCADO SEED FOR THE PRODUCTION OF BIODIESEL

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Avocados have many applications though their seeds are rendered to be of no use and disposed of in landfills. Though they have a very high starch content, avocado seeds cannot be used as livestock feed as they have a high polyphenol content which gives them a bitter taste and making the seed toxic when ingested. The seed is about 26%wt of the avocado and produce a lot of lipids up to 35% of their total weight. This project seeks to utilize the vast quantities of oil in these seeds and use them in the transesterification process in order to produce biodiesel. Studies were carried out in the literature review so as to gather a lot of information concerning the extraction of avocado seed oil. Experiments were also carried out to determine the moisture content, the extraction of the oil and the production of biodiesel. The extraction of avocado seed oil can be done in various ways but for this particular project, the solvent extraction method was used as it yielded 35% oil. The oil upon extraction was characterized and then used in the transesterification process with a base catalyst. The experimental results were recorded and they showed that the best method for production of biodiesel requires an agitation intensity of 600rpm, a temperature of 600C with a methanol to oil ratio of 6:1 this experiment yielded a 95%conversion proving avocado seed oil to be a suitable oil for biodiesel production. The calorific value of the biodiesel was determined to be 38.51MJ/kg.The material balances which are the mass and energy balances were carried out based on the experimental results and these were then used in the equipment design. The equipment designed for this particular project was a batch reactor. All the dimensions and specifications of the reactor were specified and tabulated. The control of the reactor was also done and it will be using the feedback control method to control variables like temperature and pressure. The necessary instruments for the control process were also determined. The HAZOP analysis was carried out to ensure safety during the operation of the plant with safety measures and procedures also put up. The economic analysis was carried out to ensure the economic feasibility of the plant. The cost of equipment, fixed capital investment, total investment cost, return on investment and breakeven analysis were computed and obtained. It was deducted that the project was feasible since the economics of the project were deemed achievable with a payback period of 2.34years which is also accepted. Recommendations were also suggested to improve certain areas relating to the project work which include investigating the feasibility on specific species of the avocado seed for oil extraction and discovering new ways to purify the crude biodiesel.

Keywords: *avocado seed oil; transesterification reaction; soxhlet extraction; biodiesel*

DESIGN OF AN ADSORPTION SYSTEM FOR THE REMOVAL OF CHROMIUM (VI) METAL IONS FROM WASTE WATER USING ACID MODIFIED WHEAT BRAN.

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Treatment of industrial wastewater is an important part of efforts aimed at reducing effluent toxicity to levels that are tolerable before discharging into the water bodies. Due to the increasing level of toxic metals found in residual streams originating from industrial discharges, new methods and techniques are developed for environmental control. Metal adsorption by porous solids is one of the most useful options for this type of problems. Adsorption processes are being widely used by various researchers for the removal of heavy metals from waste streams and activated carbon has been frequently used as an adsorbent. Novel adsorbents from various forms of biomass are being investigated for use as cheaper, and more effective adsorbents. Acid modified wheat bran with citric acid was developed and Cr(VI) adsorption was investigated by changing various parameters .By varying the concentration of the solution as well the adsorbent dosage and studying its effects we have selected the best result obtained for percentage removal of Chromium. An increase in the amount of adsorbent increases the percentage removal of Cr(IV) from water with 20g/L giving an adsorptive capacity of 83.4%. The results obtained from experiments were used to perform a scale-up process of an adsorption column from the laboratory level to an industrial level. Acid modified wheat bran adsorbent used in this experiment has demonstrated to be an effective adsorbent material. From the economic analysis it can be deduced that the project is feasible as it has a payback period of approximately 2.32 years and a return on investment of 43%.

Keywords: *adsorption, chromium, wastewater, wheatbran*

DESIGN OF A LEACHING PROCESS TO RECOVER 1800GPD OF PALLADIUM FROM CONVERTER MATTE.

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Platinum Group Metals are valuable metals that are found in composition with Gold and other valuable minerals. These metals consist of Palladium, Rhodium, Osmium, Ruthenium and Iridium with Platinum. They are found in minute quantities of ore which is dependent on the type of the head grade of the ore. As for this project, Palladium was found in quantities of 2g/t into which there is only 2 grams in every tonne sample but, this quantity varies from 1.5g/t to 2g/t. Refining processes are done by various hydro-metallurgical methods that use various methods of extracting the metal as an individual out from the ore. This project is centred on ensuring successive recovery of the Palladium from the ore by use of Aqua regia as the leaching agent. The objective is to obtain a 96% recovery in the leaching tanks but, this had to be obtained via using a volume of 70ml of Aqua regia, 16ml of Hydrofluoric acid and 14ml of Hydrogen peroxide onto an ore of 15g with 1.8g of Palladium. For extracting the Palladium from the leach liquor, an organic extractor (Di-n-hexyl sulphide) dissolved in toluene was used to load the Palladium ions. These ions were then stripped off from the extractor by use of Ammonia mixed in Ammonium chloride experimentally. The stripping agent removed the loaded Palladium complexes with increased concentration of the stripped ions at equilibrium. An addition of Hydrochloric acid

resulted in precipitation of the dissolved ions into insoluble salts of Palladium complexes. The salt is then calcined, thus liberating solid Palladium metal as well as fumes of Chlorine and a black layer of Ammonium chloride. The shiny silvery sponge is then send for characterisation by using an Induced Coupled Plasma Atomic Emission Spectroscopy (ICP AES). This project proved to be economical since the Payback period was approximately 3 years with a Rate of return which is 30.20%. The net profit per annual was $533446.97 thus, showing the profitability of the project. This research opens a pathway into further view of other methods for refining that involves all available hydrometallurgical means that uses other potential leaching and extraction agents.

Keywords *Leaching, Palladium, Hydrometallurgy, Aqua regia, Di-n-hexyl sulphide*.

DESIGN OF A PROCESS FOR THE EXTRACTION OF 30TPD ETHYL CELLULOSE FROM BAGASSE

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In Zimbabwe there is currently no production of ethyl cellulose and a lot of industries for example the pharmaceutical industry, paint industries and food industries have been relying on imported ethyl cellulose of which importing is costing us more millions of dollars every year which could be used to for other investments in the country.This project is basically focussed on the design of a process that can be used in the extraction of cellulose from bagasse and further processing it into ethyl cellulose and for the bagasse we will focus on Hippo Valley Estates in Chiredzi. The process of producing ethyl cellulose from bagasse which can be used in pharmaceuticals as a tablet binder and also as a flavour fixative in food industries was done successfully through the implementation of many chemical and process systems engineering basics. Experiments were carried out to determine optimum process conditions for the extraction of ethyl cellulose from bagasse and these were used in the process design and equipment design. In the acid hydrolysis experiment the maximum amount of hemicellulose was dissolved when 1% acid was used instead of 5% and 10%. Results obtained from the delignification process proved that the process is more effective when 1% acid was used at maximum temperature of 90°C. a continuously stirred tank reactor was designed and a HAZOP analysis and process control was done on the reactor so as to maintain a safe working environment and use environmentally friendly processes. A detailed economic analysis was done and economically the project was proven to be viable since it has a payback period of 2.6 years and a return on investment of 39%.

DESIGN OF A PROCESS TO EXTRACT GOLD FROM REFRACTORY ORES

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Microorganisms have unwittingly been used in the extraction of minerals such as copper and gold since ancient times. Thanks to the progression of science we have been able to identify that the particular set of microorganisms that take part in the extraction of these minerals include bacteria such as Acidithiobacillus ferrooxidans and Acidithiobacillus thiooxidans. This project aims to utilise the ability of these organisms in the extraction of gold from refractory ores, these bacteria function by mainly leaching the sulphide minerals that encapsulate the small molecules of gold. A literature review was conducted in order to collect as much information on the process to be done and also on the bacteria's specific activity in the process. Simulation software was used in order to determine the specific conditions that would be most favourable, the software that was used was matlab optimum conditions for temperature were determined to be 400c and the optimum pH level was determined to be around 2.8 it was also observed that the pulp density of the slurry should be closely controlled . Material and energy balances were done and these were used to come up with the equipment design the equipment that was designed in this project was the batch reactor, a HAZOP analysis was done on the equipment in order to ensure the safety of equipment and also that of workers .the economic feasibility of the project was ascertained through an economic analysis where the fixed capital investment and total investment cost were calculated .from the economic analysis it was determined that it would take 2 years for there to be a return on the investment

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PRODUCTION OF 10 TONNES / DAY OF ACTIVATED CARBON FROM SPENT MALT/BREWER'S SPENT GRAIN FOR ADSORPTION OF POLYPHENOLS FROM BEER

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Activated carbon is a carbonaceous material, of highly porous adsorptive medium that has a structure mainly composed of carbon atoms. It is derived from carbonaceous specialty materials, usually organic materials such as coal. Most of the activated carbon that is used in Zimbabwe is derived from coal. This project seeks to investigate whether it is feasible to produce activated carbon from brewer's spent malt which can be used in the adsorption of polyphenols from beer. 113g of activated carbon was produced from 150g of spent malt through pyrolysis in a furnace. Pyrolysis was done at 300^0C and chemical activation at 450^0C. This corresponds to a conversion

of 75.3%. The activated carbon produced had an iodine number of 906.1mg/g. the activate carbon was used for the removal of polyphenols from beer. An optimum carbon dosage of 1.5g was used to treat 100 ml of beer for 25 minutes. The polyphenols concentration was reduced from 180.6 mg/g to 25.737 mg/g. An optimum time of 15 minutes was then taken which corresponded to a polyphenol concentration of 27.101 mg/g. A breakthrough analysis was carried out for different flowrates of 20ml/min, 25ml/min and 30ml/min. A flowrate of 25ml/min was then chosen for the purpose of design of an adsorption column. This had an exhaustion time of 50 minutes and exhaustion volume of 1250 ml. However a breakthrough time of 12 minutes was selected with a breakthrough volume of 300 ml. This gives the polyphenol concentration of 28mg/L. An adsorption column was designed which can treat 5000L of beer per day using 14 kg of activated carbon to a polyphenol concentration of 28 mg/L using the experimental results. From that, we can safely say that activated carbon produced from spent malt can adsorb polyphenols from beer. The economic balance has shown that it is economically feasible to remove polyphenols from beer using activated carbon. It will take 5.7 years to pay back the investment with a rate of return of 18.6%.

Keywords: *Activated carbon, adsorption column, iodine number, polyphenols, spent malt*

DESIGN OF A PROCESS FOR THE RECYCLING OF 5TPD OF USED LUBRICATING OIL USING ACID CLAY TREATMENT PROCESS

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Due to the absence of an oil production plant in Zimbabwe, which causes high costs of lube oil on the market since it is being imported from other countries. This project focuses on the design of a process that recycle 5 tons per day of used oil by applying acid-clay treatment process. The design process has three main stages that are pretreatment of the oil using sulfuric acid, elimination of light hydrocarbons and purification of the treated oil. Experiments were done to determine the effective and economical of acid clay treatment process and also to determine the quality and yields of recycling oil. These experiments were used in mass balance to determine the amount of materials needed and hence the size of equipment design. A detailed design was done for the major equipment. An adsorption column of height 4m and diameter 2.67m, which operate at 15^{o}C, linear velocity of 10 m/h, was designed. Hazard operability has been analyzed in trying to monitor deviations that may rise in the process. An economic analysis for the project was carried out and the project proved to be economically viable with a payback period of 1.8 years. From the process and equipment design, it can be concluded that it is possible to recycle 5 tons per day of used lubricating oil. Further character testing may also be executed to evaluate oxidation stability, thermal stability and foaming character of the recycled oil.

Key words: *used engine oil, activated clay, acid treatment, adsorption column*

DESIGN OF A PROCESS FOR THE MODIFICATION AND STRENGTHENING OF 200 TONNES PER YEAR OF BITUMEN USING SILICA NANOPARTICLES.

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Zimbabwe's bitumen bound paved surfaces are deteriorating quickly as a result of several causes such as rains, sunlight and reactions with chemicals which cause the bitumen to break down. Such quick deterioration results in the need for frequent maintenance services and resurfacing of the roads which end up demanding huge amounts of funds of approximately $956970 considering a road network of about 93000 km, bitumen prices of $0.70-$0.80 per litre, and 2.45litres of bitumen required per square meter. Utilizing nanosilica in bitumen modification to improve the rheological properties of bitumen by blending of the two materials is not only necessary but of vital importance if we are to succeed in economically reducing the rate of deterioration of paved surfaces in Zimbabwe. Nanosilica modification will thus reduce the frequencies of maintenance services on the roads while at the same time improving the quality of our roads. This paper focuses on the design and development of a process that produces about 200ton/year nanosilica modified bitumen (NSMB) for road construction. From the experiments conducted, optimum loading results for different concentrations by weight silica nanoparticles and bitumen were used. These compositions were obtained as follows: 2%wt, 4%wt and 6%wt NSMB. The results were validated using statistical analysis and it was shown that there was a significant improvement of bitumen mechanical properties especially in 6%NSMB. Process and equipment safety was ensured by maintaining the temperature at 160°C, working pressure of 159KPa and agitation of the stirred tank reactor was maintained at 3000 rpm coupled with baffles for uniform mixing. For a Total Capital Investment of US$319268, the Return on Investment is 58.6% with a Payback Period of 1 year and 7 months.

Keywords: *Bitumen modification, Nano silica, process design, road construction*

DESIGN OF A PROCESSS TO PRODUCE 15 TONNES PER DAY CASTOR OIL USING POLYVINYLIDIENE FLUORIDE (PVDF) ULTRAFILTRATION MEMBRANE AS AN ALTERNATIVE FOR WATER DEGUMMING.

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The seed, *Ricinus Communis* (Castor bean) from which castor oil is extracted contains phosphatides that need to be removed because these have oxidizing agents which cause decolouration of the oil and compromise oil quality. Conventional methods of phosphatide removal include water degumming which results in the generation of phosphate-ridden wastewater. In this project, this conventional method of water degumming has been replaced by membrane technology to eliminate waste water generation on the degumming unit operation. The polyvinylidiene fluoride (PVDF) membrane has been used to degum the oil as a filtration medium. The separation process is based on the molecular weight and size of the phosphatides. The PVDF membrane will separate the phosphatides from the rest of the oil on an ultrafiltration basis because this type of filtration is capable of retaining the phosphatides on the membrane surface as they cannot pass through they will be in the retenate. This project focuses on the design of a process that produces 15 tonnes a day of castor oil using polyvinyilidiene fluoride ultrafiltration membrane as an alternative to water degumming. Experiments were done to determine the quantities of the oil's physical and chemical parameters as well as monitor membrane performance based on the oil flux rate and degumming ability. The oil viscosity at 28℃ was found to be 0.928cP with a pH of 6.32. The maximum oil flowrate through the membrane was 0.375ml/min and phosphatide testing was done qualitatively and the phosphomolybdenum complex formed during quantitative testing had the greatest absorbance peak at a wavelength of 830nm. The seed from which the oil was obtained has a moisture content of 4.29%. These experiments were used in computing mass balances to determine the amount of raw materials needed and hence the size of equipment designs. A detailed design was done for one of the major equipment; a cross flow filter which operates at ambient temperatures and a pressure of 3.4 atmospheres. A Hazard and Operability analysis (HAZOP) was done on the cross flow filer in an attempt to monitor deviations that may rise in the filtration process. An economic analysis for the project was carried out and the project proved to be economically viable with a payback period of 4.7 years, a return on investment(ROI) of 21.26% and a break-even point of $78 068.25 with 1906 units sold. From the process and equipment design it can be concluded that it is possible to produce 15ton/day of oil from castor seeds.

Keywords: *Ricinus Communis, Polyvinylidiende Flouride, Degumming*

DESIGN OF A PROCESS TO PRODUCE 400L PER DAY OF METHANOL FROM INDUSTRIAL CARBON DIOXIDE

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There is no methanol producing plant in Zimbabwe. This causes problems of high costs in methanol and materials produced from methanol since it is being imported from other countries. This project focuses on the design of a 400 Liters per day methanol plant that uses industrial carbon dioxide and methane as raw materials. The designed process sees the bio synthesis of methanol from carbon dioxide through the use of methanotrophic bacteria, Methylosinus trichosporium IMV 3011. Experiments were done to synthesize a methanotrophic

bacteria cell suspension as well as methanol synthesis. These experiments were used in mass balances to determine the amount or raw material needed and hence the size of equipment designed. A detailed design was done on the disk bowl centrifuge. Hazard operability has been analyzed in trying to monitor deviations that may rise in the plant. An economic analysis for the project was carried out and the project proved to be economically viable with a payback period of 4 years. From the process and equipment design it can be concluded that it is possible to produce 400 liters per day of methanol

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***Keywords**: methanotrophic bacteria, industrial carbon dioxide, Methylosinus trichosporium IMV 3011, methanol*

DESIGN OF A CYANIDE DETOXIFICATION PLANT TO TREAT 45.555 CUBIC METRES/HOUR GOLD PROCESSING EFFLUENT USING SULPHUR DIOXIDE: CASE STUDY – FREDA REBECCA GOLD MINE

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The use of cyanide in the purification of gold has become a cause for concern. The International Cyanide Management Code for the manufacture, transport and use of cyanide in the production of gold with respect to plant operations (ICMC), requires the management of cyanide process solutions and waste streams to protect human health and the environment. Section 4.2 of the Principles and Standards of Practice (International Cyanide Management Code (May, 2002)). Freda Rebecca Gold Mine is a gold mine which utilises cyanide for gold recovery. The average free and weak acid dissociable cyanide concentrations in their waste effluent were higher than that recommended by the ICMC which resulted in liberating more free cyanide and consequently hydrogen cyanide gas, which is toxic. The purpose of this project was to introduce a cyanide destruction plant which reduces the cyanide concentrations to the ICMC recommended concentrations using the INCO process. Experiments were carried to determine the amount of reagents required for the process and the residence time for the process. The reagents for the process were Sulphur dioxide gas and lime. All experiments were done at ambient conditions. The obtained results were scaled up to design an optimum process. Process control and hazard operability studies (HAZOP) were done on the designed equipment to ensure safe operations. On completion of the project it was proved that it is possible to destroy the cyanide in the tailings using the INCO process. The economic analysis carried out showed that the project is a viable project with a payback period of 4 years.

Key words: *Cyanide, Destruction, Sulphur dioxide, Effluent*

DESIGN OF A PROCESS THAT PRODUCES A TONNE OF BIO-ETHANOL PER DAY FROM WASTEPAPER USING THE SIMULTANEOUS SACCHARIFICATION AND FERMENTATION METHOD.

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Among the problems faced in developing and developed countries in the 21st century waste disposal and an increasing fuel demand and crisis. Environmentalists and industrialists have come together in bid to counter these problems and from this a number of solutions. One of which is extraction of valuable material from waste material such as what this project focuses on. This project is aimed at the production of a ton of bio-ethanol from waste paper. Due to the mandatory law of fuel blending, the increasing demand of fuel becomes directly proportional to the demand of ethanol for blending. To produce bio-ethanol from the waste paper, various experiments were carried out. The amount of cellulose in different types of paper was determined from literature and from this; a pre-treatment step at 60oC was done to achieve efficient conversion of lignocellulosic biomass to soluble sugars. Enzymatic hydrolysis and subsequent fermentation of the glucose yielded 0.4/1g of bio-ethanol. The products from the SSF Tank are then distilled to produce 95% ethanol. An SSF Tank was designed so as to give quality products since they are at the points where quality determination of the products is done. The size and design considerations of the equipment were based on the experimental work and the mass balance results. The HAZOP study on the designed equipment was done to ensure equipment operability and safety of the SSF Tank. The project has a payback period of 3.03 years, a return on investment of 33% at a breakeven point of 1 098 900 units which tallies to $840 000. It was concluded that it is possible to design the plant and Zimbabwe"s economy would benefit immensely from the project.

Keywords: *Bio-ethanol, lignocellulose, cellulose, fermentation, waste paper.*

DESIGN OF A PROCESS TO PRODUCE 120 TPD OF SODIUM LIGNOSULFONATES FROM TIMBER SAWMILL RESIDUE.

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The use of lignosulfonates in construction is a new concept and its range of uses has been widening ever since it was introduced. It has a potential to substitute some of the plasticizers like

glucconic acids used in Portland cement which are expensive resulting in higher prices of cement. The purpose of this project was to come up with a process for the production of sodium lignosulfonate which can be used in cement as an additive to improve the physical and chemical properties of cement such as the strength, flowability and setting time. Experiments were carried out in the laboratory using saw dusts and 70% NaOH and 30% Na2SO3.All experiments were done at atmospheric pressure. The obtained results were scaled up to design an optimum process including a detailed design on the evaporator which has an area of 228m2. Process control and hazard operability studies (HAZOP) were done on the designed equipment to ensure safe operations. On completion of the project it was proved that it is possible to produce sodium lignosulfonate using this process. The economic analysis for a 120 TPD sodium lignosulfonate producing plant was carried out and showed that the project is viable with a payback period of 2.05 years and return on investment of 48.8%. Zimbabwe has one of the largest timber plantations in Southern Africa producing more than 140 000 tonnes/year of timber sawmill residues, which could be beneficial from the value addition of these waste biomass

. **Keywords:** *Sodium lignosulfonate, Evaporator,plasticizers.*

DESIGN OF A PROCESS THAT PRODUCE 4.6T/H OF BRIQUETTES FROM MUNICIPAL SOLID WASTE.

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Municipal Solid Waste management is one of the major challenges being faced by developing countries like Zimbabwe. This municipal solid waste contains a lot of energy that is left unrecovered in landfills. This project focuses on the production of briquettes from organic municipal solid waste particularly food, agricultural and yard and waste plastics. Briquetting process results in a product with high energy value which is close to that of coal and these briquettes can be used for both domestic and industrial processes. On the other hand the coal output in Zimbabwe has decreased greatly leaving the country's power stations to operate way below their full capacity, therefore there is need to fill this energy demand gap with these briquettes. Several experiments were done and the results obtained showed that it is feasible to produce briquettes from organic municipal solid waste and waste plastics with the addition of a binder. Design of screw press briquetting machine was done, including its controls and HAZOP analysis. An economic feasibility was done on the project and was found to be viable. The project had a break-even point of 6880 units in tonnes, payback period of 2.3 years and return on investment of 44%.The total capital investment required is $1114560. Key words: municipal solid waste, briquetting, screw press, HAZOP

DESIGN OF A PROCESS THAT PRODUCE 645KG/DAY OF CAO NANOPARTICLES FROM PHOSPHOGYPSUM

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The purpose of this project is to come up with an alternative process for the reduction of the amount if phosphogypsum at ZimPhos that is lying idle and causing environmental pollution. The raw material was phosphogypsum, nitric acid, water and sodium hydroxide. This project was carried out at Harare institute of technology. Experiments were done to determine the appropriate concentration that is required to purify phosphogypsum, UV spectroscopy was used to characterize the nanomaterial and a maximum absorption peak at 380nm was found. Pb test was used to test for the product and when 1g of CaO Nanoparticles was placed in a solution with a concentration of 0.01 Pb ions it was found that after filtration of the precipitate the residue was tested for the presence of Pb ions and the residue remained colourless instead of yellow which indicated the absence of Pb ions hence it was successful in removing them. The results obtained led to the design of a batch reactor. Process control and HAZOP were done on the designed equipment to ensure safe operations. A detailed economic feasibility of the project was done. The project has a payback period of 2.70years and a return on investment of 37.72% which are acceptable financial indicators. It was concluded that it is possible to design an economically viable and environmentally friendly CaO Nanoparticles manufacturing plant. Further optimization of the process to examine the use of other acids like sulphuric acid for the purification process and also testing of gases that are produced during the purification process. Alternative uses of phosphogypsum should be found to completely eradicate the problem that the company is facing. Purification process was done to remove impurities like Pb, F- and also MgO using 15% nitric acid.

KEYWORDS : *Phosphogypsum, Nanoparticles, UV Vis-Spectroscopy, HAZOP*

DESIGN OF A PROCESS THAT PRODUCE 5 TONNES PER DAY OF BIOMETHANE FROM CHICKEN DROPPINGS, COW DUNG AND WATER HYACINTH USING SILICA GEL.

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This research work has been performed to produce biogas form water hyacinth, cow dung chicken droppings in different proportions using the catalytic effect of silica gel. Biogas production was measured for a period of thirty days and volume of biogas produced was determined using the balloon method. The bio-digesters were immersed in a water bath at 37

oC to create mesophilic conditions. Digester F with proportions of cow dung, water hyacinth and chicken droppings in the ratio in the ratio of 2: :2:1 respectively produced largest volume of biogas of 520cm3 with silica gel. The biogas was analysed using the Orset gas analyser model VSC and the results were CH4 (70%), CO2 (12.40%), H2S (13.25%), CO (2.40%)and traces gases (1.95%). The results showed that silica gel improves the gas quality by absorbing carbon dioxide and increases the gas production by activating anaerobes present in organic matter. Mass and energy balances were carried out based on the experimental results and these were then used in the equipment design i.e bio- digestion reactor. Cascade control method was used to control temperature, flowrate and pressure of the bio-digestion reactor and instruments for the control process were also determined. The HAZOP analysis was carried out to ensure safety during the operation of the plant. The economic analysis was carried out to ensure the economic feasibility of the plant using profitability indicators such as return on investment (ROI), payback period (PP), break-even (BE) point analysis and rate of return (IRR) shows that the payback period of 3.1 years.

Keywords: *biogas production, bio-digester, orset gas analyser model VSC, water hyacinth, chicken droppings, cow dung, silica gel.*

DESIGN OF A PROCESS TO PRODUCE 924 TONNES/YEAR OF NANOSILICA REINFORCED CEMENT MATERIAL

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Waste non-returnable glass bottles accounts for 12% of non-biodegradable waste in Zimbabwe (EMA waste management plan; 2015). The average drinking bottles contain 60-80 wt.% silica and other components such as CaO (H. Mori, 2003). On the other hand, urbanization has led to increase in population resulting in increase in infrastructure development hence more construction is taking place. The intent of this project is to prevent environmental pollution and effect remediation by adding value to these non-returnable bottles. Experiments were carried out for the extraction of Silicon tetra hydroxide (Si (OH)4) and using it as a precursor in the making of nano Silica. Nano silica was synthesized by poly-condensation. Fourier transform infrared spectroscopy (FT-IR) characterization was done and the data supported the presence of hydrogen bonded silanol group and siloxane groups in Nano silica. Nano silica was added at a ratio of 0.6wt% of Ordinary Portland cement as a reinforcing material. Hardness tests were carried out to determine the effects of nano silica on the cement compressive strength. The results showed an increase in compressive strength by 9% compared to conventional Ordinary Portland Cement. Further design of the batch reactor to synthesize silicon tetra hydroxide was done. A HAZOP and control analysis was done on the piece of equipment to ensure safety. An economic analysis was done to determine the feasibility of the project financially. The project has a payback period of 2.8years and a return on investment of 36%. As a conclusion, it is feasible to

carry out the design project. Recommendations were also included for further research work to be done to improve the design work.

KEYWORDS: *Silica, non-returnable bottles, silicon tetra-hydroxide, poly-condensation, Ordinary Portland cement, nanosilica.*

DESIGN OF A PROCESS FOR PRODUCTION OF SOY BASED WOOD ADHESIVES FROM SOY MEAL

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Adhesive bonding of wood plays an increasing role in the forest products industry and is a key factor for efficiently utilizing timber and other lignocellulosic resources in Zimbabwe. The diverse and various forms of wood utilization highlight an abundance and diverse market for wood adhesives. Adhesives play a prominent role in a wide array of industrial fields including construction, aerospace, automobile manufacturing, packaging, wood products, and many more. Currently synthetic adhesives are widely used include petrochemical-based and formaldehyde-based adhesives such as, phenol formaldehyde resin and urea-formaldehyde resins in the preparation of wood composites. The purpose of this design and innovation project was to come up with an alternative way of producing wood adhesives from renewable raw material (soy meal). Soy flour is denatured in alkaline conditions so as to activate functional groups which aid in adhesive binding properties. However, despite the need to completely eradicate use of phenol and formaldehyde, denatured soy flour resin cannot meet all the standard adhesive properties. Soy meal/ phenol- formaldehyde matrix can meet the required standards. Experiments were carried out to determine the effect of addition of phenol and formaldehyde to a sample of denatured soy flour and a sample of only denatured soy flour resin was used as a control. Three samples were prepared, sample A which consisted of a denatured soy flour resin only, sample B which consisted of denatured soy flour and formaldehyde which acted as a stabilizer from further denaturation, and finally sample C, a resin which consisted of denatured soy flour, phenol and formaldehyde. From experimental results sample C showed the best adhesive properties with shear bond strength of 0.6133Kpa and solids percentage of 36.5%, comparatively to a sample A of denatured resin with shear bond strength of 0.2267Kpa and solids content of 30.2%. high solids content prevents adhesives from penetrating wood sample which results in high shear strength of adhesive, hence an important parameter. An economic assessment was done on the project to find out if it is economically feasible to produce wood adhesives from soy meal. A payback period of 2.6 and rate of investment of 38.5% were obtained.

Key words: *Defatted Soy Flour(DSF), Soy-Protein, Phenol, Formaldehyde, Resin*

DESIGN OF A PROCESS TO PRODUCE 20 000M^2 / DAY OF A NANO SILICA-SILVER COTTON COMPOSITE FABRIC.

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The following document details the production of a nano silica-silver cotton composite fabric by use of the solgel method using sodium silicate and silver nitrate as the base chemicals. For starters, the nano silica solgel was prepared by first creating the sodium silicate solution by dissolving 32g of NaOH and 24g of SiO2 in 120ml of distilled H2O while heating at 230oc. The solution was then made up to 300ml, and 300ml of 2.67M HCl was added dropwise to the solution while sonicating at 55oc. To synthesize the silver nanoparticles a 0.02M solution of sodium borohydride was prepared by dissolving 0.757g of the solid in 1L of distilled water in an ice bath whilst stirring continually for 20 minutes. Three solutions of silver nitrate were prepared each with concentration 0.015M, 0.01M and 0.005M. The 0.015M solution was prepared by dissolving 2.55g of solid silver nitrate in 1L of distilled water. The 0.01M and 0.005M solutions were prepared by diluting portions of the 0.015M solution accordingly. The three solutions of silver nitrate were characterized. For the treatment of the fabric with the solgel, the silica solgel was flocculated at 200 rpm for 30 min at 200 rpm. The nanosol slurry was then divided into four equal portions and placed in 1L beakers. The first portion was made up to 800 ml. To the other three portions, 250 ml of each solution of the silver nanoparticles was added and the balance made up with distilled water to make 800 ml solutions. These four solutions were then stirred in a flocculator for 1 hr at 200 rpm. Four of the 32 pieces of cotton were left untreated, four were placed into one tray, and the remaining three groups of eight were each placed in the remaining three trays. Into the tray containing four pieces of cotton, the pure nano silica gel solution was poured. The other three solutions were poured into each of the three trays consecutively. The cotton was left to undergo an impregnation process for 1 hr. After an hour, each piece of cotton was taken out of solution and rolled using the hand held roller on the rolling board. The four trays were washed and the four groups of treated fabric were placed back in the tray where they would wait to be cured in the oven. The oven trays were lined with the tin foil and one piece of untreated cloth, one piece of cloth from the nano silica solution and two pieces of cloth each from the three varying solutions of nano silica and nano silver were placed in the oven and cured at 80oc. This curing process was repeated with more fabric from each batch at 100oc, 120oc and 140oc. After curing the fabric pieces were placed in sample bags for testing and characterization.

Keywords: *ultrasonication, nano silver, nano silica, solgel, nanosol, curing, padder, reduction, characterization, UV Vis, FTIR, absorbance spectra, Lotus effect, hydrophobic, antimicrobial, synthesis, hydrolysis, alkaline, inhibition, E. coli, stain repellence, water repellence*

DESIGN AND IMPLEMENTATION OF AUTOMATIC IRRIGATION SYSTEM

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In agricultural field, use of proper system of irrigation plays an important role in providing enough production of food items. In the conventional irrigation system, the farmer has to keep watch on irrigation timetable for their gardens, which has different water needs for different crops at different times. This work makes the irrigation system automated. With the use of affordable and user friendly soil moisture sensor and humidity/temperature sensors and the simple circuitry this work aims for efficient and user friendly system, which can use by any farmer. This work is best suit for places where water is scarce and has to be used in limited quantity. Also, the third world countries can afford this simple and low cost solution for irrigation and obtain good yield on crops. A PIC microcontroller is to be used in this project and a 16×2 LCD is connected to the microcontroller, which displays the soil moistures level, the temperature and humidity level in the soil and switches are provided to set the limits of moisture for switching the individual solenoid valves controlling the water flow to the field. The humidity and temperature levels are transmitted at regular time interval to the LCD through a serial port for data display and analysis. The Yl-69 Moisture sensor and DHT11 Humidity and temperature sensor are used for better accurate readings. The aim is to use the readily available and low cost and modern sensors for. Relays are controlled by the microcontroller through a BC548 transistor provided for controlling solenoid valves, which controls the flow of water to different parts of the field. Other relay is used to shut-off the main motor which is used to pump the water to the field. Performance of sensors in terms of energy consumption has also been analyzed.

***Keywords**: humidity, irrigation, microcontroller, sensor, temperature.*

VITAL PARAMETER TESTS FOR HEALTH PROFESSIONALS

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Vital parameter tests system uses a PIC16F877A microcontroller to monitor the temperature and pulse rates of outpatients in real time. The prototype sensors easy pulse sensor and LM35 were the ones which were used to monitor the heart rate and temperature respectively. The parameters measured (temperature and pulse rate) were displayed on a Liquid Crystal Display (LCD) and logged to the patient's android phone through a Bluetooth interface. The measured parameters are sent to the Bluetooth module using serial communication thus UART. In cases of the measured parameters being out the threshold value range, a message displayed on a LCD and the message was sent to the professionals with the use of an MIT APP inventor software operation. The system requires low power about 5V.

***Keywords**: Bluetooth, heart-rate, serial communication, temperature.*

REMOTE CONTROL OF ELECTRICAL DEVICES USING DUAL TONE MULTI FREQUENCY TECHNOLOGY

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The aim of the project was to develop a remote control system for appliances based on Dual Tone Multi Frequency (DTMF) technology. The hardware comprised a set of components mounted on the PCB and a detachable mobile phone connected to the control system circuit. The key components were the MT8870 DTMF decoder, PIC16F877A microcontroller, L293D motor driver and relays. The DTMF decoder was used to detect and decode 16 specific frequencies assigned to the keys on the 4*4 keypad. This helped to identify a key pressed on the system

connected mobile or on the mobile calling the system mobile. The microcontroller polled the output of the DTMF decoder and performed appropriate control operations according to user input and the programmed control software. The L293D motor driver was used to drive a fan representing appliances requiring pulse width modulation, while basic LEDs were used to demonstrate switching control. A 240V to 12V * 2 transformer stepped down the socket voltage which was rectified and regulated to get a 5V power supply for the microcontroller, DTMF decoder and motor driver. The circuit was designed and simulated using Proteus Design Suite version 8.5. The MikroC Integrated Development Environment was used to write the microcontroller software in the C language.

***Keywords**: appliances, Dual Tone Multi Frequency*, *modulation, voltage.*

DESIGN AND CONSTRUCTION OF A MODERN STORAGE GRAIN CONTROL FACILITY

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A modern grain storage facility was designed and developed in this project. The prolonged existence of grains in storage is highly sensitive to the moisture content present, as well as the temperature present in the storage facility. As a result, these two parameters were chosen as the two critical parameters to be measured and controlled in the project. The system was designed with a provision to allow the farmer to monitor the critical parameters outlined above, and the system automatically controls the parameters if they are seen to be out of range. An application was designed using the C programming language. The Mikro C compiler software was used to develop the program code which allowed the microcontroller to display the critical parameters via an LCD screen, as well as to set the values beyond which the control mechanism (a 5V DC fan) will be activated. The program code was loaded into the PIC 16F877A microcontroller, thus, allowing it to interpret the incoming analogue data from the Temperature and Humidity sensor. In addition to the temperature and humidity sensors, a load cell was used to measure the mass of

the grain present in the facility, which would allow the farmer to determine the quality of his seeds in storage.

***Keywords**: facility, control, humidity, temperature.*

POWER CONTROLLING SYSTEM FOR SINGLE PHASE SUPPLY

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The ability to monitor the kilowatt hour usage of an appliance is crucial for knowing the energy consumption of the device and its electricity bill. In this project, studies have been conducted in making a power controlling device for single phase supply. It consists of ACS712-30A current sensor, voltage measurement circuit and Global System for Mobile communication interfaced with PIC18F45k22. The microcontroller reads the values of the current and voltage from the load converts them into a digital value and calculate the kilowatt hour and the result are displayed on a liquid crystal display LCD. The user is notified using short message service when the kilowatt hour is above a certain value and simultaneously switches the load off. More so the load was being controlled by a short message service to allow offsite functions. It measured both ac and dc loads including resistive and inductive.

***Keywords**: consumption, global messaging service, measurement, short message services.*

REVERSE PARKING OBSTACLE POSITION DETECTION

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This is a prototype of a system that detects the position of an object relative to a reversing vehicle. There is a PIC18f542 microcontroller used to give the commands of distance measurements which are then displayed on the graphical LCD. Three cost effective ultrasonic sensors are used to represent ultrasonic sensors that are placed at three positions at the back of the vehicle. One of which is placed on to the left back while the other is at the center and the third one at the right. The one at the center is placed on the stepper motor, rotating at an angle of 90o from the object position detection of another ultrasonic sensor to another. Any object within that premises is detected and its position is recognized relative to the vehicle. The project was done using Mikro C programming language and the simulation was done on Proteus. All worked well. When the reverse gear is engaged, the three ultrasonic sensors are then switched on simultaneously. From that time there is continuous detection of obstacles from the rear. The Graphical LCD displays the object while the car is in reverse thus minimizing the chance of crashing into them. When an object is at hundred centimeters from the vehicle, three LEDs are switched on all at the same time. When the driver continues to reverse to up to fifty centimeters, then there is the switching on of the buzzer and it begins to sound warning the driver of the impending danger of a crush at the back.

***Keywords**: commands, detection, distance, ultrasonic*

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DESIGN OF AN AFFORDABLE MICROCONTROLLER BASED PATHFINDER FOR THE BLIND

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Vision is one of the most importance process of the physiology. This project mainly focused on aiding the blind and the visually impaired during their navigation from point one to point two. The other key objective of this project was to make a device that is affordable to my Zimbabwean

market. The system is mainly made up of three HC-SR04 ultrasonic sensors interfaced with a PIC16877A for detecting obstacles the other significant components building the system are vibration motor buzzer that are controlled by the PIC16F77A microcontroller based on the input data/information from the HC-SR04 ultrasonic sensors. The system is powered by a rechargeable battery or a power bank that is capable of delivering a voltage of 5V.

***Keywords**: impaired, obstacles, rechargeable, ultrasonic, vision.*

MICRONTROLLER BASED GREENHOUSE MONITORING AND CONTROL SYSTEM

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For increased yield, farmers have now resorted to greenhouses which have adjustable parameters necessary for growth such that every hour of the day the plants keep receiving the constant amount of all the climatic parameters thus there is maximum production disregarding the time and climatically changes. A microcontroller based greenhouse monitoring and control system was developed in this project. An interface was created between the DHT11 (humidity and temperature sensor), the moisture sensor (FC-28) and a PIC16F877A such that the data from the environment is continually captured. A mikroC program was created which was able to process the data received from the sensors and the captured data was sent to an LCD. A control mechanism was put in place for when the parameters (temperature, moisture, humidity) exceeds a set threshold so as to maintain some constant environmental condition. The mikroC program created is able to initialise control mechanisms for the inappropriate environmental conditions, a heater to raise the temperature in the greenhouse and a fan to increase wind circulation when the humidity gets too high and when the temperature exceeds the required amounts to cool the temperature. The fan and heater are hard-wired to the microcontroller via the relay circuits and each powered using a 5V supply.

***Keywords**: environmental, control, greenhouse, parameters.*

IOT BASED MPPT CHARGE CONTROLLER WITH REMOTE LOAD MONITORING

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In Zimbabwe one of the major concerns in the power sector is the day-to-day increasing power demand but there is unavailability of adequate resources to meet the power demand using our conventional energy sources. Demand has increased for renewable sources of energy to be utilized along with conventional systems to meet the energy demand. This project document outlines the design technique and implementation of a stand-alone off-the-grid photovoltaic (PV) system that utilizes maximum power point tracking (MPPT) to obtain maximum adaptable efficiency, the system encompasses a charge controller, an area that has been identified to supply up to 30% gain in efficiency. Due to the inherent losses that occur in photovoltaic systems, it is essential that maximum power is extracted. The charge controller will comprise of a Beaglebone Black microprocessor, numerous sensors (namely voltage, current, temperature, and irradiance), 20x4 LCD screen, and MPPT buck-boost circuitry. Sunlight incident on the solar panel will cause generation of electricity via the photoelectric effect, this unregulated power will be fed into the charge controller, the MPPT algorithms and battery charging algorithms in the microprocessor will ensure a regulated voltage and current is delivered to the battery. The LCD will provide the vitals of the system through display on site. The project provides remote load monitoring were the user logs in to the systems website, were all the vitals are displayed and there are control buttons to switch on and off the load connected to the system. The IoT based MPPT charge controller with remote load monitoring can be used at different sites for example industrial setups, homesteads, offices and farms etc.

Keywords*: algorithms, load monitoring, maximum power point tracking, renewable unregulated.*

RFID BASED SYSTEM FOR DESTINATION NOTIFICATION

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The increase in business commitments and activities worldwide is making travelling by train to be one of the busy activities. One of the activities is tourism where tourists travelling always forget their destinations or may not be even aware of where they are going. This may cause some inconveniences. Therefore, in order to solve this kind of problem, an RFID based system was developed for destination notification. The prototype used an RFID (MFRC522) tags and readers, a serial communication protocol (UART/ SPI) and an FPGA. A VHDL program was written for an LCD to display information on destinations. A UART communication protocol was used as a communication interface between Altera DE2 board and RFID reader. Tags or cards were placed on each station and each tag with a unique identification number used to identify each station. When the train reached a certain station, the reader would hover over the tag or card. The reader sends a signal to the FPGA on the number contained in the card corresponding to that particular station. The FPGA execute the information with respect to what has been predefined in the VHDL program. The name of the station is displayed on the screen inside the train. This system can replace the current system in Zimbabwe where people board a train with the knowledge of where they are going. The system is a disadvantage to passengers who are unfamiliar with certain places.

Keywords*: communication protocol, FPGA, notification, RFID.*

SMART VEHICLE PARKING SYSTEM

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Due to the proliferation in the number of vehicles on the road, traffic problems are bound to exist. This is due to the fact that the current transportation infrastructure and car park facility developed are unable to cope with the influx of vehicles on the road. The smart parking system has been designed to solve the aforementioned problem. The Smart Vehicle Parking System is an RFID based system which interfaces RFID tags and reader. The RFID cards were used as a form of authentication whenever a vehicle is entering the parking area. The main purpose of the system was to minimize the congestion of traffic that usually happens when cars want to use a parking area. IR obstacle detection sensors were used to sense if a car has entered the parking area giving the current status of the parking bay. In addition, different LEDs were also used to give the status of the parking lots depending on their colours. All these components were connected to a PIC16F877A microcontroller that is the processer of then system. The system assigns and directs a vehicle to the optimal parking space through the use of IR sensors and LEDs.
Keywords: *detection, parking, RFID, traffic.*

SMART SHOPPING TROLLEY

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The design and implementation of the Smart Shopping Trolley is a model that is able to perform arithmetic operation, addition and subtraction of prices. The items are scanned by use of RFID tags and the prices are fetched from the database in the computer via Bluetooth (HC 05). Each item will have a tag with corresponding price that is added to the total and displayed on the LCD. If an item is to be deducted a subtraction button is pressed and item is scanned again and the total is displayed on the LCD after deduction. The database of the items in the retail shop and their corresponding prices was developed using C#. This smart trolley system help reduce customer's burdens of estimating prices in the retail shop and also long queues

***Keywords**: Bluetooth, database, subtraction, trolley.*

LIQUEFIED PETROLEUM GAS LEVEL IN AN ENVIRONMENT MONITORING SYSTEM

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The country's usage of Liquefied Petroleum Gas (LPG) has been growing over the years with 2017 LPG imports in the first eight months of the year almost surpassing last year's full figures. According to statistics provided by Zimbabwe Energy Regulatory Authority (ZERA) the amount of imported LPG has grown to 24,97 million in 2016 from 6,6 million kilograms in 2012. The liquefied petroleum gas monitoring system was implemented to find application in all the places where a hazard due to leakage of this gas can arise. This project used an MQ- 6 analog gas sensor to continually monitor the levels of gas in an environment. The level of gas was displayed on graphical LCD as percentage and when the gas levels rise to dangerous levels, an audio-visual alarm was triggered and an SMS was sent to specified users alerting them. The PIC16f877a was used as the processing unit and the GSM SIM900 was used to send the text message a buzzer and LEDs were also employed to alert people. The display unit used in this project is a 128*64 graphical LCD this provided a clear and visible status of the gas level which anyone can notice while working and take action to cut off the gas supply. Furthermore, a suction fan was employed to suck the air out and blow in fresh air.

***Keywords**: monitoring, level, alerting, LPG,*

RFID BASED ATTENDANCE LOGGING SYSTEM

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The project is an attendance logging system for students that is based on RFID technology. Radio frequency identification (RFID) is matured technology that uses radio waves to transmit data from an electronic tag that is attached to an object through a reader for identification. This technology allows automatic recording of attendance. This is done by embedding an RFID tag on student ID cards. These tags when swiped record attendance and the time of attendance as well. Data loggers which record the attendance and time to a host computer and database is achieved through serial communication using a USB to TTL cable. The information used for the identification of students is stored in a database created with the names and other essential information on the student. This database enables us to store the attendance register for all the students every time they log in for a lecture. A microcontroller, being flexible and a reliable device, is employed to develop an electronic instrumentation to measure the parameters and acts as a central unit of the system. It receives signals and data from the RFID module and enables the serial communication to allow the data to move into the database for identification and storage. It provides the major link between the module and the host computer. The system requires low power of 5v and this can be supplied by the cable from the host computer as it receives and sends data. Since our system requires a computer all the time there is no reason for an external power supply and the voltage from the USB to TTL cable is sufficient.

Keywords*: attendance, communication, database, identification logging.*

DESIGN AND DEVELOPMENT OF A HEAD GESTURE BASED WIRELESS CONTROL OF ELECTRICAL DEVICES.

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A head based sensor system for controlling external AC circuits was developed. In this project there was use of a PIC16F877 in line with a tilt sensor, the ADXL 335. The tilt sensor detected 3 dimensional coordinates, that is, (x, y, and z planes). However, the X and Y planes were the main focus of this project as it only assumed and noted motion in the two mentioned planes. A mikroC

program that described the operation of the system from the detection of coordinates by the accelerometer to the wireless sending of the signal to the relay-transistor circuit and then it was downloaded into the PIC16F877. An external relay-transistor circuit was developed which then switched ON and OFF the external AC devices when there was a designated signal sent to the transistors from the microcontroller. An I2C communication protocol was used to interface the accelerometer and the microcontroller. Four devices where controlled in this project, and a single direction was used to turn on and off a device inter-changeably. An adjustable frame that would hold the helmet was also designed and had it produced. The frame holds the helmet or the hat that has the tilt sensor attached to it. A 433Hz RF module was used to provide a wireless platform for the microcontrollers to communicate on.

Keywords: *accelerometer, communication, coordinates, devices, wireless.*

DESIGN OF A COLLISION WARNING SYSTEM WITH AN AUTOMATIC BRAKING SYSTEM FOR HEAVY VEHICLES IN THE MINING INDUSTRY

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Many accidents occur in mines due to inadequate reaction time of drivers and absence of warning systems in case of the presence of a collision. Accidents also occur due ignorance of drivers in the case where a warning system is present. A microcontroller based collision warning and automatic braking system was developed for heavy vehicles in the mining industry such as excavators. The system was meant to prevent accidents due to absence of collision warning systems and automatic breaking systems in these vehicles. A prototype was used for representation of the heavy vehicle and testing of the system. The collision warning was achieved by means of an LED which emitted light when the distance between the two vehicles was less than two meters. This warning was meant to give the driver a chance to apply brakes before the automatic breaking system would take over control of the vehicle. Measurement of the distance between the two vehicles was done through the use of an ultrasonic sensor module and the distance was then displayed on an LCD. Automatic breaking of the vehicle was achieved through control of the speed of rotation of the wheels connected to DC motors. Control of the speed of

rotation of the DC motors was done through the use of Pulse Width Modulation technique. The DC motors were interfaced to the PIC microcontroller through the L293D IC motor driver. It provided a balance between the current needed by the PIC microcontroller and the DC motors since connecting the DC motors directly to the PIC microcontroller would damage the microcontroller. The automatic braking system was initiated when the distance between the two vehicles was one and a half meters. The prototype stopped after a few minutes before collision occurred and thus collision was prevented. The system was designed for vehicles moving at a speed less than 10km/hr. in order to achieve a minimum breaking distance needed for the effective use of the system and was also meant to prevent front end collision between vehicles in the mines.

***Keywords**: accident, automatic, braking, collision, modulation, motors,*

AUTOMATIC ELECTRIC GEYSER CONTROL UNIT

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In this project, an electronic device that automatically monitors and regulates the heating and usage of water in an electric geyser was created. A PIC16F877A microcontroller was interfaced with level switches and a temperature sensor in order to obtain parameter data from the geyser for processing. Actuators – heating element and solenoid valve - were also interfaced to the microcontroller through relays to control water input and heating based on parameter data. This was in an effort to reduce the power consumption of electric geysers, which accounts for about 40% of domestic power consumption.

***Keywords**: heating, processing, power consumption, temperature,*

AUTOMATIC BOTTLE FILLING SYSTEM

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The aim of this project was to design and implement an automatic bottle filling system. A laser module and a LDR module where used to detect the presence of a bottle. When no light was detected by the LDR, its resistance would increase, resulting in a low voltage signal being transmitted to the microcontroller. The internal ADC module of the microcontroller converted the analog signal to digital form. This data was processed by the microcontroller and used to open the solenoid valve. To ensure that all the bottles received an equal amount of water, the flow rate of the solenoid valve was determined, and then manipulated so as to decide for how long the valve would remain open. A 12V power supply was used to power the solenoid valve, the other components required 5V power supply. The electronic circuit was designed and simulated on Proteus 8 Professional whereas the program was build using mikroC PRO for PIC.

***Keywords**: automatic, filling, bottle, resistance. .*

ALCOHOL FERMENTATION MONITORING SYSTEM

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This paper presents a real-time fermentation monitoring system, which continuously measures the fermentation parameters in different alcohol fermentation tanks and displays them on the pc. The system comprises of a series of sensors for the measurement of density, PH and temperature throughout the process of fermentation. The sensors used in this project include sen-0161 for measuring ph, ds18b20 for measuring temperature and a load-cell to determine the density of the alcohol which is used in the calculation of alcohol concentration. The measured parameters are sent to the pc using serial communication. This was achieved using an RS 232 module and a max 232 for voltage level conversion .On the display the alcohol concentration, temperature and PH of the alcohol are continuously displayed .The system also provides the

control of flow of alcohol from one tank to another through the use of solenoid valves and a pump, which are controlled using buttons on the windows form.

***Keywords**: alcohol, communication, fermentation, measure.*

AUTOMATED WATER LEVEL CONTROL AND pH MONITORING SYSTEM

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The aim of the project was to design and implement an automated water level control and pH monitoring system. HC-SR04 ultrasonic sensor and SN0110 pH sensor were the two sensors used. SN0110 pH sensor was used to determine the quality if the water and if the set threshold were surpassed, the solenoid valve will be closed so that water would not be allowed to the next stage. The buzzer would be ON to notify the responsible personnel so as to decide on the action to be done on the pump or the valve via Bluetooth module. The ultrasonic sensor would determine the level of water in a storage tank and the data was manipulated in the microcontroller so as to determine the action to be done to the pump. When the maximum set threshold was reached the pump will be OFF and on minimum set threshold it would be triggered to be ON so as to reduce spills or under storage. 12V power supply was used to power the pump and the solenoid valve. 5V was used to power the microcontroller. The electronic circuit was designed using Proteus 8.5 Professional version and the code was developed using MikroC PRO for Pic

.

***Keywords**: Bluetooth, level, microcontroller, threshold.*

ANDROID APPLICATION BASED BLUETOOTH HOIST REMOTE CONTROL

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The everyday use of the hoist (overhead crane) which is controlled by a cabled controller gave the operator very little clearance from the loaded hoist during transit exposing them to a fatal risk of being crushed by tones of load in the event of a cable snap. The cabled controller also meant that the operator follows behind the hoist every time it is in transit which was a tiresome thing to do repeatedly. An Android application based remote controller for a hoist also known as an overhead crane via Bluetooth serial communication protocol was developed. The system was sustained by the computation power of the PIC16F877A microcontroller. A Bluetooth module, HC-05 configured in the slave mode was the portal of data reception from the master, an Android version 5.1.12 or advanced enabled mobile device. An android remote controller application was used to communicate directional commands to the hoist. Upon receiving the command, the brain of the system computed the commands and configured respective output ports to the desired configuration. A series of relays each for every direction was connected to the selected output ports and it switched on the motor that was responsible for that particular direction. The system had an activate button to protect it from interference from other Bluetooth devices in the proximity meaning that without activation the system does not receive commands.

***Keywords**: android, Bluetooth, communication, motor, remote.*

CABLE FAULT LOCATOR USING PIC16F877A

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Transmission companies are now resorting to underground cables for power transmission. They are not affected by transverse weather conditions which is their major advantage. When a fault occurs it is difficult to locate it as digging is involved which is expensive and time consuming. In mind of this this has led to the development of this system, a cable fault locator. This is a project

that uses a Pic16F877A microcontroller to locate the position of a fault in a hidden electrical cable. It uses analog to digital conversion to find the voltage in a microcontroller and then taking the analog step values it converts them using an algorithm into distance in Kilometers. The system has got a three phase system and the results obtained are displayed on an LCD. The system uses an array of relays that serve the purpose of isolating the microcontroller to avoid over voltage and also to enable multiplication of current. A voltage is sent in the normally open part of the microcontroller and the voltage line (simulating the transmission cable) is tapped at different positions for distance approximation. These tapped outlets are connected to a microcontroller and this is where the ADC levels are read and the conversion into distance is thus done using the microcontroller. The system is an online system which is pre-installed with the hidden cables and at when a fault occurs, a switch is used to put it on. The system is fast and takes close to four seconds to display the approximated distance on the LCD.

Keywords*: current, distance phase, voltage, online, isolating, transmission.*

BLUETOOTH BASED AUTOMATIC WEATHER MONITORING SYSTEM

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The design and implementation of weather monitoring system is the model with the ability to perform data acquisition on temperature, humidity and pressure and it can give these sensors data to ADC port of Pic16F877A microcontroller. The aim of the project was to provide a system that automatically monitors weather, displaying the accurate readings of temperature, humidity and pressure on a 16*2 LCD and send the values to the control room via a wireless communication using Bluetooth module. The project aimed at providing faster and real time information of weather without the operator checking the measurements continuously i.e the system requires minimum human intervention. The prototype of this project was based on cheap and simple electronic components which include a microcontroller (PIC 16F877A), temperature and humidity sensor (dht11), 16*2 LCD, HC-05 Bluetooth module. The system is divided into two main parts: transmitter and receiver section. Transmitter section mainly consist of the sensor circuit, microcontroller unit, and the Bluetooth module. The sensor circuit contains the temperature sensor, pressure and relative humidity sensor. The receiver section consist of the

display unit and the PC (personal computer). The measured parameters will be displayed on an LCD display. A C# application then provides the GUI (Graphical User Interface), which enables the operator to observe the weather in real time.

***Keywords**: Bluetooth, communication, data acquisition, temperature.*

AUTOMATED MONITORING AND CONTROL OF GREENHOUSE CONDITIONS BASED ON PRECISION AGRICULTURE TECHNIQUES

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This paper presents an automated monitoring and control of greenhouse conditions based on precision agriculture techniques using technology that allows data measurements at a distance using sensors and data loggers which record data over time to a base station (host computer) that is achieved through serial communication using RS232 module. A microcontroller, being flexible and reliable device, is employed to develop an electronic instrumentation to measure the parameters and acts as a central unit of the system, driving actuators based on input from an array of sensors. Soil moisture sensors, temperature sensors and humidity sensors deployed throughout the greenhouse obtain data and this serves as the basis for regulation of the internal environment in the greenhouse after comparison with a set of desirable value thresholds in the microcontroller. This information is used to automatically control the motion of cooling fans and sprinkler On and Off in real time depending on the result with reference to preset values of the parameters until the recommended ranges are reached this data is also displayed in a real-time on an LCD that is installed in a safe location in the greenhouse .the system makes use of a dht11, MH flying fish sensors. The dht11 sensor is a sensor that records both temperature and humidity of the greenhouse and a flying fish sensor is a moisture sensor. The system also controls the air circulation through the fan system. For data monitoring purposes, the obtained values are sent to a PC in a separate monitoring room using an RS232 connection cable, so as to limit any need to physically attend to the system inside the greenhouse, as this could upset the enclosed ecosystem.

***Keywords**: actuator, ecosystem, greenhouse, location, regulation.*

EMBEDDED SOLAR POWERED SIREN SYSTEM FOR - GRID LOCATED SCHOOLS

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Nowadays, managing resources and time plays an important role in our daily life, so the need for an embedded solar powered siren system for off-grid located schools is now a necessity which has been evolved with the revolution in technology and boost in the education system where electricity limitation and time is a major factor affecting the educational system where the time has to be accurate. The advancement in automation and solar power technology is employed in this system. This designed system finds a tremendous use in off-grid located schools, primary and secondary school levels as well as in colleges where the teaching sections can span over eight periods including breaks. The advantage of this design is that the system is solar powered and the embedded siren rings at the start of each period without any human intervention to a great degree of accuracy and hence its takes over the manual task of switching on/off the siren system with respect to time. The system is solar powered, it uses Real Time Clock (DS1307) which track the real time**.** All the Siren timings and durations are predefined and set in the microcontroller. The user can set the timings using a keypad and the siren ringing time can be edited at any time, so that it can be reused again and again at normal class timings as well as at exam times. A LCD display is used to display the timings. The timings set by the user are stored in the microcontroller. When this programmed time equals the real time then the buzzer is switched ON via Relay for predetermined time. The relay is used as a switch to operate the siren. As soon as the duration is over, the signal is stopped and waiting for the next set time. This system is going to be mainly uses in off-grid Schools, Colleges and other companies where siren system is implemented. There is no need of a person managing the siren timings. The microcontroller program is written in MikroC programming Language.

***Keywords**: automation, electricity, off-grid, solar, timing.*

POWER GRID SYNCRONISATION FAILURE DETECTION BASED ON VOLTAGE AND FREQUENCY VARIANCE

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In modern power system, electrical energy from the generating station is delivered to the ultimate consumers through a huge network of transmission and distribution. There are several power generation units connected to the grid such as hydro, thermal, solar, wind etc., to supply power to the load. Thus, for satisfactory operation of loads, it is desirable that consumers are supplied with substantially constant voltage and frequency. In this paper I present the development of a system to detect the synchronization failure of any external supply source to the power grid on sensing the abnormalities in frequency and voltage. For feasible transmission, the frequency and voltage of the AC supply should be within the limits as decided by the grid, depending upon the demand of the power supply. As per ZERA Regulations in Zimbabwe, variation of the system voltage should be of +- 10 % and that for frequency is +-2.5% close to 50 Hz and shall not allow it to go beyond the range 49.2 to 50.3 Hz or a narrower frequency band specified in the Grid Code, except during the transient period following tripping. In case these limits are exceeded and the demand for power is more than the demand for supply, it results in grid failure. In such situations, the feeder unit is completely disconnected from the grid, causing islanding situation. Thus synchronization is needed between the grid and the feeder unit, so as to prevent the large scale brown out or black out of the grid power. In this paper, I am presenting a system which can warn the grid in advance so that alternate arrangements are kept on standby to avoid complete grid failure.

Keywords*: consumers, distribution, feeder, frequency transmission, synchronization.*

MICROCONTROLLER BASED LOAD ISOLATOR AND LOAD MONITORING

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The purpose of this project is to develop microcontroller based load isolator and load monitoring was developed in this project. It utilizes the Bluetooth technology, power line communication and GSM technology in order to control, isolate and monitor load status. A graphical user interface and mobile application was developed and are used to control and monitor the loads. An application was developed using Processing software. The application communicates with the Bluetooth module (HC-06). This device (HC-06) is interfaced to a PIC16F877A microcontroller and communicates with it serially through the UART port. The microcontroller sends the received data from the Bluetooth to power line module that sends the data using the existing power line. At data reception the data that was sent is received and the microcontroller will control the loads depending with instruction sent. The loads where switched on and off using a mobile phone and a graphical user interface phone using the power line carriers. A GSM was used to give status of the loads and also gives sends message if there is an error with the circuit, or if the load trips

***Keywords**: Bluetooth, communication, power, GSM, interface, load.*

MICROCONTROLLER BASED HOME SECURITY SYSTEM WITH GSM

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In this research a microcontroller based home security system with GSM notification was developed successfully. The system developed in this project has the ability to drive out iron bars from the ground when an intruder has been noted by the system's sensors to give extra security to the property and scare away the intruder. There is also the feature of notifying the owner of the security status around his or her property via GSM. The owner will not arm the system if any of

the sensors is in violation state. What this means is that the owner is forced to check if all doors and windows are closed before arming the system. The owner will also have the assurance that they are secure, since the system will give information about any violation.

***Keywords**: alarm, GSM, intruder, security, sensor.*

DESIGN AND DEVELOPMENT OF AN RFID BASED INVENTORY MANAGEMENT SYSTEM USING PIC16F877A

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The conventional methods of tracking and monitoring the movement of stocks and inventory using the Barcode system has over the years become unpopular. Barcodes have many limitations such as the amount of information they can carry which is very little and they also need line of sight for communication with the barcode reader. Advancement of technology in Radio Frequency Identification (RFID) has seen many organizations in the industrial manufacturing, warehouse, plant production and supply chain sector adopt this technology, giving it preference over the Barcode. Most Products and other pieces of inventory are now packaged and distributed with an RFID tag and not the Barcode. This document presents an RFID based Inventory Management System that was developed for tracking the movement of stock inventory in a warehouse or production plant. The Inventory Management System used the PIC16F877A Microcontroller for interfacing the RFID Reader and transmitting the events to the Database via the ESP8266 WiFi module. When inventory was removed from storage, the RFID transponder attached to it was read by the RFID reader. This data was then sent to the Database via the ESP8266 WiFi module through serial communication. A microcontroller program was written in C language on the MikroC IDE for the operation of the designed system. A power supply unit was designed to supply 5 Volts to the PIC16F877A microcontroller, LCD and RFID reader. The LM317 Adjustable Voltage Regulator was also incorporated into the power supply. The purpose of this LM317 regulator was to produce 3.3Volts supply for the ESP8266 module The RMD630 RFID reader was chosen because of their read range of 10cm. The RMD 630 RFID readers use the

UART only and they are not I2C or SPI capable. A multiplexer was used therefore to interface the RFID Reader, ESP8266 via UART to the PIC16F877A Microcontroller.

***Keywords**: barcode, database, inventory, regulator, tracking voltage.*

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DENSITY BASED TRAFFIC LIGHTS

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Traffic lights are designed to control traffic at the intersections. They ensure safe and efficient movement and passage of traffic especially in central business districts (CBDs) without congestions. They are also meant to ensure safe pedestrian crossings because of high volume of traffic in CBDs. It is difficult for motorists to effectively communicate on their own hence the employment of traffic lights. The currently employed traffic lights were pre-programmed to give precedence to other streets, or they just give equal flow time to the streets they manage. These systems are now failing to control the intersection they manage due to the increased number of traffic in the CBDs. Of late they were designed based on the assumption that only a limited number of vehicles will be found in CBDs, but due to the increased rural urban migration the number of vehicle owners has been on the increase in the main cities of the country, and the traffic lights were not designed to manage those high traffic volumes. This is the reason why you find traffic officers controlling traffic on the city intersections even if the traffic lights are functional.

***Keywords**: traffic lights, central business district, congestion, intersection, vehicles.*

AN AUTOMATIC CHANGE OVER SYSTEM

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An automatic change over system designed basically disconnects load from its main power source and transfers it to a standby power source in the case of power failure. This change occurs at very high switching speeds so that minimum change occasioned by the transfer process goes unnoticed. It also incorporates a system that uses the mains to charge the batteries in case of solar failure, if batteries reach large power dissipation. The system also has an effective battery monitoring mechanism that protects the battery from conditions that affects its life. This process is controlled by a microcontroller that keeps sensing the availability of power from the main power supply and also make decisions on whether to use solar or mains to charge the batteries. The sensed voltage on the input and output side is displayed on a 16 x 4 LCD module

Keywords: *automatic, batteries, changeover, charging, power, solar.*

MICROCONTROLLER BASED AUTOMATIC FIRE SUPPRESSION AND MONITORING USING THE DELUGE FIRE EXTINGUISHING SYSTEM

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In industries such as power plants or chemical plants fire management is essential due to very high operating temperatures and various factors like flammable chemical processing, different chemical reactions etc. For most hydrocarbon fires, it is necessary to have automatic foam/water sprinkler system for protection against industrial fires. The Deluge sprinkler system effectively offer protection from severe hazards due to industrial fire. In this paper, the designing of a PIC microcontroller based remote controlled deluge automatic fire sprinkler system is explained in

detail. The ability to identify and suppress fire may mean the difference between life and death and hence these deluge automatic sprinkler systems play very important role in fire risk management. This project deals with the design and construction of a microcontroller based automatic fire sprinkler system controller. It is aimed at minimizing fire risk at the loading terminal. It is actually a modification of the existing fire system. The existing system is highly mechanical and depends heavily on the thermo-sensitive glass. The microcontroller used in this project is a PIC 16F877. It is programmed to startup an alert system and control the deluge valve that deliver foam to the sprinklers in order to extinguish the fire which will have been detected by their flame detector at the loading bay.

***Keywords**: automatic, extinguish, fire sprinkler, thermosensitive.*

DESIGN AND DEVELOPMENT OF SOLAR TRACKING SYSTEM

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Fuel costs are increasing these days, increase concerns in climate change, and an ever-growing increase in demand for electricity, using renewable energy sources becomes necessary. Solar is one kind of such a renewable energy resource. There is need to harvest solar energy as much as possible. Solar tracking is controlled by pic16f877a that decides where there is greater light intensity and then the motor will move as instructed by the PIC. The circuit is a simple solar cell tracker, which help us to rotate solar panel to tracking the sun to get maximum power from solar panels.

***Keywords**: energy, fuel, renewable, solar, tracking.*

AUTOMATIC LIVESTOCK FEEDER (DRY)

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The project met the demand in production of healthy livestock as well as reducing time spend during feeding livestock of the operator/farmer. The existing systems that are normally used by SMEs are those of using circular containers that are topped with food manually by human beings if the food is finished .This was becoming a problem as a farmer may spend much time filling these containers as well as un equal positions of the diet of animals as mixing different animal feed was tiresome .This project uses electric motors as a source of kinetic energy for the system also specialized conveyors to move animal feed from one point to designated place .The project concept can be applied to any system that requires feeding of livestock or any animals kept by human beings .The system can be huge or small depending on what is being fed by the system e.g. the size that feeds pigs or cattle are completely different because of the rate of consumption of the animals is different .The technology that has been used by the project are load cell, DC geared motor and relays among others .

Keywords: *consumption, filling, production, kinetic energy, motors.*

A MICROCONTROLLER BASED BODY MASS INDEX CALCULATOR WITH GSM

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The aim of this project was to design and implement a Body Mass Index calculator with GSM. Load cells were used for weight measurement and an ultrasonic sensor was used for height measurement. The problem arose from the manual nature in which the BMI measuring process is

undertaken particularly in Zimbabwe. The process is too manual hence prone to multiple measurement errors resulting in wrong remedial action given because of wrong results. My project was to cater for those error moreover reducing BMI measurement time by measuring weight, height and computing the results and display the results and category simultaneously. Furthermore the system went an extra mile by asking the user to input their phone number, the results were then sent to the number with the BMI results

***Keywords**: computing, body mass index, measure, phone.*

GSM CONTROLLED AUTOMATIC IRRIGATION SYSTEM.

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This project presents the design and construction of a GSM controlled automatic irrigation system. This is a reliable system that takes over the task of automatic irrigation for horticultural crops all year round, in and out of season with less human intervention. The design of the project is mostly suitable for the current trending cost effective irrigation system called Drip irrigation whereby water is supplied to the roots of the plants. This system will be able to be controlled remotely thus to turn the irrigation pump on or off from a distance by a mobile phone and even automatically switching on or off the irrigation pump as a result of sensing some parameters such as soil moisture content and ground temperature enabling farmers to reduce operation costs, damaging of crops due to uncontrolled irrigation, hustle free operations and ultimately increase farm yields. The ground temperature is crucial to monitor since farming will be all year round and hence in other seasons such winter there is need to supply more water so that frost and other weather hazards doesn't damage our cash crops.

***Keywords**: automatic, costs, GSM, irrigation, pump.*

BLUETOOTH CONTROLLED HOME AUTOMATION SYSTEM

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This project is a successful design and implementation of a Bluetooth Controlled Home Automation System. The design of this system came into effect as a result of the need of humans requiring remote control of appliances in the home. The user or owner of the appliances who is in the Bluetooth range can switch on or off the appliances with just the click of a button without necessarily having to be physically present on the appliance or the appliance switches.

Keywords*: appliances, automation, Bluetooth, button, remote.*

ANDROID BASED SPEED AND DIRECTION CONTROL

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This paper presents an Android based speed and direction control project which was developed in order to vary the speed and direction of a DC motor .An android application was developed using MIT App inventor. The developed android application was installed in a smart android mobile phone which was then used to send a command to the PIC using Bluetooth technology with help of the HC-05 Bluetooth module whilst at the same time the android application displays the speed of the DC motor in revolutions per second. In this project DC motor speed and direction was controlled using PIC16F877A microcontroller. To achieve this PWM technique was used, with the use of PIC16F877A inbuilt CCP module. The L293D motor driver integrated circuit was used to interface the PIC16F877A microcontroller and the DC motor. The PIC16F877A has been programmed using the PWM library of MikroC PRO version 6.6.1 simulation software and the model was implemented on Proteus 8.6 design suit.

Keywords*: android, command, direction, pulse width modulation, motor, speed.*

AUTOMATIC INFANT INCUBATOR MONITORING AND CONTROLLING SYSTEM WITH GSM NOTIFICATION

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This project is focused on monitoring, controlling infant incubator temperature and humidity with gsm notification. Temperature and humidity are critical parameters to the survival of new born babies especially if they are sick, of low birth weight or pre-term (premature). The added functions of gsm notification when the baby's body temperature is above or below set temperature or when diaper is wet or soiled ensures added safety and comfort for the baby. The relatively lower cost and low power consumption of the system will ensure availability at most health institutions which in turn cater for people of diverse financial backgrounds and social classes hence help in the survival of infants.

***Keywords**: health, infant, power, notification, temperature.*

SYSTEM DYNAMICS APPROACH FOR ANALYSIS OF URBAN PUBLIC TRANSPORT TO DEPICT POSSIBLE CAUSES FOR THE FAILURE OF HOLDING BAYS

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Urbanization in the 21st century has led to increase in demand for public transport. The demand had been elevated mainly due to the withdrawal of buses from the system which was influenced by the liberalization and deregulation rules. These rules managed to speed up the growth of mini buses business. The mini buses have now reached a stage where they cannot all be accommodated by the available pick up and drop points. Although the government through the city council managed to construct the holding bay they proved to be fruitless since the it only operated in its hay days due to different which are going to addressed by this project. The focus of this project is on depicting the factors that led to the failure of the holding bay and to come up with suggestion to bring back the infrastructure to its full function again. A system dynamic model was developed to study the public transport behavior and the trend patterns of human behavior in terms of acquiring transport. Vensim Software Package was used to create and simulate the behavior of the holding bay system. Model was simulated, and results were analyzed to draw conclusions and reasons why holding bay system failed to ease the chaotic urban public transport in the CBD of Harare. The analysis of results showed that increasing the capacity of the public transport can reduce the demand of public transport. Introducing other communications methods alone is not able to increase the efficiency since communication is dependent to management policies. From the simulations it was proven that when siting the location of the holding bay the distance from the pickup and drop points should be taken into consideration. The current holding bay have failed the due to poor management policies, poor communication between the two points and other factors further explained in the document.

Keywords: *Urbanization, Public transport, Holding bays, Decongestion*

PREDICTIVE MODELS TO FORECAST POWER DEMAND IN ZIMBABWE USING ARTIFICIAL NEURAL NETWORKS

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Energy is a dynamic commodity in every nation to ensure economic growth hence care has to be taken to be taken for the nation to attain sustainable development. There is no accurate energy analysis and prediction tools or models for use by power utilities in Zimbabwe. There has been increase in energy consumption due to urbanisation and development in the agricultural sector. There is need for power utilities to have more accurate energy analysis tools such that power utilities in Zimbabwe does not lose out due to power shortages and generating or importing excessive energy. This project is focused on predicting short term power demand (1-7 days). This thesis will be using artificial neural networks for the modelling of the daily energy demand predictive model and the suggested model incorporates daily energy demand as the input data. The predictive model was simulated using matlab toolbox and the accuracy of the predicted power demand was measured using different accuracy measures (mean absolute percentage error and the root mean square error). The accuracy measures of the proposed model were compared to that being applied at a certain power utility in Zimbabwe. This project shows that the artificial neural network model presented superior performance with mean absolute percentage error of 4.146% for forecasting energy demand than the existing one applied at the power utilities which has a mean absolute percentage error of 13.624%.

Keywords: *Artificial neural network, Back-propagation, Mean absolute percentage error*

DESIGN OPTIMIZATION OF AN AUTOMATED MORTAR MIXING MACHINE

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This work design employs the optimization design of an automated mortar mixing machine. This was developed on the backdrop of the current challenges being faced in Zimbabwe of loss of mortar due to wrong estimations made by builders. Overestimation of the quantity of mortar required to perform a particular result in loss of mortar as it dries out due to chemical reactions, hence it cannot be stored once mixed. Improper measuring of mortar constitutes causes mortar to dry up quickly before the builders have time to use it due to the formation of a hard concrete which is unusable for building purposes. Manual methods of mixing mortar also cause diseases like dyspnea, asthma development, cough and upper respiratory symptoms. A literature review was conducted on all major areas pertaining this project. Data collection methods such as surveys, interviews, experiments, internet and library were used. . A code was developed which help the operator to calculate the quantity of mortar required either for plastering or brick laying. The mortar constitutes will be calculated, measured and mixed automatically by the machine with the user having only to input the length, width, height and thickness of area he/ she wants to work on.

Keywords: Mortar mixing, Mortar calculation

DESIGN OPTIMIZATION OF A MOTORISED POTATO SLICING MACHINE

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The use of manual labour in slicing of chips at Chicken Express Food Outlet is inefficient, dangerous and time consuming. Therefore the aim of the project is to design a motorised potato slicer. Upon examinations, it was clear that there was need for this design because more time was taken by the worker in slicing the potatoes. To achieve this, mechanical parts of the machine were designed. Literature was reviewed on different areas that would affect the design. Techniques created in order to manipulate the project include, observations, interviews, plant records and literature review. Data presentation in form of tables and graphs were done and the design which included possible solutions generation, calculations and prototyping were done as part of the methodology used. The design is expected to be effective, environmentally friendly and work fast in slicing. There will be reduced manual labor hours and improvement in safety.

Keywords: *Potato slicing, Motorised, Food outlets*

DESIGN OPTIMISATION OF SHRINK WRAPPER HEATING TUNNEL CONVEYOR SYSTEM AT CHIBUKU SUPER

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This project seeks to do a design improvement on Chitungwiza Chibuku super plant packaging production line by changing the current design of shrink wrapper tunnel conveyor system from the roller dependent system to a chain and sprockets driven system. The company every month loses an average of 8 hours (640 hectolitres) rectifying the problems of conveyor dragging and sideway catching. At least 2 hours are also lost waiting for the temperature to drop before actual work commence. The current design also involves many confined spaces and some machine

modules are underneath other components which lead to high downtimes in accessing those areas before even the actual work starts. This project is intended to reduce the average monthly downtimes from 8 hours to at most 1 hour through introduction of some retrofits to the machine including accessible conveyor tensioning system hence providing adequate maintenance working space. The conveyor with chains and driven by sprockets in order to arrest slipping and free sideways movement and a lubrication system is to be introduced. Automatic lubrication system is to be considered for other plant machinery use.

Keywords: *Shrink wrapping, Conveyor system*

Design of a wet pan gold ore mill

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The aim of this project is to design a wet pan mill usable by small scale gold miners in Zimbabwe and the developing world. The design will support the ZIMASSET mandate of beneficiation and value addition of our gold ore deposits. Zimbabwe has lost a great deal of gold due to poor crushing techniques which resulted in the gold not being fully harnessed. The purpose of the design optimization of the wet pan mill is to increase the efficiency and effectiveness of gold ore crushing for small to medium scale gold miners. The project will make use of research and testing of the project prototype to come up with an optimised design of the machine. No current crushing techniques equal the wet pan mill in terms of efficiency and effectiveness as the wheel is in constant contact with the base and the force induced on the wheel to the pan base where the ore must pass through is immense. An increase to the area of contact between the wheels and the pan base, increase in ore size that can be crushed and holding energy consumption constant or decreasing it are some of the areas of further improvement that can be looked into.

Keywords: *Crushing, Mill, Wheel, Pan, Gold ore*

Design of an urban storm drainage cleaning machine

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Sanitation is one of the major goals of any city council with regards to the mandate of the Environmental Management Agency. However this mandate has been disturbed by lack of cleanliness in the pavements during the rainy season as a result of the storm drain blockages. Blockages of storm drains lead to the occurrence of flash floods which have adverse social effects on the citizens through urging the outbreak of waterborne diseases and escalating the damage of various properties such as motor vehicles. The manual cleaning method that was being used by the city council workers was not proving to be efficient and effective, hence overlooking large particles of dirt such as plastics and organic material that would eventually block the drains. This research project aimed at designing an ergonomically motorized drainage cleaning machine that would assist the workmen efficiently and effectively perform the drainage cleaning operation. In order to achieve this, a frame was designed to support the power system and the driving mechanism of the chain coupled-sieve in an upward rotational motion as it scoops up litter from the runoff. Solid works was used to perform simulations of the impact forces that are associated with the supporting frame of the machine. The machine proved to be more efficient compared to the manual methods as much of the dirt in the storm drain was. The failure modes and effects analysis highlighted the ways in which the drainage cleaner might fail to perform its intended cleaning operation.

Keywords: *Manhole, Storm drains, Flash floods*

DESIGN OF A HOME MICROCONTROLLER TIMER BREAKER

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In Southern Africa most electrical companies are still using mechanical circuit breakers. The seeks project to design a socket micro-controller timer breaker working as a voltage detection fast tripping down device on returning of power during power outages and that also trip down on detection of an overcurrent. Conventional circuit breakers like miniature circuit breaker or a fuse is good at breaking the circuit when a short circuit fault occurs only. Modern appliances and electronic components are very complex, sensitive and could easily burn out if over-current occurs and if they are subjected to high voltages. The design of the step down mechanism, the design of automatic trip-down trip-up change over mechanism and the re-design of the voltage detection and current overload circuit were looked at in detail. The result was a home microcontroller timer breaker that will trip down automatically on detection voltage during power outages and during overloads and switch on automatically after 2 minutes. The design senses the current passing through a series element and the corresponding voltage drop is rectified to dc. With the use of a PIC microcontroller the voltage is converted into a digital value and compared against a pre-set value to generate an output that drives a relay to trip the load. The result is an extremely fast unit that overcomes the drawback of the conventional circuit breakers by automatically reclosing if it is a temporary electric fault or unexpected load shedding.

Keywords: *PIC Microcontroller, Overload, Over-current, Conventional circuit breakers, Trip-down trip-up change over mechanism.*

DESIGN AND FABRICATION OF A SHREDDING AND COMPACTING MACHINE

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The project was based on the design and fabrication of a shredding and compacting machine. The existing shredding machines and compacting machines are used as different workstations hence during the process of shredding the chips are just left flowing downwards and they have to be collected further and packed hence the shredding and compacting machine actually does all

that at the same time. The shredding mechanism, compacting mechanism, frame design and fabrication of the machine were done and the final result was a shredding and compacting machine. The Oshuga model was followed and also other methods of collecting data like use of E-books, observation and interviews were conducted to come up with new model of machine capable of improving landfill operation by saving space and generating more energy. The conceptual generation was done and the final design was chosen from the conceptual designs using concept scoring and the decisional matrix. The final prototype functioned as expected and it improved material handling during the process of shredding and packing.

Keywords: *Landfill, Hydraulics, Waste compactor, Shredder*

DAILY DIRECT NORMAL IRRADIATION PREDICTION USING REGRESSION METHODS AND ARTIFICIAL INTELLIGENCE

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The design and operation of solar thermal systems comes with a responsibility to predict and stabilise energy outputs in various range of applications. It has been proposed that there is need for a Direct Normal Irradiation (DNI), major energy source for solar thermal systems, predictive model which can forecast DNI at any given point in time, using meteorological data and surface data, with high degree of accuracy. This paper looked at two methods of predictive model construction; Artificial Neural Networks (ANNs) and Regression analysis. For the ANN model construction particular attention was given to the selection of input parameters, training and learning algorithms, transfer functions and number of hidden neurons. For the Regression model attention was focused on the selection of input parameters incorporating the P-value hypothesis to select parameters with the highest linear prediction strength. The results of the prediction models showed that the ANN model was able to estimate daily DNI with better accuracy than the Regression models evidenced by Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) of 0.210 kW/m^2/day and 1% respectively having; surface pressure, average and clear sky clearness index, relative humidity, maximum and minimum temperature

and dew/frost point temperature as input variables. The multivariate regression model performed relatively inferior with RMSE and MAPE of 2.238 kW/m^2/day and 1.8% respectively incorporating; clear sky insolation clearness index, atmospheric pressure, dew/frost point temperature, average specific humidity, maximum temperature and minimum temperature as predictor variables.

Keywords: *Artificial Neural Networks, Direct Normal Irradiation, Regression analysis, Solar thermal systems, Multivariate regression*

DESIGN OF A HEAVY VEHICLE MULTI - LEAF STEEL SPRING FITTING MACHINE

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Manual lifting of multi-leaf steel springs on heavy commercial buses and trucks, during spring replacement is causing continuous back aches on mechanics. The spring weighs an average of 120kg and there is confined working space on buses. The purpose of this project was to design a multi-leaf spring fitting machine that will assist a mechanic when fitting and removing of the leaf spring on buses. The researcher merged the electric lifting technique and the forklift lifting technique to come up with a design that is safe, light and easy to use. A prototype of the spring fitting machine was developed and taken to commercial bus workshop where it was tested to remove and fit multi leaf springs and the results were positive.

Keywords: *Multi-leaf, Spring, Lifting techniques*

DESIGN OF A COMMUNICATION CONTROL SYSTEM FOR AN EXCAVATOR.

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The hazardous environment in which heavy hydraulic machines are used poses serious health consequences to the operators as there are possibilities of the machinery toppling over or sinking in quick sands. Manual operation of land excavators has high risks of operator injuries and also poses serious health threatening conditions of operations, therefore there is need to develop remote controlled heavy hydraulic machinery. In this project the designer seeks to develop an effective communication system for an excavator to enable remote controlled operations. The designer achieved this by designing an independent CAN/WIFI network system for data transmission, designing a control circuit which is stable and less affected by the high temperatures and noise as well as designing an effective electronic-hydraulic interface. In the course of the project development industrial visits, informal and formal interviews were conducted, much of the information was extracted from journal and patents. The result was a communication system and an electronic-hydraulic circuit which can be implemented in excavators. Few design improvements will make it usable in any hydraulic machinery to enable the remote control capabilities.

Keywords: *Hazardous environment, CAN/WIFI, Communication control*

DEVELOPMENT OF AN ORDERING AND INVENTORY MANAGEMENT SYSTEM FOR A FOOD OUTLET

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Stock taking is time consuming and tedious especially in tertiary school restaurants. As a result manual ordering and storage management systems are at times inaccurate, involve a lot of paper work and are laborious thereby causing inefficiencies and delays in canteen day to day operations. Such work includes calculations about resources and groceries utilized in the real

time, budgets, sales reports, orders reports and others. This project was aimed on developing a desktop application based system for food ordering and inventory management for a university canteen. Such a system uses a software database for placing orders, resource planning, supplies, evaluating and giving reports. The tools used in the project development are visual basic programming language, Email server, Microsoft outlook, and Microsoft Visual studio for the graphic interface. The database for the management system is MySQL. The system offers a user friendly graphic user interface for data capture, login and information delivery. It has a database module for automated food entries and receipting. The system also gives a synergistic integrated inventory management module for raw materials and relevant resources. The electronic ordering and inventory management system was primarily designed for a local university's canteen system for stores control and ordering management. However, such a system can be applicable to workshops and organisations of all sizes. It is recommended that the system should be integrated to a web based application software platform to in-cooperation of both online and offline features. This should also offer a feedback platform on user experience with the system.

Keywords: *Ordering, Inventory, Database*

DESIGN OF A HEAT AND MOISTURE MECHANICAL CONTROL SYSTEM FOR THE GRAIN ELEVATOR SILO

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Most of the African population lives on a diet based on grain as a staple. It is important that the grain maintains its post-harvest quality in order remain consumable. The majority of post-harvest quality deteriorations occur in storage. A common grain storage facility in Zimbabwe is the grain elevator silo, which attributes losses to moisture gain eluding to germination and moulding. This is because the silo conditions are uncontrolled and reliant on historical records to know when to remove moisture from the grain. Changing climatic conditions and rise in popularity of the hybrid grain have rendered this method unreliable. This research project aimed to design a control system that will aid grain elevator silo operators in controlling the heat and moisture content within the storage silos. In order to achieve this, a heating system to provide optimum moisture removal temperatures, a ventilation mechanism to aerate grains, a sustainable power source input to run the control system and a cooling system to minimize moisture migration after moisture removal were designed. The control system settings were based on an oven test experiment conducted by the researcher on the effect of drying temperature on grain quality. Failure mode and effect analysis was to detect consequences of potential failures and value engineering was used to conceptualise profitable designs for the system. A control system which has duration settings on the running of the cooling fan to control the demoisturising rate, a valve on the duct supplying hot air from the heater that controls heat flow to the silo, a thermocouple connected to a digital display for temperature monitoring, a perforated floor and vibrator for ventilation purposes. It maintains a temperature range between 45°C- 60℃, which is the optimum drying temperature range for maize fit for human consumption.

Keywords: *Relative humidity, Moisture content, Temperature, Germination percentage*

DESIGN OF A FIRE PROOF DUST EXTRACTION UNIT USING A STEPPED SEPERATOR.

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This project research is about Dust Extraction System using a Stepped Separator with Reverse Pulse and Metal Filter, the researcher stands on the shoulders of several inventions by industry experts but their works had some gaps and this research tries to advance the clean air environment technology from nearly perfect to complete perfect by redesigning the fabric filtration unit that is prone to fire outbreaks and clogging. This has contributed to too much downtime and extraction inefficiencies. The researcher designed a multi stage filtration unit with built in metal filter that replaces the fabric filters. This was prompted after several companies in Tobacco Industry suffered huge losses in breakdowns due to fire explosions at their dust rooms and sometimes stopped by authorities due to noncompliance in terms of dust level requirements and exposure limits. A case study of Tobacco Processors of Zimbabwe was done, and the researcher generated the concept of a fire resistant filtration system after several consultations with users and industry experts. Existing solutions were combined with new technologies to come up with several design concepts. The expected result is zero chance of fire and clogging of the Dust Filter Unit.

Keywords: *Fire proof, Extraction, Steppered separator*

DESIGN OF A BOTTLE COOLER MAINTENANCE SYSTEM USING VISUAL BASIC

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This research sought to design a Maintenance Management System based on existing operational processes between the Sales and Refrigerator Services department at Schweppes Zimbabwe Northern region. The design will rely on the logging in of information by the sales team on the faulty refrigerators in the market. In addition, the design then prompts the Services team on logged in units whilst stating the location of refrigerator and make of unit, this information will be pulled out from the main data base. More over to these features the system shall also prompt the services team of refrigerator units due for service as per scheduled maintenance plan. Currently, there hadn't been a system custom made to suit the needs of the organisation hence the researcher was prompted to model a system that can optimise Schweppes Zimbabwes'maintenance and breakdown response through working with the Sales team as they are the first point of contact with customers in the Market. A working prototype was designed and developed using Visual Basics Application (VBA), to create login platforms that interacts with the database. Results and findings indicated that the system was capable of accepting information and updating in the database and also allowing the services team to retrieve it when needed. The project was recommended by Schweppes Zimbabwe Refrigeration and Sales Department of Northern Region.

Keywords: *Database, Prompt, Retrieve, Maintenance Planning, Scheduled Maintenance*

DESIGN OF A WATER TANK STAND

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The lack of standard way of designing water tank stands, has resulted in individuals constructing their own tank stands from any materials at their disposal such as, bricks, any metal and wood, without taking safety into considerations hence increasing the risk of tank stand failure. In order to come up with a standard way of designing the water tank stands the researcher has embarked on a project which is aimed at designing and optimization of water tank stand stands. The first step was to determine the best material which can be used for the construction of water tank stands, through the use of solid works software. The second step was to determine the best method to

use in the connection of member between welding and bolting. This project deals with the induced stresses of water tank stand. The modelling was done by using solid works software. In modelling two stages involved, the design of the individual components of water tank stand, second was to assemble those components. For creating the components, the work was done in part module and in assembling the components assembly module was used. Finally, after creation of the geometry the module was imported to analysis software ANSYS. Different stresses were found at different loading conditions and the results were compared and tabulated along with graphs. This project the small scales to medium scale tank stands manufactures.

Keywords: *Stress, Analysis, Structural, Solid Works, Design*

DESIGN OF AN ELECTRICITY THEFT MONITORING SYSTEM

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Having an estimated monthly return of $80 million dollars after all technical losses have been considered, as it stands ZETDC is having an average monthly return of $50million, $30 million shy of its true potential and this was recorded after the introduction of Smart meters which were planed so as to increase electricity bill payments which was generating a return of $65 million in 2011 and this tells that there was an increase in electricity theft from 2011 to 2015 and now maintaining that high loss. This gave rise to the conclusion that electricity theft had been given rise by the increase in electricity bill and the increase in unemployment in Zimbabwe. Standing at this view, the researcher searched on ways to reduce electricity power theft. After a series of research, the researcher got to know of various means to reduce electricity theft and evaluated them. Data used for evaluation was collected from ZETDC. Deemed necessary, economical and easy to maintain was the electricity power theft monitoring system based on current drops as proposed by Kirchhoff. This system used GPS mobile communication system to relay electricity power theft if current drop exceeded set limits.

Keywords: *Electricity, Bill payments, GPS*

DESIGN AND MANUFACTURE OF AN EFFICIENT THERMAL COLLECTOR FOR SOLAR FOOD DRYERS

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Performance in terms of conversion from solar energy to thermal energy has become a matter of great concern in the food processing industry since it affects the rate of production and volumes

of produced dried crops. In this study different techniques were used to increase the efficiency of thermal collectors for solar crop dryers which is currently at 28%. Glazing material thickness, type and material of collector absorber, insulation material, integral thermal storage system and size of collector were changed in order to come up with a thermal collector that has a higher efficiency than the other existing ones. A series of experiments were done for five different days to measure the performance of the designed thermal collector. After experimentation, the results showed that the efficiency of the thermal collector was increased by 4% which goes on to prove the feasibility of the project in increasing the efficiency of thermal collectors for solar crop dryers.

Keywords: *Solar crop drying, solar thermal collector, Efficiency*

DESIGN OF AN AUTOMATIC OZONE BOTTLE WASHING CONTROLLER

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Dairiboard Chitungwiza specializes in the production of dairy products and its ozone set point is manually operated to such an extent that at times bottles passing through the rinser would be partial cleaned. That affects the production of the company and the consumers. Other similar projects like the automatic water tank level controller uses the water controller circuit to automatically control the on and off of the domestic water pump set. The aim of the project is to design an automatic ozone bottle washing controller which would ensure that the set point of 0.60 parts per minute of ozone is achieved in the washing of bottles in the rinser. The ozone and water supply to the rinser does not affect the production volumes, but it affects the production quality. The impact shortens the shelf life of the products as well as exposes the consumers to unhealthy products. Experiments were conducted at Chitungwiza Dairy Industry and it was discovered that a set point of between limits 0.45 and 0.60 parts per minute of ozone was ideal to effectively ozonise the rinser. The designer came out with a design of an automatic ozone bottle washing controller using the following variables; voltage, current, pressure and volume. These variables would be controlled by the NE 555 IC microcontroller. Ozone would be controlled by the Programmable Logical Controller (PLC) in the ozone generating plant. The results are that the

PLC produces output signal to the solid state relay switch which would open and close the circuit when ozone is at set point and below set point respectively. The designer found that implementing a control system to monitor the ozone rinser would prove a sound financial investment. Prototyping, a model automatic ozone bottle washing controller was fabricated and demonstrated well the easy of ozonating the rinser. From the prototype, the designer managed to come out with the required set points limit of between 0.45 and 0.60 parts per minute of ozone. Preliminary results suggest that the ozone controller efficiencies can be substantially improved by adopting demand-controlled systems and save tens of thousands of dollars per year.

Keywords: *Ozone washing, PLC, micro-controller*

DESIGN OF A MATERIAL HANDLING DEVICE TO AID ALIGNMENT DURING MACHINERY INSTALLATIONS

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It is an intent to lift heavy machinery including vehicle engines, industrial electrical motors and any other related equipment, that manual systems cannot be implored to be effective and safe to implement. Solutions though of lifting heavy machineries found in industry have been devised but lack of effective alignment in the lifting devices when it comes to installation is the problem that needs curbing to faultlessly allow processes like machine servicing, engine reinstallation, electric motor removal and installation, to be easy and effective. From the later statement the researcher devised an aim in which to design a material handling device that aids in machine installation for effective alignment. The scope of the project was focused on the alignment of light weight motor vehicle engines during installation in the compartments. In this document the researcher used customised five step methodology approach to develop the project. The methodology allowed the researcher to identify the problem and then clarify sub problems. This resulted in brainstorming of several sub solutions to each sub problem with the issue of alignment during installation of machines being one of the sub problems as well as the link on the suspension in existing solutions. Upon obtaining the brainstormed solutions, the researcher formulated a research

methodology to find out information related to engine installations. The researcher then used engineering tools such as AutoCAD and Excel to develop three concepts which were then analysed using the scoring procedure to determine the final design for the device. In accordance to the aforementioned methodology, the researcher developed a prototype for testing and evaluating. Upon finish the prototype must include a mobile frame with steel wheels, hydraulic powered arm and an alignment set. On testing the prototype has to allow movement of the engine in two axes.

Keywords: *Alignment, Installation, Lightweight motor vehicle engine*

OPTIMIZATION AND FABRICATION OF A BERNOULLI -PAD FOR NON-CONTACT ADHESION FOR WALL CLIMBING ROBOTS

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It is a challenge for mobile robots to climb walls primarily due to requirements for reliable locomotion, high manoeuvrability, robust and efficient attachment and detachment. Surface material condition is the major contributing factor which needs attention when designing surface adhesion mechanism. The researcher aim's to determine the variable parameters affecting the existing Bernoulli pad so as to be able to customize and optimize the Bernoulli pad to be used as a technique for surface adhesion mechanism of robots. The Five-step concept generation methodology was used in this project to accomplish the stated objectives and produce a prototype which literally float in air without any contact to the surface. As part of the methodology experiments were carried out in order to determine the effect of increasing force of a Bernoulli gripper on the distance from the object with the help of electronic journals, internet research, site visitation and observation as research tools. SPSS and Matlab simulation where used to present results from the carried experiments for analysis in graphical form. The customized Bernoulli pad is connected to an air compressor as the source pressure supply. The radial out flow starts with a hire pressure in the middle which creates a force against the bottom disk and lowers the total adhesion force of the device before it decreases under the ambient pressure. Deflection of the air

stream to the sides of the devices will then allow the release of pressure on the surface through disk holes. This pressure force will allow the disk to fight against gravity and by releasing the pressure it goes up.

Keywords: *Surface adhesion mechanism, Variable parameters, Locomotion*

AUTOMATION OF TOBACCO BALE PRESS MACHINE FOR A2 FARMERS

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Current tobacco baling technology utilizes hydraulic power as well as manually operated to press tobacco into bales. The high system pressures at which hydraulic systems operate pose a risk to workers. Hydraulic systems are costly and hydraulic oil leaks contaminate baled tobacco. An automated, electrical driven, vertically oriented, stroke baler was designed as an affordable alternative to current hydraulic balers. System was chosen due to the lower system operating pressure and absent risk of tobacco bale contamination. The transmission of power was achieved through a reversible pneumatic gear motor and manually operated turning left and right hand acme threaded rods coupled together to form a power screw, square threaded. The pressure was driven by a metric spindle and was used to take advantage of the non-linear force response of tobacco. The baler was tested with burley tobacco grown during the 2016-17 season at the Norton. The compressive force and pressure plate displacement was measured for each bale produced. These readings were used to determine the compressive force as a function of plunger travel and the compressive force as a function of bale density. The baler required 3-4 presses to produce burley bales roughly one metre cubed and weighing approximately 100-120 kilograms

Keywords: *Press machine, Hydraulic power, Baler,*

DESIGNING AN AUTOMATIC PRESSURE FILLING SYSTEM WITH FAULT DETECTING MECHANISM

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An automatic tyre fault detection pressure monitoring system project is a prototype capable of automatically detecting the faults on the tyre before pressure filling takes place and communicates with the user on the mobile android phones. Since tyres are the most important parts of the vehicle that are in constant contact with the surface, proper care should be taken. If not might result to fatalities, reduction in vehicle performance, reduction in braking, acceleration efficiency and efficiency of management and driving comfort. The core Researches on pressure monitoring systems in general, pressure vessel designs, mechanical, software technique to control the system were done in the beginning. The implementation was based on the usage of simulation and training. The system comprises of a tyre fault scanning module that is connected with the main tyre regulating module made up of electro-pneumatic valves and pressure level sensors. The fault scanning module scan the tyre first for fittness and communicates with the driver or an operator on the condition of the tyre through an android application. The scanning results will also cause an automatic pressure regulation on the inflating process. The pressure monitoring sensors will give information about pressure level for continuous monitoring and the information will appear on the mobile android phone screen. The design will bring new inflating and fault detection era in pressure containing vessels as its core aim is to detect the tyre fitness and monitor the pressure to avoid tyre bursting and other tyre fault related hazards due to pressure fillings technologies currently existing to the Zimbabwean industries.

Keywords: *Tyre pressure monitoring system, Tyre scanning module, Bluetooth module, Pressure sensor, Vehicle safety*

DESIGN AND MANUFACTURE OF AN INDUSTRIAL SOLAR DRIER MONITORING SYSTEM

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The purpose of this research was to design a system in answer to constantly changing weather conditions during food drying using a solar drier. Whilst quality of final dried product is judged using final moisture content, colour, taste and shape(Arah *et al.*, 2015) ,problems being faced were poor quality of final product and fruit rotting during drying, hence the design was made to ensure quality preservation. The objectives pursued were to monitor and control dryer environment, to analyze water content of fruit during drying, to add a buzzer for alerting the user and to reduce product defection. Research scope was limited to the Harare, Zimbabwe region and mainly focused on the local manufacturers, Insti Foods here at Harare Institute of Technology, with the design focus being limited to the monitoring system only. In trying to eliminate this problem, a standard model of the design process was used and solutions were obtained from numerous attributes to come up with the best solution. A detailed design was worked on which consists of a system that uses temperature and moisture sensors and a buzzer. Needed parameters are set on the sensors and any variation in set parameters will cause the buzzer to alert the operator and the system will be monitoring moisture content of fruit3. The prototype produced was of an appropriate size to be used inside the solar driers for monitoring. This project targets all industries where food preservation is done.

Keywords: *Food quality, Solar drier, Temperature, Humidity, Fruit moisture content*

DESIGN OF MOBILE ROAD MARKING MACHINE.

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The purpose of this project was the development of a semi-automated road marking machine. In Zimbabwe, some previously marked roads have begun to, fade out and new roads which have been commissioned have increased the risk of road accidents. The current methods used in road marking are very slow, labourious and ergonomically un safe. In addition, only a small portion of area is covered in a longer space of time and also some of the Zimbabwean roads due to high cost investment take a long period of time without being marked. The methods used in this study

were concept generation tools, field observation circuit modelling with Proteus software, Micro C and MPLab language for programing the circuit and animation with Autodesk Maya. A prototype was developed that was able to mark lines at its optimal standard flow rate and at an effective speed. The final design was very light weight as compared to current designs and uses ultrasonic technology to monitor the painting mechanism. The design is recommended for use on Zimbabwean roads by city as an assistive tool in road marking

Keywords: *Road marking, Semi-automated, Ultrasonic technology*

OPTIMISATION OF A HYBRID EFFLUENT TREATMENT SYSTEM

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Unsafe disposal of industrial effluent has become a threat to human health, aquatic life and also causing environmental pollution, thus it is very necessary for the industry to prevent such problems. A case study was undertaken at company x whereby, alkaline effluent is discharged in sewage pipes and some of it disposed to the environment. The purpose of this research was to design a hybrid effluent treatment system that recycles the effluent for further uses, which is for use at thermal power stations as well as for consumption. Current effluent treatment systems in Zimbabwe end on filtration stage to correct pH only. They do not reuse the waste water. The designed hybrid effluent treatment system incorporated three levels of treatment which include primary level, secondary level and tertiary level. An advanced technology called an Ultra Violet Disinfectant mechanism was incorporated in the tertiary level of effluent treatment to clean water effectively by killing all the bacteria in water. Various sensors were used in the system to detect pH levels, Biochemical Oxygen Demand and Chemical Oxygen Demand. Adobe effect was used to simulate the processes in the system and showed how the sensors work in the system, thus it managed to show expected flow of the processes in the treatment system. A prototype was fabricated and tested and managed to clean water without any contaminants remaining in it. The system was able to operate effectively through the use of simulation runs and prototype testing. In future, if we use this advanced effluent treatment system, we can no longer face problems of effluent disposal and also as a result industries will be cutting costs in terms of water usage.

Keywords: *Effluent, Hybrid, Treatment, Ultra-Violet, Sensors and System*

DESIGN OF A PROCESSING SYSTEM OF WASTE GASES FROM A COAL POWERED BOILER

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Global warming has become a trending issue of concern all over the globe due to its evident disastrous effects to global climate and the way of life for the average man, therefore it is of great concern that industry controls its pollution so as to minimise its rise. The focal point of this research is to design a system that does the processing of exhaust fumes after combustion of fossil fuels with the objective of making them safer before disposal to the environment. The systems currently in use, that is precipitators, can only remove particulate matter whilst leaving the bulk of the gases to be disposed into the atmosphere unprocessed hence justifying the need for this system in helping to curb air pollution. A series of carbon dioxide gas sensors were used to detect the amounts of carbon dioxide before and after the processing in liquid lime, of which the information was to be processed through a raspberry pi microcontroller, and displayed on the computer as graphical information of the real time events on the levels of pollution. A simulation of the results and the project was done using the blender software, showing the flow of the project. After experimentation, the results showed that the level of carbon dioxide was reduced after the processing of the exhaust fumes, from 8000ppm to 3000ppm, which goes to prove the viability of the project in controlling emission levels for air pollutants.

Keywords: *Global warming, Exhaust fumes, Air pollution, Carbon dioxide*

DESIGN OF A SMART WATER TAP

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Due to inconsistent supply of water in most parts of Zimbabwe, water wastages are experienced on the next supply of water due to negligence by consumers in not closing taps after realising that there is no water coming out of the tap. This research sought to develop a smart water tap which would play a vital role in reducing these unnecessary wastages. A flow sensor that detects

changes in flow rates was used and the sensing system made use of a combination of a solenoid valve, a microcontroller and a push button. When the flow rate decreases to zero, a microcontroller sends a signal to the solenoid valve so that it closes and when the flow sensor senses an increase in flow rate of a buzzer is alarmed to notify the user. Proteus 8.5 was used for circuitry and simulation purposes. MikroC programming language was used. This results in a device with zero wastages of water even if the tap is open.

Keywords: *Flow sensor, Solenoid valve, Microcontroller, Push button, MikroC, Proteus 8.5*

DESIGN OPTIMIZATION OF A CONTROL CIRCUIT FOR AN AUTOMATIC OPERATING AIR CONDITIONING SYSTEM WHICH RETAINS MEMORY AFTER POWER INTERRUPTION.

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The cooling needs in rooms, data centres and server rooms in banks, industrial purposes other departments, like in a lot of buildings, are usually high during the day when the temperatures are a bit higher. It is during this time of the day when a lot of heat is generated as a waste product hence the need to continuously drive it out of the room more than it is generated in the room to maintain acceptable and expected cooling levels. This project is aimed at designing an integrated automatic operating air conditioning system which incorporates a memory device, sensors (temperature sensors included). The objective of the system is to maintain optimum indoor air quality, reduce energy use or power consumption, reduce manpower costs (manual operation), and minimize maintenance problems and to improve plant operation and match the load that is to improve cooling capacity factor (CCF) and monitoring system performance. To design an automatic operating air conditioning system, the cooling needs were first considered on an hourly basis over several days and also factors contributing to cooling load. The cooling needs of in the country were studied and an air conditioning system was designed based on day maximum cooling load of 180kw and night maximum cooling load of 30kw. Also environmental factors were considered in order to come up with green cooling systems. An economic analysis was done at the end to determine the feasibility of the project. The researcher recommends this design as it is advantageous to the electricity production and distribution companies since it tends to stabilize consumption in the national grid.

Keywords: *Cooling capacity factor, Electrical energy costs, Refrigeration, air-conditioning*

DESIGN OPTIMISATION OF AN AUTOMATIC SOLAR PANEL CLEANING SYSTEM

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This project focuses on the optimization of automatic solar panel cleaning machine, the machine is able to clean the surface of a solar panel in order to increase the rate of light rays absorption. The solar panel cleaning system consists of a control circuit and a mobile cleaning mechanism mounted on the solar panel which moves up and down the solar panel cleaning the panel. On the prototype, the cleaning mechanism was made using a dc electric motor which provides torque, rack and pinion gear which transmit power from rotational motion to linear motion. The rubber wiper and a brush are attached to the end of the rack. This prototype used proximity sensors to limit movement of the cleaning mechanism attached to the rack over length of the solar panel. The overall actuation is controlled by the PIC Micro-controller and the instructions are displayed on the LCD display. In the research the designer used the information obtained from internet, experts and textbooks. During the design selection and development of prototype the designer uses concept selection method. The machine was tested and it performed well all,

Keywords: **Automatic,** *Solar Panel Cleaning Machine, Light Rays Absorption, Rack And Pinion Gear, Micro-controller*

DESIGN OPTIMISATION OF HYDRAULIC MOBILE WORK PLATFORM ELEVATOR

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The conventional use of ropes, ladders, scaffolds and mechanical scissors lifts in accessing elevated heights poses a lot of limitations(time and energy consumption, comfortability and amount of load applied on the plat form), which a hydraulic mobile work platform elevator will achieve. However the position of the actuator has a direct effect on the mechanical and velocity ratio of the system, therefore prudent placement of the cylinder can influence the magnitude of the force applied and the stress levels in adjacent arms. In this project the maximum weight to strength ratio and the optimum hydraulic cylinder orientation is determined to achieve a height of 4m with a maximum work platform load of 200kg. In carrying out the research the designer use the information obtained from internet, experts and textbooks.

Keywords: *Cylinder orientation, energy consumption, conformability*

DESIGN OF A PIEZO/TRIBOELECTRIC POWER GENERATING SYSTEM

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The purpose of this project was to design an electricity generating system from human footsteps. Currently due to electrical challenges, a Zimbabwean dining hall has been unable to provide sufficient lighting in the event of random unscheduled power cuts during the evening. Alternative

lighting sources such as a diesel generator and solar power have been used to try and address the problem, however the generator used is of industrial size and it has long set up times and at times it had difficulties in starting up. As for solar power, it is a light depended and its power output is severely reduced on overcast days. The methods that were used in this study included the review of electronic journals and articles, company reports, conceptual modelling, circuit design, CAD and simulations. A prototype was developed that uses a Piezo/Triboelectric hybrid generating system. The system generates electricity that is corresponding to a mechanical force exerted on it. The design is recommended for use in areas that have high human traffic, so as to harvest energy from the motion of individuals.

Keywords: *Piezoelectric, Triboelectric, Energy harvesting, Electric lighting*

DESIGN OF A CONCENTRATING SOLAR THERMAL ELECTRIC GENERATOR.

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The purpose of this project was to design an alternative solar power generation system. In the perturbing and rural areas of Zimbabwe, there is inconsistent power supply for lighting and charging small energy consuming devices. This unavailability of power has led to running out of cell phone batteriess and inadequate lighting which is essential for students who will be undertaking their studies at night. Methods used in this project included use of electronic journals, concept modelling, circuit design with Proteus and simulations with MATLAB. The design was developed that comprised of a solar parabolic dish concentrator and a thermoelectric generator (TEG), which can be used for charging and lighting purposes as well as auxiliary water heating. The design is recommended for use in household setups in the periurban and rural areas of Zimbabwe and sub-Saharan Africa.

Keywords: *Power generation, Solar concentrator, Thermoelectric generator, Lighting, water heating*

DESIGN OF A USB/DC POWERED COOLING UNIT FOR INSULIN STORAGE.

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The purpose of this project was to design a USB/ DC powered cooling unit for the storage of insulin. Insulin is a necessary supplement for some diabetic individuals and due to its sensitivity to harsh temperatures it requires proper storage. Once, an insulin pack is opened, the insulin can lose its potency if it exposed for long durations in harsh temperature conditions (very cold or hot) hence it is a requirement that it is stored between 15℃ and 25℃. Currently diabetic patients use storage devices such domestic refrigerators, insulin thermal bags and cabinet storage, which are either unreliable or expensive and in in most cases unavailable particularly on the Zimbabwean market. The methods used in this study include review of articles and electronic journals, conceptual design and analysis, circuit construction and circuit simulation. The Pahl and Beitz methodology was used the development of the project and a systematic approach was used in coming up with the prototype. A prototype was made which uses thermoelectric cooling technology and input power is through a Universal Serial Bus (USB) terminal. This design is recommended for use by diabetic individuals who live in or travel through geographical locations in which harsh ambient temperatures are experienced leading to the reduction of insulin's potency and effectiveness i.e. temperatures above 25℃ and those under 15℃.

Keywords: *Thermoelectric technology, Universal serial bus, Diabetics, Insulin storage.*

DESIGN OF AN ELECTRONIC MANAGEMENT SYSTEM (EMS) FOR DIAMOND POLISHING COMPANIES

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The purpose of this project is to design an electronic diamond management system in order for the diamond companies to justify diamond inventory available in the system and also to identify their registered polishers. There is need of an automated system that can be used for recording and storage of data. The system has been designed as a web based application that is a capable of supporting hundreds or thousands of users at any time. The researcher made use of consultations and electronic journals. A combination of My SQL database, Hypertext pre-processor (PHP) and barcode scanning were used to come up with a robust system that has high levels of security. The researcher made use concept scoring and concept screening techniques to come up with the best solution .The system can only be accessed by users who have valid log in user names and passwords. .The system has the ability to identify individual polishers since they are using identification cards for verification.it also has the ability of updating daily opening and closing balances of the diamond,

Keywords*: EMS, SQL, diamond polishing*

DESIGN OF AN AUTOMATED SOAP PACKAGE HANDLING SYSTEM

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The purpose of the project is to design an automatic soap handling system for soap product. Currently a small soap-manufacturing firm is manually packaging and cutting the soap product. Also once packaged, the soap needs to be carried manually to the inspection section and that particular process is causing time delays. As a result, the time taken for these activities increases, leading to delay of supplying them to customers, which in turn has caused attrition to occur. Research methods used were problem identification and feasibility, data collection, work-study analysis, design development and fabrication of prototype. A prototype was developed that used

sensing technology and PIC microcontroller that reduced packaging and transportation change over. The project is recommended for use in the small and medium scale soap industry, in order to reduce manual labour by considerable amount by implementing an automatic soap package handling system.

Keywords: *Automatic soap handling, Small to medium enterprise, Sensing technology*

DESIGN AND MANUFACTURE OF AN ORANGE PEELING MACHINE FOR SMALL-MEDIUM SCALE FARMERS

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On farm production of an orange concentrate by small-medium scale farmers with less impurities from orange peels and pulp has become a major problem, however it is the focal point of this research project to design and manufacture a machine capable of peeling oranges produced on a high to medium scale right on the farm. Currently for very large scale farmers and industries they are making use modern technology that makes use of robotic arms and sophisticated sensors which will make the machine very expensive to adopt. This research tend to achieve the same objectives as those of modern technological current ones but using simple material and parts and at the same time making use of no sophisticated components. The parts and materials that will make up the proposed design will be of readily available and cheap materials which will intern makes the machine affordable for the farmers. A series of experiments were conducted using different types of oranges produced with the main aim of choosing the best peeling cutter and to also assess the drive mechanism in relation to the human capacity (work study). After all the experiments were done it proved possible to have such a machine that is also affordable and having a payback period of 0.064 years.

Keywords: *Farm oranges, Orange loses, Orange concentrate, Orange peeling*

MODELLING OF A COMPUTERISED PLANT MAINTENANCE MANAGEMENT SYSTEM

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This research sought to design a Computerised Maintenance Management System (CMMS) based on programmable logic controller (PLC) technology. The design automatically records run hours, store maintenance history and print work orders when maintenance is due. In addition, it enhances maintenance effectiveness by cutting off equipment power supply if maintenance tasks are not carried out. Currently in Zimbabwe, the majority of CMMS available are not locally developed, as a result there is support service challenges. According to research, the other biggest drawback with CMMS in the market is lack of decision making abilities to enforce compliance by maintenance team. This prompted the researcher to include a decision making mechanism in the design. A model was designed and developed using Microsoft Excel programming language, Visual Basic Application (VBA), to create a human machine interface and manipulate the desired output through the use of a PLC. Results and findings indicated that the system was capable of automatically recording run hours, print work orders, and could terminate power supply when maintenance work was not done. The project was adopted and implemented by African Distillers Zimbabwe.

Keywords: *Computerised, Manipulate, Interface, Compliance*

DESIGN OF AN INTELLIGENT CATTLE MONITORING AND MANAGEMENT SYSTEM

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In Zimbabwe, agriculture is the backbone of the economy and many people depends on it .Currently farmers are failing to detect cattle illness in time since focusing on individual cattle is a challenge. Tracking of lost or stolen livestock is tedious and time consuming. According to police statistics thousands of cattle went missing and veterinary service reported that Zimbabwe is losing 3% of its herd annually due to late detection of contagious diseases such as foot and mouth.This research project was aimed at designing a GPS collar and development of a mobile phone database management system to capture or retrieve details of each individual animal .The system consist of several technological combinations that involves Global Position System (GPS) collar which is used to locate the herd, Geofencing feature that monitors the boundary or forage perimeter up to 200km radius. SIM 800L was used to establish a two way communication between the farmer and collar. The system consist of a real time temperature monitoring system to detect abnormal fluctuations in beast temperature. Proteus was used for simulation of design circuit, C language for programming and E draw for drawing detailed diagrams. These tools were used to design the system that assisted farmers to ensure that sick animals receive early treatment at the early onset of the disease by monitoring ambient temperature 37℃ and quick tracking if the cattle is lost or stolen. The collar was able to alert the farmer when tempered with or if unfastened, when temperature is abnormal and cattle is out of geo-fence. This system was applicable to livestock industry in Zimbabwe or Southern Africa region.

Keywords: *Global Position System (GPS), SIM 800L, Ambient Temperature, Geofencing*

DESIGN OF AN AUTOMATIC FUMIGATOR FOR STORED TOBACCO - CASE OF ZIMBABWEAN SMES FARMERS

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Tobacco is one of the most important cash crops grown in the country and for this, the quality of tobacco produced is very vital to every farmer. The small to medium scale tobacco farmers are resorting to the manual application of chemicals to tobacco at its storage stage. This fumigation technique poses health problems to those being exposed to the chemicals especially over a long period of time. This manual application method is time consuming and it is not ergonomic. There is an issue of lack of protective clothing provided for the workers due to the high comparative cost of protective clothing compared to income. There is also a tendency of using very toxic substances which are banned due to the propaganda by some exporters that more toxic agrochemicals are more effective. The aim of this project is to design an automatic fumigator for tobacco whilst it is stored in the warehouse. It comprises a compressor, pesticide tank, a timer, a pump and an electric motor. It works in such a way that, when the fumigation time has been set by the operator, an alarm rings to alert everyone to evacuate the warehouse, and then the pesticide will be sprayed automatically. After fumigation is complete and the pesticide has settled down, an external alarm rings to notify workers that it is now safe. This project is aimed to the small to medium scale tobacco farmers of Zimbabwe.

Keywords: *Electric motor, Alarm, Compressor, Pesticide tank, Timer*

DESIGN OF A HYBRID ORE CRUSHING HAMMER MILL

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With the inability of the current hammer mills to process gold ores that are over forty millimetres in size, gave rise friction in its adaption and acceptance in most mining areas in Zimbabwe since most gold ores comprises of huge rocks. It has propelled the designer to come up with a solution in form of a ore crushing hammer mill, which can crush ores that are over forty millimetres and processing this at a rate which is faster than the existing ones. To come up with the project the designer has managed to research extensively on the existing hammer mills and crushers and ways of optimizing both the hammer sizes and the number so as to give an allowance for the crushing of ores that are over forty millimetres. Engineering designs and calculation were considered to come up with a machine capable of ore crushing but conserving energy through high efficiency. This design project is intended for the artisanal, small and medium gold miners in Zimbabwe for the mechanisation of all small-scale industries in accordance with the ZIMASSET.

Keywords: *Hammer mill, Gold ores*

DESIGN OF A HELICAL COIL SPRING COMPRESSING MACHINE FOR LIGHT MOTOR VEHICLES

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This project is about the design of a helical coil spring compressing machine for light motor vehicles. Coil springs used in automobile suspension system have very high shock forces as in strut springs and great care must be taken when assembling or separating the spring from the shock absorber for maintenance purposes. The use of unstandardized hooks or clippers pose a major safety hazard to the operator and environment when the spring suddenly unleashes tension which may cause death or serious damage to the surroundings. The aim of this project is to design a spring compressing machine which can withstand different shock forces of the strut spring, reduce the time for assembling the strut system and the machine will also accommodate different sizes of the strut springs. A collective consultation and use of engineering principles is then combined and described on how the machine was designed, assembled and put to test. The prototype was developed, tested and the machine managed to compress the coil spring efficiently without any harm to the operator.

Keywords: *Coil springs, Compressing Machine, Suspension system, Shock absorbers*

DESIGN OF AN AUTOMATED BALL MILL FOR GOLD ORE GRINDING.

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Ball mills are commonly used for most secondary crushing operations during mining procedures due to their high size reduction ratio. Small and medium scale miners overload ball mills leading to fatigue failure, malfunctioning and increased risk of accidents. This research project seeks to design an automated ball mill crushing machine that will serve as an alternative gold ore crusher for small and medium scale miners throughout Zimbabwe. In order to counteract overloading, the following systems where developed, weight control system, speed variation system, control system for monitoring mill speed and mill load ; finally vibrating table for ore separation after grinding. The project was restricted to solving problems that arise due to overloading and the related effects of overloading, particularly how they affect grinding capacity. Literature review was intensively done on all the major parameters that affect mill load behaviour such as mill speed, ball size, weighing systems, machine design principles. Software programs such as Autodesk inventor, Autodesk AutoCAD were used for force analysis and Proteus was used to model control circuits. Most competent design was generated through benchmarking the possible design option against standard design specifications. Prototype testing was successful, weighing system capacity measured weights up to 250kg and the grinding rate was 187kg/hr.

Keywords: *Ball Mill, Overloading, Grinding capacity, Mill load behaviour*

DESIGN AND MANUFACTURE OF A SEMI-AUTOMATED SOLID WASTE SEGREGATION MACHINE.

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Solid dry waste management has proved to be one of the most pertinent issues nationwide. With a continual advancement of civilization waste composition becomes more complicated thus segregation can be implored which involves the separation of waste into different categories. Since waste segregation in Zimbabwe is currently carried out by making use of manual techniques which are laborious and increases the time before waste can be sent for recycling there is need for simpler ways to achieve this. The research aims at designing and manufacturing a semi-automatic dry waste segregation machine, which reduce the time taken before waste recycling. Design of a semi-automatic machine that separates waste according to its particle size, air classification and metallic properties is the focal point of this research paper, which will be made possible by use of a trommel screen, air blower, magnet and a conveyor. Reviewed literature is on current situations, sources of waste and its effect which helped in evaluation of their working principles and mechanisms for the purpose of designing a semi-automated waste segregation machine. Relevant data was collected from waste management authorities using instruments such as informal interviews and other locally published waste management articles. The expected outcome was a design that would have eliminated the limitations in the machines and any other segregations machines currently available. However the research is only limited to design of a semi-automated segregation machine, in which further research can be done in compaction and bailing techniques.

Keywords: Segregation, *Trommel screen, Air blower, Magnet, Recycling, Dry waste*

DEVELOPMENT OF AN ENERGY HARVESTING SPEED HUMP SYSTEM.

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The purpose of this project was to develop an energy harvesting speed hump system to be utilised as a powering source for street lights in Zimbabwe. In Zimbabwe, a number of roads do not have street lights and also the other popular alternative of solar powered street lights have been difficult to install as some roads have trees that overlap thus making it difficult for solar installation as it may result in costly environmental changes. This leaves many pedestrians and

motorists vulnerable to attacks during the night, robbery and raises the risk of insecurity on the roads. The methods in this study were observations, analysis of electronic journals and articles, simulations and conceptual modelling and design. A prototype was then developed which utilised pneumatics and an electromechanical setup to produce enough power to light several street lights. The project is recommended for use in areas with high volume traffic in Zimbabwe and also where alternative powering systems are a challenge to implement.

Keywords: *Energy harvesting, Pneumatics, Electromechanical, Street lighting*

DESIGN OF A MAIZE STALK PICKING MACHINE

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Harvesting is an inevitable farming chore that is not so cherish able at times. The most common means of maize harvesting in Zimbabwean rural areas (used mostly by subsistence farmers) is the handpicking method. Walking around the maize field from one stalk to the other becomes quite exhausting for the persons doing the harvesting especially for larger fields. At times, this calls for an increased number in human labour. A number of remote subsistence farmers have already voiced out the absence of any affordable machine that would better or improve the walking part of the handpicking process. The researcher scrutinised different methods of improving or cutting down on the walking times that the hand pickers have to go through. The researcher also identified the gap or need for a cutting solution to better the part were the farmers manually slash the stalk off the field This led to a cost effective but efficient picker that does the picking of the maize stalk and stacks them up for easy collection of the chaff(which will still have the grains on it).The researcher, with the effort of coming up with a solution that cuts the field faster and more efficiently, ended up coming up with a motorised and wheeled picker that uses an efficient system of rotating blades to cut off the maize stalk.

Keywords: *Subsistence farmers, Blades, Hand-picking*

DESIGN OF A MICROCONTROLLER BASED AUTOMATED PRE-PAYMENT SYSTEM FOR PUBLIC TRANSPORTATION USING A TRANSPORT CARD AND BIOMETRIC AUTHENTICATION

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This study sought to develop a biometric fingerprint based pre-payment system for public transportation. It was motivated by the apparent need for a cashless solution in country where liquidity constraints are rampant. From literature researched and various sources of daa obtained from experiments, observations expert advice from experienced stakeholders in the banking, engineering and the general public. The system was designed using Proteus, Visual studio C#, Fingerprint Software Development Toolkit and Atmega microcontroller programming from Atmel studio. The system was able to capture fingerprints of customers, enrol customers' names into database and relay information to other remote databases. An auxiliary queue management system for efficient pre-payment queues was created. It is essential that future improvements be implemented to increase the performance of the system such as the use of more robust internet of things protocol, a commercial fingerprint software development kit and more.

Keywords: *Biometric, Pre-payment, Fingerprints*

OPTIMIZATION OF AN AUTOMATIC WATER LEAKAGE DETECTION SYSTEM: THE CASE OF THE ZIMBABWE NATIONAL WATER AUTHORITY

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Clean water leakages in urban areas results in most urban dwellers in Zimbabwe losing lots of mega litres of purified water. Failure to detect the leakages early by the Zimbabwe National Water

Authority (ZINWA) results in shortage of purified water supply and increasing cost of supplying purified water to deserving people. This paper therefore seeks to optimize the water leakage detection system by incorporating a low power consuming wireless leak detection module. The module uses volume balancing technique with Global System for Mobile (GSM) wireless communication. The system consists of units each with an ultrasonic flow sensor, a Peripheral Interface Controller (PIC) for data processing, a power supply and a GSM module installed at three kilometre intervals. If a leak is detected between units, the downstream unit will send an SMS message to a cell phone at the ZINWA offices to prompt maintenance action by the maintenance personnel. The current leakage detection systems consume more power and do not use the GSM technique resulting in more time taken before the pipe is attended to, consequently wasting purified water. With the optimised system, the position of the leak is indicated on the message sent over through GSM thus reducing water loss by promptly attending to the problem. The prototype is tested and leaks are detected with the system being able to notify through an SMS message quickly, with minimum power consumption.

Keywords: *Global System for Mobile (GSM), PIC microcontroller, Ultrasonic flow sensor, Water leakage, Wireless communication,*

DESIGN OF AN AUTOMATED AND MECHANIZED ORE LIFTING HOIST FOR SMALL SCALE MINERS IN ZIMBABWE

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The hoisting system is essential for the transportation of equipment, personnel, mined ore and thus for the productivity of the mine. It consists of various components in which there are winders, ropes and electric motors. The safety and reliability of the hoist depends on its design, therefore proper and accurate design of a hoist is essential. In this research, the design of the components making up the hoist was done through literature survey. Different types and configurations of hoisting systems were considered and compared regarding their suitability to small scale mines. This research aims to provide a solution for small scale miners using ill-designed and unsafe

systems for hoisting and hauling purposes in their mines. A cost effective hoisting system is a great call for small scale miners who cannot afford to import a proper hoisting system.

Keywords: *Hoist, Automated, Mechanized*

OPTIMIZATION OF PARKING SEARCH TIME USING ARENA SIMULATION

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Urbanisation in developing nations has seen an increase in private owned vehicles which has resulted in increased congestion, increased fuel consumption and an increase in greenhouse emission because of the time taken searching for a parking bay in the Central Business District (CBD). The focus of this project is to reduce parking bay search time using ARENA simulation by providing information of parked bays and booked bays to motorists which are searching for a parking bay. The results that were obtained from simulations by Arena simulation were the ones assisting motorists on finding empty parking bays as parked and booked parking bays are shown. This information is displayed on a monitor where drivers can see parked and booked areas and can also book a place to park if it is available. The presence of a vehicle on a parking spot is recognised by cameras which are able to cover up to 8 parking bays each. The information by the cameras is then sent to the central processing unit which then processes it and send a signal to the display monitor to show that the space is occupied. If a motorist logs in the data is sent to the central processing unit and then the central processing unit sends back a signal to the monitor to show the booked parking bay.

Keywords: *Optimization, Modelling, Parking prediction, Parking search time.*

SYNTHESIS OF AN ABSORBABLE AND BIODEGRADABLE SUTURE FROM CATTLE SMALL INTESTINES

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A suture is a medical device used to hold body tissues together. The use of sutures is the most commonly used technique in closing wounds across the globe. Such material is bio based textile. Zimbabwe does not make its own suture materials hence have to rely on importing the sutures each time they are needed. The cost does not come any cheap. The research sought to address the problem by developing a locally made suture capable of serving the same purpose yet meeting the minimum standards as required by the trade. In this work, cattle small intestines were steeped in cold water and Potassium Hydroxide and were allowed to undergo slow decomposition of the unwanted external membranes leaving the submucosal layer. Chromic salt solution was used to improve the tensile strength of the gut while iodised salt was used to sterilise the formed sutures. The addition of Polyvinyl Acetate (PVA) was to improve on biocompatibility of the suture with body. The cost of the developed suture was found to be USD 26.10 against current price of between USD 77.00 to UDS 139.00 on the imported sutures.

Keywords: *Sutures, cattle gut, adsorbents, biocompatibility*.

UTILISATION OF BANANA PEELS AND USED TYRE RUBBER FOR WASTE WATER TREATMENT.

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The study focused on the conversion of waste banana peels and used tyre rubber to make an effective powdered heavy metal ions adsorbent. Studies on the individual materials having been used as adsorbents were successfully done before but no work had been carried out which involved blending the two materials for use as an adsorbent. The results of the research revealed that the blended adsorbent was twice more efficient than the individual materials. Chemical analysis using Boehm titrations proved that the adsorbent has multi-functional groups that are responsible for the efficient removal of heavy metal ions from waste water. The higher % removal efficiency (11.57% against 2.7% of current material) was also thought to have been influenced by the larger surface area exhibited by the combined adsorbent.

Keywords: Adsorbent, banana peel used rubber, heavy metal ions, water treatment.

DESIGN AND FABRICATION OF A POLYESTER/ FIBREGLASS RE-INFORCED BASKETBALL HOOP BOARD.

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The research reports on the replacement of wooden basketball hoop boards with polymer-based boards. Basketball is an outdoor sport and its equipment is vulnerable to the harsh weather conditions form time to time. Most wooden boards absorb moisture during the rainy seasons and end up distorting the configurations of the board as desired by the sport standards. UV light is also seen to attack the wooden boards leading to undesired environmental stress cracking causing the layers of the board to crack and peel off. The replacement costs per given time period has remained a huge cost to the sporting fraternity and schools in general. By replacing wood with fibreglass reinforced polyester hoop board, challenges of moisture and UV attack were solved on the instance. The incorporation of UV stabilisers into the formulation of the polymer resin ensured that the board achieved a much longer service life than ever before. Whilst the cost of the polymer based hoop remained higher than that of the wooden one, the replacement costs outweighed the use of a polymer –based board

Keywords: *fibreglass, polyester, basketball hoop, wooden board.*

SYNTHESIS OF SYNTHETIC PAPER FROM PP, PP WAX, CALCIUM CARBONATE, AND ZINC OXIDE.

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For years human beings and aquatic life have been exposed to the risk of highly polluted environment brought about by the pulp and paper manufacturing. This is due to the bleaching processes which result in organo-chlorines which are releases into the water which serves communities and animals. In order to address such challenges, this research work seeks to develop a polymer based writing paper which is capable of replacing pulp and paper in function. The research produced a writable synthetic paper although more needed to be done to reduce the density of the paper largely influenced by the addition of polypropylene into the formulation. The cost of the synthetic paper remained comparably higher than the pulp based paper.

Keywords: *Synthetic paper, wooden paper. PP, PP wax.*

SYNTHESIS OF BIO-BASED ETHYLENE FROM BIO-ETHANOL DERIVED FROM SUGARCANE AS A VALUE ADDITION PROCESS.

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This project considered use of ethanol derived from sugarcane as a source of making ethylene which is a necessary monomer in the production of polyethylene plastics used in flexible food packaging industries. Using phosphoric acid as a catalyst in the synthesis process, it was observed that higher dehydration yields of ethylene from ethanol were obtained. To determine whether ethylene monomer (gas) was produced bromine in dichloromethane was dripped slowly into the produced sample and a reddish –orange colour was decolourised into a colourless dibromide liquid. This is indicative of an unsaturated ethylene gas. The change of potassium permanganate from purple to a slightly green solution is indicative of the presence of the alkene being oxidised to ethane 1, 2 diol. When unripen fruits such as bananas and avocados were placed in a plastic film with the sample gas and left for 3 days the fruits ripened as opposed to those without the sample gas, this was so because only ethylene is known to be a ripening hormone. The research produced a proposed plant design and necessary equipment for the production of this monomer.

Keywords: Sugarcane, bio-ethanol, bio-based ethylene monomer, dehydration, Polyethylene plastics.

UTILISATION OF WASTE TYRES AND PLASTICS IN ASPHALT CONCRETE PAVEMENT.

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The continuous increase in number of vehicles worldwide demands roads which carry heavy cyclic loads continually. Due to unpredictable and ever-changing weather conditions, bitumen becomes very soft in summer and very brittle in winter leading to poor load bearing roads. The research is addressing the challenge by incorporating polymer waste materials into the bitumen formulation in order to improve the glass transition and viscoelastic behaviour of the materials constructing Zimbabwean roads which have become pot-hole infested lately. When the rubber crumb was dissolved in Sodium Hydroxide, its adhesion to the stone aggregate increased and the ring opening reaction between KOH and epoxy resin facilitated the formation of a chemical bond between functional groups of asphaltenes and the aggregate. Such chemical bonds are seen to improve the erodibility of the materials at their interface in the mixtures .Also the availability of polymers assisted in the water penetration which largely caused tarred roads to sag when heavy loads are applied to them.

Keywords: *Tyre waste rubber, waste plastics, asphalt, bitumen, polymer –modified concrete.*

SYNTHESIS OF A POLYESTER RESIN FROM BIO-BASED SUCCINIC ACID FOR PROTECTIVE METAL COATINGS.

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Succinic acid is a high potential candidate for the formation of renewable chemical resources. It has been successfully produced by fermentation and can be processed into a great variety of products among them polyesters. In this research sugarcane bagasse was used as the source of carbon in the production of the bio-based succinate which was then transformed into a polyester resin using 70% alcohol and methylated spirit. The produced polyester resin was cured using methyl ethyl ketone peroxide (MEKP) resulting in a cross-linked thermosetting plastic. The curing resin was then applied onto a sandblasted metal plate where it made a protective coating against rusting and acid corrosion.

Keywords: *Bagasse, succinic acid, polyester resin, metal coating*.

SYNTHESIS OF LIGNIN-BASED EPOXY

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The scope of the project was to determine the optimal source of lignin between woody and non woody biomass samples and to use the lignin in the synthesis of a lignin-based adhesive. Pine wood and straw was used as the test sample. Upon determining that non woody biomass has the most lignin, epoxidation was carried out using the non woody sample.

Due to the absence of epichlorohydrin which was a fundamental material in the epoxidation process there was need to synthesise it and this was done by reacting glycerol with hydrochloric in the presence of acetic acid as a catalyst.

Epoxidation process was successfully carried out and a strong adhesive was produced and the produced sample was characterised by means of a UV-Vis spectrometer which confirmed the presence of an epoxy ring characteristic of an epoxy based resin.

Keywords: *Lignin, epoxy resin, adhesive*.

PREPARATION AND CHARACTERIZATION OF STARCH / POLYVINYL ALCOHOL (PVOH) BLEND FILMS FOR BIODEGRADABLE PACKAGING MATERIALS.

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Eggshell powder was added to the Starch/PVOH blends in order to improve tensile strength and elongation to break. Tensile strength (TS) and elongation at break (Eb) of the prepared films were studied. Increasing the glycerol level, increased the elongation at break but decreased the tensile strength of Starch/PVOH blend films. The addition of plasticizer also increased the biodegradability, water absorption, and water vapour transmission of the blend films. Films made up of banana peel starch and PVOH with high ratios of zinc oxide showed high resistance to various solvents. The physico-mechanical properties of the prepared eggshell powder incorporated films were improved by also incorporating zinc oxide giving the films with antimicrobial properties. The water uptake and weight loss in both soil and water of the zinc oxide incorporated films were lower than those with no zinc oxide. Finally, the produced film can be used as biodegradable packaging materials for various applications including shopping and garbage bags that are very popular and environment friendly.

Keywords: *Biodegradable blends, PVOH packaging films*.

INVESTIGATION OF THE SYNTHESIS OF POLYURETHANE FROM POST CONSUMED POLY ETHYLENE TEREPHTHALATE

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This study presents work on synthesis of polyurethane from post consumed PET bottles. PET is one of the major plastics causing environmental degradation, so the study focuses on deriving value from post consumed PET bottles. This study ensures to provide benefits to social, economy and environment, by creating employment if implemented on a large scale while reducing solid municipal waste and preventing environmental degradation through land pollution. Polyurethane has various applications hence it is of great importance to the industry.

Post consumed PET bottles were collected from HIT environment, cleaned, dried, cut manually into PET flakes and were depolymerised by aminolysis forming BHETA under ambient temperatures. The aminolysis reaction was conducted with a condenser in the presence of a catalyst. The BHETA formed was reacted with pthalide in a ring opening polymerization forming a polyol using a condenser in the presence of a catalyst. The polyol was cooled and then reacted with toluene-2,4-diisocyanate in the presence of xylene forming polyurethanes.

Percentage degradation was calculated, its average was 59,4%.Confirmatory tests of polyurethane were conducted, which included solubility and chemical resistance tests. The polyurethane dissolved in DMF but could not dissolve in ethanol and acetone, these were solubility test. The polyurethane was resistant to sodium hydroxide and sodium chloride but degraded in dilute sulphuric acid.

Keywords: *PET, Environment, aminolysis, polyol, polyurethane*.

DEVELOPMENT OF A PLASTIC TRAY FROM WASTE POLYPROPYLENE DERIVED FROM SELECTIVE DISSOLUTION AND PRECIPITATION METHOD.

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Polypropylene gained a strong popularity very quickly due to the fact that PP has the lowest density among commodity plastics. PP has an excellent chemical resistance and can be processed through many converting methods such as injection moulding and extrusion. Polypropylene is a polymer prepared catalytically from propylene. It is major advantage is related to the high temperature resistance which makes PP particularly suitable for items such as funnels, pails and bottles. This study presents work on the preparation, characterization and application of polypropylene trays produced from selective dissolution and precipitation technique and cast moulding of waste polypropylene. Plastics generally cause land pollution so the study is aimed at establishing how best to derive value from abundant polypropylene waste. Waste polypropylene collected form dump sites in Harare were dissolved and precipitated to produce pure polypropylene. The PP was then cast moulded to produce trays. The PP was characterized using the tensile test and impact strength.

Keywords: Polypropylene, waste plastics, trays.

School of Industrial Sciences & Technology

DEPARTMENT OF FOOD PROCESSING TECHNOLOGY

DESIGN OF AN ELECTRIC BOTTLE GOURD (*LAGENARIA* SICERARIA) SEED BUTTER MAKING MACHINE

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The aim of the project was to design, construct and evaluate an electric bottle gourd (*Lagenaria* siceraria) seed butter machine. The objectives were to design an electric bottle gourd seed butter making machine and produce bottle gourd seed butter thereby adding value to the underutilised bottle gourd seeds. The 5 linear design model of design was used in the design of the electric bottle gourd seed butter machine which included problem definition, conceptual design, preliminary design, detail design and design communication. The design considerations were functionality, usability (user friendliness and user manuals), cost, ergonomics, safety, environment, durability, materials, time, aesthetics, failure and ethics. Components of the electric

bottle gourd seed butter machine included the grinding container, shaft, sieve, butter collector, top lid, electric motor and support frame. During the operation the dehulled and roasted bottle gourd seeds are fed in through the hopper. Inside the grinding container, the electric motor drives the shaft onto which horizontal blades are mounted. These rotating blades decrease the size of the seeds through abrasion, shear and frictional forces, homogenise and form a paste. Continuous size reduction produces the desired finely textured, butter. The electric bottle gourd seed butter machine was designed, constructed and the seed butter produced. The throughput of the machine was 4.75kg/hr and its efficiency, 83.7%. To improve the efficiency of the machine it was recommended that an improved design could add a shredding chamber for dehulling the seeds, a smaller sieve (200μm) can also be used to avoid falling of the seed powder at the beginning of the grinding process and the hopper can be put direct on any side of the grinding container to allow the desired size to be used as increasing the hopper size can increase the efficiency of the machine.

INVESTIGATING ANTIMICROBIAL PROPERTIES OF SNOT APPLES (MATOHWE)

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The objective of the present study was to investigate the antimicrobial activity of snot apples (matohwe).The snot apples were obtained from the local market and processed into mucilage which was then evaluated to determine antimicrobial activity of the fruit. The method that was used to evaluate the antimicrobial activity was the dilution method. The dilution method that was used in this study involved testing microorganisms for their ability to produce visible growth on a series of agar plates (agar dilution) containing dilutions of antimicrobial agent. The Minimum Inhibitory Concentration (MIC) of the snot apple mucilage was then determined by subjecting the microorganisms to a range of antimicrobial concentrations (0.05-0.50g/ml) in a solid medium in a defined atmosphere and at a defined temperature for a period of time. The macroscopic inhibition of growth was measured as the absence or near absence of growth on a solid medium. The microbiological analyses indicated that all snot apple samples had fewer yeasts and molds

colonies as compared to the number coliforms. The analyses indicated that the samples contained a range of 5.7690×10^4 to 7.680×10^4CFU/ml average colony count (all microorganisms in raw milk), 0.7480×10^4 to 0.9872×10^4 CFU/ml yeasts and mold colony count and 1.4989×10^4 to 1.8024×10^4 CFU/ml average coliform count. The controls had average colony count range of 5.8100×10^4 to 9.5240×10^4 CFU/ml, 1.0200×10^4 to 1.3908×10^4 CFU/ml and 1.5940×10^4 to 2.1014×10^4 CFU/ml respectively. From the results obtained, conclusions can be drawn that the snot apple mucilage has effective antimicrobial inhibition properties on yeasts and molds than on coliforms.

OSMOTIC DEHYDRATION OF POTATO (SOLUNUM TUBEROSUM) STRIPS FOR EXTENDED STORAGE LIFE IN AMBIENT CONDITIONS

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The main aim of the project was to reduce the water content of potato strips using osmotic dehydration to increase the storage life of potato slices at ambient temperatures. Citric acid treatment was done to prevent enzymatic browning of potatoes upon cutting. The idea was based on the fact that potato consumption has increased by nearly 45% globally and of that percentage, just about 50% of potatoes are consumed as French-fries. French-fries are common in fast food outlets such as restaurants, hotels and hospitals. These fast food outlets have resorted to the purchasing of pre-cut potatoes which are commercially provided frozen. The transportation and storage of frozen potatoes can be a cost which can be curbed such that potatoes are delivered and stored at ambient conditions with no freezing costs. There was need to investigate dehydration of potatoes and increase their storage life without freezing. It is also of importance that the dehydrated potatoes remain viable for deep fat frying and essential nutrients such as ascorbic acid (Vitamin C) are retained. The osmotic dehydration was investigated where the

dehydration variables including processing time, temperature, sucrose concentration and sodium chloride concentration were taken into consideration and the optimum treatment parameters were determined by the desirability function method. The optimum treatment parameters were found to be at a temperature range of 20-25°C with sucrose and salt concentration at 55% and 15% respectively with a processing time of 5.5 hours. The potato cuts dehydrated at these parameters had a storage life of 16 days. The rate of dehydration and osmotic dehydration equilibrium kinetics were investigated to justify the optimum parameters. Quantitative analysis of ascorbic acid was investigated and quality evaluation was carried out using a panel and the results were favourable.

EVALUATION OF THE EFFECT OF LYCOPENE, AND REDUCED NITRITE LEVELS ON KEEPING AND SENSORY QUALITY OF SAUSAGES.

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The aim of this study was to evaluate the effect of tomato powder and reduced nitrite content on the keeping and sensory quality of sausages by reducing the nitrite concentration while increasing the tomato powder concentration and determine the effect. The nitrites and nitrates are mainly added to the meat emulsions to; fix and develop pink colour; inhibit microorganisms (Clostridium botulinum); it act as an antioxidant and develop desirable flavours. Nitrites are a preservative against C botulinum and as an antioxidant is the main preservatives used to avoid undesirable effects during storage hence can't be completely substituted. Nitrites reacts with secondary and tertiary amines to form carcinogenic compounds called nitrosamines. Numerous studies have confirmed nitrites contribution to various cancers including colorectal, stomach and pancreatic cancers. Sausages were prepared with tomato powder at 0% (T1),1%(T2); 2% (T3), 3% (T4)and 4 %(T5) levels and reduced nitrites from 18g/kg, 16g/kg, 14g/kg, 12g/kg and 10g KNO_3 per kg of meat respectively. The sausages were stored at 4^0C and were constantly tested for the sensory and keeping quality for 12 days. From the results, addition of tomato powder have a significant (p<O.05) effect on microbiological stability and also recorded a significant (p<O.05)

decrease in the rate of lipid oxidation and in redness of sausages. Sample T5 containing 4% Tomato powder and 12g KNO_3/kg meat was the optimal formulation. The scores of overall acceptability in samples containing tomato powder were significantly higher (p<O.05) than that of control sample (T1)within the 12 days of refrigerated storage (5° C).The sausages with tomato powder up to 4% were found to be well acceptable. The optimal sausages formulation had increased storage stability, same taste and better color with well documented health benefit due to the functional additive Lycopene in tomato powder.

EXTRACTION OF COLLAGEN FROM BOVINE BONE FOR USE IN THE REMOVAL OF HEAVY METALS (CU) IN PIPED WATER.

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This study was aimed at extracting collagen from bovine bone for use as an adsorbent in removal of heavy metals in piped water mainly targeting copper. Collagen is a fibrous protein which is dominant in the connective tissue of animals. The collagen was extracted using both acid and enzyme hydrolysis whereby acetic acid and pepsin were used respectively. It is important to regulate copper levels in water because excess amounts of copper in the human body is associated with adverse health effect such as liver and kidney damage, anemia, schizophrenia, and Alzheimer's disease. Conventional methods that are currently used are expensive to treat low levels of heavy metals in water since they require large infrastructure and expertise. These methods include chemical precipitation, chemical coagulation, chemical oxidation and advanced oxidation. Bio sorption which involves the use of a biological material to adsorb metal ions is a better alternative to conventional copper removal methods. The structure of collagen shows that it contains the possible functional groups such as phosphate, carboxyl, amine and amide, that are involved in the bio sorption of heavy metals. In this study, collagen was extracted from bovine bone and was used as a bio sorbent in the investigation of copper sorption capabilities under different collagen to copper mass ratios and contact times. With the use of a collagen to copper mass ratio of 1.4, 15.3% of the copper was removed after four hours. After three days, 30% of the

copper was removed with the application of a collagen to copper ratio of 1.2. Larger amounts of copper added and longer contact times yielded higher sorption percentage of the collagen.

DESIGN OF A COLD PLASMA GUN FOR USE IN DISINFECTION OF BIOFILM INFECTED SURFACES IN THE DAIRY INDUSTRY

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The main aim of the project was to design a cold plasma gun for use in the disinfection of biofilm infected surfaces in the dairy industry. The scope was to produce a cheaper method of disinfection that does not involve the use of chemicals and enzymes. The use of chemicals is costly in the long run and if not total removed in the pipelines they may distort the product taste. There is need to come up with a design model for use in the designing of the gun, in this project the 5-linear design model was used. The biofilm causing species of bacteria were identified and isolated. These include *E. coli, Bacillus spp* and *L. monocytogenes*. These microorganisms were inoculated into sterile milk and cultured until 1000 colonies were grown. The gun was fabricated and tested at using air and nitrogen at different pressure, exposure time and distance. Results obtained indicated that the use of a pressurised gas is more effective than the use of air. The closest distance between the gun nozzle and the biofilm produced the most effective results. The optimum conditions that had the highest bactericidal effect were found to be a gas pressure of 1 kPa, at a distance of 5mm from the biofilm surface, and exposure time of 300 seconds using nitrogen gas.

INVESTIGATION OF FUNCTIONAL PROPERTIES OF *MUSA ACUMINATE* (BANANA) PEEL PECTIN FOR USE IN FOOD APPLICATIONS.

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The main aim of the project is to extract pectin from banana peels and investigate its functional properties in food systems. The idea was based on the fact that pectin is an expensive commodity, which is being imported into the country at very high prices. The use of banana peels which are being regarded as waste products, have been found to contain about 10- 21% crude pectin which can be of economic importance as a source of pectin, rather than relying on pectin from citrus fruits and apple pomace. There is need to investigate the functional properties of the banana pectin, so that it can be used in the food processing industry as a thickener, jellying agent and a stabilizer.

DEVELOPMENT OF A NATURAL SWEETENER FROM SORGHUM STALKS (SORGHUM BICOLOR (L.) MOENCH)

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This study generally focuses on the development of a natural sweetener from sorghum stalks. Cane sorghum is the juice of the plant, Sorghum bicolor (L.) Moench, a grass technically, that is boiled down and clarified to make a syrup used as a natural sweetener. The project emerged due to a number of reasons which include prolonged droughts in Zimbabwe, the Ministry of Agriculture has been encouraging the farming of small grain crop like sorghum, millet and rapoko which are drought resistant (UNICEF Zimbabwe, 2016). There is minimum utilization of sorghum stalk as it regarded as waste material. Also due decrease in sugar production there is need of production sugar uses other sources. Also when comparing with table sugar, which is believed to be 100% empty calories devoid of nutrition, a purely natural sweetener like sorghum syrup is believed to have some nutritive value (Woods, 2000).

DEVELOPMENT OF A PEROXIDASE SYSTEM FOR PRESERVATION OF FRESH ORANGE JUICE

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The scope of the study was to develop and evaluate a peroxidase system for the preservation of fresh squeezed orange juice. The activity and concentration of peroxidase enzyme in fresh squeezed orange juice was determined. The effect of pH and temperature on the activity of peroxidase enzyme was also evaluated. Activation of the peroxidase enzyme was done by adding thiocyanate and hydrogen peroxide, and optimization was done. The initial pH, titratable acidity, total soluble solids content was measured. Microbial analysis of fresh squeezed orange juice was done using serial dilution plate count technique, and the numbers of colony forming units of Eschericia coli, Salmonella species and Bacillus species in fresh squeezed orange juice was determined by the serial dilution plate count technique on selective media. Four treatments containing 5, 10, 15 and 20mg of thiocyanate and 1.7, 3.4, 5.1 and 6.8mg of hydrogen peroxide respectively, were used to activate the peroxidase system. The effect of these treatments on the physiochemical properties of fresh squeezed orange juice over 30 days of storage at 7 and 25℃ was studied. The antimicrobial efficacy of the four treatments against microbial survival in fresh squeezed orange juice and against Eschericia coli, Salmonella species and Bacillus species over 30 days of storage at 7 and 25℃ was determined. The shelf life of the peroxidase treated orange juice was evaluated at two varying storage temperatures of 7 and 25℃. Sensory evaluation of the of the peroxidase treated juice in terms of appearance, colour, aroma and taste was done relative to fresh squeezed orange juice. Data obtained was statistically analysed using ANOVA. The concentration of peroxidase enzyme in fresh squeezed orange juice was found to be 126U/L, with optimum pH and temperature of 4.2 and 25℃ respectively. The optimum concentrations required for the activation of peroxidase enzyme were found to be 20mg and 6.8mg of thiocyanate and hydrogen peroxide respectively. The peroxidase system was found to exhibit the best antimicrobial properties in preservation of fresh squeezed orange juice at a pH of 4.2, 25℃ processing temperature, 8 hours processing time and at a storage temperature of 7℃. The peroxidase system in treatment four was found have no effect on the physiochemical properties of fresh squeezed orange juice. The peroxidase treated orange juice attained an 80% overall acceptance in sensory evaluation and was found to have no effect on the sensory properties of fresh squeezed orange juice. The peroxidase system was found to achieve a $5\log_{10}$ reduction in the microbial load of unpasteurized fresh squeezed orange juice. The peroxidase treated juice was found to have a shelf life of 30 days at 7℃. It was then concluded the peroxidase system can be employed as a non-thermal method of preserving orange juice without adversely affecting the physiochemical and sensory properties of the orange juice.

DESIGN AND FABRICATION OF A GARLIC PEELING AND CRUSHING MACHINE FOR THE SMALL-SCALE PROCESSORS

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The research presents the design and fabrication of a garlic peeling and crushing machine for the small-scale processors. Hertz-Norman hybridization concepts for the designing model of the machine was used. The parameters considered in the designing of the machine includes time, speed, efficiency, throughput, costs and weight of the garlic bulbs. Peeling efficiency and throughput capacity were used to determine the performance of the peeling machine and were dependent on the peeling time, peeling speed and weight. The effect of weight and that of peeling speed on the efficiency of the peeler were further analyzed using two-way ANOVA at 0.05 significance level. The time needed to peel the cloves at different speed was also determined. Surface plot was used to determine the optimum parameters (coordinates) of the peeling and crushing machine. The ANOVA analysis indicates that the peeling speed affected the peeling efficiency to a greater extend at 95% confidence interval. The highest efficiency was observed and it was obtained at feed weight and peeling speed of 4kg and 500rpm respectively. The time needed to peel the cloves at different speed was also determined. The throughput at peeling time 10.9mins and feed weight of 4kg was observed to be 0.377kg/min. the efficiency was close to the values which were also observed in literature. However, there were distinct expected throughput values. Considering the efficiency and throughput, the peeling and crushing machine is suitable for process application for small scale operations.

DESIGN OF A PORTABLE FISH DESCALING MACHINE

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The aim of the project was to design and fabricate a portable electrical fish scaling machine and to evaluate the effectiveness of the designed machine against the current knife scaling method. The main objective was to increase the efficiency and throughput of the scaling method. An 8 linear design model of design suggested by (Khurmi and Gupta, 2005) was used in the design of the fish scaler. This design machine consists of an electric motor which provides mechanical motion to the blades. The operator does not apply greater force during the operation. The power source of the machine is a rechargeable battery of 12 volts. The portable fish scaler device was compared to the knife scaling method on its effectiveness on the removal of scales, mechanical damage on the fish skin (bruises) and throughput. The average efficiency, percentage of bruised fish and throughput of the machine was 90%, 7.14% and 18 fish per 30 minutes respectively. To improve the efficiency of the designed machine, it is recommended that an improved design of the fish scaler with longer and wider fish board and blades that can move horizontal whilst they are rotating.

PRODUCTION OF EDIBLE COATING FROM CORN STARCH: A CASE OF FRESH CUT PEARS.

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The aim of the project was to produce an edible coating from corn starch in a case of fresh cut pears. The starch was gelatinized at 160^{o}C in a water bath for 30 minutes and was cooled to 80^{o}C. Then 10% of glycerol was added. As recommended by Voilley, 1994 glycerol should be added at concentration between 10-30%. Trials of 0.5%, 1%, 2% and 3% starch solutions were prepared and each starch concentration was plasticised using 10%, 20% and 30% glycerol concentration respectively. The results obtained indicated the moisture content loss after coating, changes in weight and sensory properties. The samples were evaluated after every 2 days for 14 days. During the 14 days of storage, significant decrease of moisture from 83.5% to 69.18% as

observed in coated pears (Table 4.1). Maximum decrease of moisture was observed in sample T0 (59.38%) followed by T1 (57.69) respectively. Minimum decrease of moisture was recorded in sample T4 (69.18%) followed by the sample T3 (69.12%) respectively. Weight loss during the 14 days of storage showed decrease with uncoated pears showing the greatest decrease (45.12g) and T4 had the least weight loss with weight of 51.35g. The Anova results indicated that there is a significant difference in using different treatments on sensory properties.

ANTIOXIDANT EFFECT OF MANGO (*MANGIFERA INDICA L)* SEED KERNEL IN POTATO CRISPS

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The aim of this study was to investigate the antioxidant effect of the mango (*Mangifera indica L*) in potato crisps. Phenolic compounds were extracted from mango seed kernels using 2 methods; acidified ethanol and water extraction. The extracted phenolic compounds were added to potato crisps and subjected to 50 at different time interval of 3,6,9 upto 18days.Some of the potato crisps were exposed to air and others were packed in aluminium foils. The peroxide values were calculated to determine the stability of potato crisps. The potato crisps containing phenolic and put in aluminum bags had a low peroxide value of 0.887mEq/kg at day 3 and 8.654mEq/kg at day 18.Potato crisps without phenolic compound and exposed to air showed the highest peroxide value of 32.1meq/kg at day 3 and 221. 1mEq/kg at day 18. The differences in the peroxide values of potato crisps may be due to presence of phenolic compounds with dihydroxyl group which can conjugate transition metals, preventing metal-induced free radical formation thereby minimizing lipid oxidation. Therefore, the antioxidant properties of phenolic compounds can be used to increase the oxidative stability of potato crisps. The antioxidant and thermal stability of phenolic compounds needs further investigation.

REDUCTION OF COOKING TIME BY USING OHMIC HEATING FOR COOKING NYIMO *(VIGNA SUBTERRANEA)*

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The main aim of this project is to reduce was to reduce the cooking time of canned *Vigna subterranea* by use of Ohmic heating. 6 samples were prepared each containing 200 grams of V.Subterranea, the samples were heated were heated using Ohmic heating in which alternating current was released into the food product and resulted in internal energy generation. The samples were heated using different voltages in order to analyze the maximum temperature and the changes in sensorial attributes of the sample. The samples were heated using voltages of 20,40,60,80,100 and 120 volts. The temperature increases linearly with rise in voltage from 90 ^{O}C to 140 ^{O}C. The results showed that the sample heated using 80 volts produced good sensory attributes using the Duo-trio test. Paired comparison test was used to analyze the difference in texture, color and aroma of the sample heated using Ohmic heating and retort heating. The results showed that Ohmic sample had good texture, color and aroma as compared to retort heated sample. Ohmic heated sample was further analyzed for the anti-nutritional content and the results showed that it contained 2.4 mg/100 grams polyphenols. 1033.10 mg/100 grams phytic acid and 2.50 mg/100 grams tannin.

EVALUATING THE EFFECTS OF RESIDUAL SANITIZERS AND DETERGENTS ON ACTION OF CULTURE IN CULTURED MILK PRODUCTS

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The project seeks to evaluate the effects of residual sanitizers and detergents on action of culture in fermented milks. Natural flora and desired texture in fermented milks of indigenous varieties have been continuously changing due to the introduction and use of imported chemicals which include antibiotics used in treatment of infectious diseases in cows and also sanitizers and disinfectants used in the CIP of the dairy plant. Due to the necessity to preserve our natural starter cultures and to increase the viability of them for industrial use, investigations were carried out to evaluate the extent to which fermented milks are affected by the presence of residual chemicals of sanitizers and detergents. The aim of this project was to collect samples of yogurt in the process line which will be used for further analysis on the research. A total of 21 yogurt samples were collected and were inoculated with solutions of sanitizers and detergents used on the dairy plant. The sanitizers used include peracetic acid (CH_3COOH), Oxi-acid (), and caustic soda (NaOH) which were used at concentrations of 10^0-10^{-2}. The samples were incubated at temperatures of 40-44^{0}C for 4-5 hours using *L. bulgaricus* and *S.thermophilus* starter cultures. The samples were allowed to set in the refrigerator for 12 hours at temperatures of 7^{0}C. The pH of the yogurt samples was measured and the desired pH was obtained in samples which contained all the three sanitizers and also for nitric acid (4.6). Samples were evaluated using a hedonic scale which ranged from 1(indicating poor sensory characteristics) to 5 (indicating good sensory characteristics), evaluating the sensory characteristics of the yogurt. Samples which contained solutions of peracetic acid and NaOH showed poor starter development hence the body of the yogurt was not as desired.

PRODUCTION OF LOW SUGAR CAKE FROSTING USING STARCH FROM AVOCADO SEED

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The aim of the study was to extract starch from avocado seeds and use it in the production of cake frosting. The extraction was achieved by two methods which are alkali extraction method and enzyme extraction method. The alkali extraction method was found to have a higher

percentage starch yield than enzyme extraction method. The starch obtained was identified using three methods which are iodine test, microscopy and differential method. The starch that was obtained was stained blue black in the iodine test and when viewed under a microscopy the granules showed two distinct shapes which are circular and triangular. The differential test resulting in the starch being dyed blue with methylene dye. The purity of starch was also determined using sulphur dioxide test and the amount of sulphur dioxide was found to be in the acceptable range which is below 50mg. The functionality of the starch was determined considering the binding and viscosity. The binding properties was determined by suspending the starch in distilled water for about an hour and centrifuged. Then supernatant was decanted and the weight of drained starch was weighed. The binding properties where then calculated using an equation. Avocado seed starch was found to have higher binding capacity than that of corn starch. The viscosity of the starch was also determined and it was found that the starch from alkali extraction method was found to have higher viscosity than that from enzyme extraction method thou the difference was not significant. A starch cake frosting was then formulated based on the viscosities of starch solutions at different concentrations and then comparing them with that of sugar solution. 0.2% starch was found to have almost the same viscosity with that of 20% sugar solution and was used in the production of cake frosting. The viscosity of the cake frosting was also determined so as to confirm if it has the same viscosity with the already existing cake frosting. The total calorie of the cake frosting was estimated and found to be 855.86 calories which was lower than that of the already existing cake frosting with an amount of 800 calories.

DEPARTMENT OF PHARMACEUTICAL TECHNOLOGY

EVALUATION OF ANTIBACTERIAL ACTIVITY OF *ZANHA AFRICANA* FOR THE POTENTIAL TREATMENT OF SINUSITIS

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The inappropriate usage of antibacterial agents, has led to an increase in the cases of antibiotic resistant strains of pathogens causing sinusitis in the past decade. Amongst the strains, *S.*

pneumonia is the one responsible for the antibiotic resistance. Medicinal plants have stood the test of time in the management of various illness. In the last decade the advocacy of the use as alternative source of drugs has increased. In Zimbabwe *Z. africana* is a common plant used for the treatment of bacterial infections. In order to investigate their potential, use a research was conducted using *Z. africana* leaf and bark extracts. The active metabolites from *Z. Africana* were extracted using ethanolic solvent extraction and the disc diffusion method was used for the determination of antimicrobial activities with MacConkey agar as the nutrition broth. The phytochemical investigation carried out on the leaves and bark of the medicinal plant revealed the presence of saponins and flavonoids. Maximum antimicrobial activity was shown by *Z. africana* bark aqueous extracts which had highest zone of inhibition diameter of 17mm as opposed to that of the leaf extract which was 16mm. The MIC of 20% w/v was lower than of the leaf which is 40% w/v. Significant antibacterial activity was found with the ethanolic bark and leaf extract compared with standard drug amoxicillin (100 mcg/ml) and the one-way ANOVA analysis was used to validate this comparison. The one-way ANOVA analysis showed that the effectiveness of antibacterial activity in the leaf and bark extract is almost similar to that of amoxicillin. The study reviewed that these plants could be used for the formulation of antimicrobial agents for treatment of sinusitis. Recommendations are that further invovo studies be done to establish safety and efficacy. After safety evaluations it is recommended the bark extracts be in cooperated into antibacterial formulations

Key words: antimicrobial activity, sinusitis, minimum inhibitory concentration, zone of inhibition and *Z. africana.*

INVESTIGATION OF ANTIBACTERIAL AND ANTIFUNGAL ACTIVITY OF *C.CITRINUS* AND *S.CORDATUM EXTRACTS* AGAINST SELECTED OPPORTUNISTIC PATHOGENS

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In management of opportunistic infections (OI) the major challenge is with the increasing incidence of strains of microbial with multiple antimicrobial resistance and the persistence infections in immunocompromised individuals. It is therefore of great importance to find effective treatments for infections by microbial pathogens through scientific research. The purpose of this study was to document the indigenous knowledge of possible use of *Callistemon citrinus* and *Syzygium cordatum* in the management of opportunistic microbial infections. OIs occur when host defenses are compromised by disease or its treatment. They cause morbidity and mortality in immunocompromised person's e.g in cancer and HIV/AIDS patients. In this study the leaves and stems of *C.citrinus* and leaves of *S.cordatum* were collected from Belvedere and Mutare

respectively and were dried in an oven at 40°c. Maceration extraction using 70% ethanol and phytochemical screening was done on the extracts. Antimicrobial activity of the plants was accessed by paper disc diffusion method and through MIC tests on *P.aeruginosa E.coli, A.niger, C.albicans* and *S.aureus. Itraconazole* (25 µg/ml) and ciprofloxaxin (25 µg/ml) were used as standards. The lowest MIC value of *C. citrinus* and *S.cordatum* was found to be 3.125 against *A.niger* and 3.125 against S.aureus respectively. The combined extracts showed the synergistic effect against *C.albicans* and S*.aureas* with MICs of 3.125 and 1.56 respectively. It is therefore safe to conclude that *C.citrinus* and *S.cordatum* extracts has a potential the management of opportunistic infections as they were found to be effective against the selected pathogens .

Keywords: *C.citrinus* , *S.cordatum***,** Antimicrobial activity, Phytochemical screening

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INVESTIGATION OF ANTIBACTERIAL ACTIVITY OF *PSIDIUM GUAJAVA L.* AND *BURKEA AFRICANA* EXTRACTS AGAINST SELECTED FOODBORNE PATHOGENS

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The present study was conducted to evaluate the antibacterial activities of aqueous and ethanol extracts from leaves, of Psidium guajava L and the stem bark of *Burkea africana*. Their antibacterial activities of the extracts against were determined against two food-borne pathogens: *Staphylococcus aureus* and *Escherichia coli* by using disc diffusion method at four different concentrations: 10%, 50%, 75% and 100%. The aqueous and ethanolic extracts of P. guajava leaves were active against the gram-positive bacteria *Staphylococcus aureus* (MICs=25mg/ml,6.25 mg/ml respectively) and the gram-negative bacteria *Escherichia coli* (MICs 50 mg/ml,12.5mg/ml respectively).The aqueous and ethanolic extracts of *B.africana* stem bark were active against the gram-positive bacteria Staphylococcus aureus (MICs=25mg/ml ,12.5mg/ml respectively).The *Burkea africana* extracts showed no inhibitory effects against *Escherichia coli.* The ethanol extracts showed higher antimicrobial activity as compared to aqueous extracts indicating that the active compounds responsible for antibacterial activity is more soluble in organic solvents. The ethanolic extracts gave the highest yield percentage as compared to aqueous extracts. Psidium guajava extracts showed higher antibacterial activity

against gram positive bacteria compared to gram negative bacteria. Phytochemical screening showed that the herbal medicinal extracts under study contained saponins, cardiac glycosides, phenolics, triterpenes, alkaloids and flavonoids. Gram-negative bacteria were less sensitive than Gram-positive bacteria, which may be due to their differences in the cell wall composition.

Keywords: *Antibacterial activity, food borne pathogen, Psidium guajava, Burkea africana Escherichia coli, Staphylococcus aureus*

EVALUATION OF ANTI-ASTHMATIC ACTIVITY OF DICHROSTACHYS CINEREA IN ALBINO RATS

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The aim of the study was to evaluate the scientific basis for the traditional use of *Dichrostachys cinera(*Mupangara) roots in treating asthma using experimental albino rats. In this study, the methanolic extract of *Dichrostachys cinerea* was evaluated for preliminary phytochemical study and the asthmatic activity by histamine induced preconvulsion dysnoea (PCD) in albino rats at different dose levels. In PCD albino rats were divided into four groups and the percentage increase in the time of preconvulsion dysnoea (PCD) was recorded. The PCD time at day 0 and day 7 was recorded, the methanolic extract was administered at the doses 100, 200 and 400mg/kg in albino rats per oral given once daily for 7 days, including the one given after PCD on day 0 and two hours before PCD on day 7 and it was compared to the control promethazine at 300mg/kg per oral given once daily and also the same time, with the methanolic extract of *Dichrostachys cinerea*. Student t-test was used for statistical analysis. The phytochemical study of the methanolic extract of *Dichrostachys cinerea* revealed the presence of alkaloids, cardiac glycosides, tannins, flavonoids, saponins, carbohydrates, steroids and triterpenes. The treatments with the methanolic extract of *Dichrostachys cinerea* showed a significant increase($p^{**}<0.01$) in time in histamine induced preconvulsion dyspnea as compared to the histaminic induced preconvulsion dyspneoa time of the untreated albino rats. The results of the present study shows that, *Dichrostachys cinerea* methanolic extract of its roots, significantly protected the albino rats against histamine induced preconvulsion dyspnea. Therefore or thus It can be concluded, that the methanolic extract of the roots of *Dichrostachys cinerea* may possesses anti-histaminic activity or properties which may be attributed to H1- receptor blocking or which may be due to bronchodilating activity.

FORMULATION OF AN ORAL GEL TO ALLEVIATE SYMPTOMS OF MUCOSITIS IN CHEMOTHERAPY PATIENTS INCORPORATING EXTRACTS OF *CALENDULA OFICINALIS* AND *ACANTHOSPERMUM HISPIDUM*

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The study was carried out to formulate an oral gel incorporating crude extracts of *Calendula officinalis* (Mari gold) and *Acanthospermum hispidum (chidhongi)* to alleviate symptoms of mucositis in chemotherapy patients. Mucositis is a condition characterized by pain and inflammation of the surface of the mucous membrane in the mouth which occurs in approximately 40 percent of patients receiving standard dose chemotherapy. The formulation of *C. officinalis* and *A. hispidum oral gel* has antifungal, antibacterial and anti-inflammatory properties and is cost effective relative to the existing treatments. 70% ethanolic solution was used to extract the phytoconstituents from *A. hispidum and* hydro distillation was used to extract *C. Officinalis* oil. Standard phytochemical tests from the British formulary were used to cornfirm the presence of tannins, sapponins, alkaloids and flavonoids which are responsible for pharmacologic effects. MIC tests were done using the extracts and the oil on C. *albicans* and S. *aureus* using Fluconazole and ciprofloxacin as standards. Freeze thaw and window ledge tests were used to test for stability of the produced gel.124 ml of *A. hispidum* extract obtained were used in the MIC test and produced an inhibition at 50% on S. aureus and 100% on C.*albicans* . 72 ml of *C. officinalis* oil was obtained and used in the MIC tests which was 50% on S. aureus and no inhibition on C. albicans. Fluconazole exhibited a zone of inhibition (ZI) of 18mm at 100% concentration. The formulated gel incorporating *A. hispidum and C. officinalis* passed all the stability tests. It was concluded that the plants Calendula officinallis and *Acanthospermum hispidum* crude extracts have the potential in alleviating symptoms of Mucositis as they were found to be effective against C. albicans and S.aureus. Further tests on the plant species used are highly recommended as they possess potential for use in treating other ailments. Formulations of other dosage forms such as a mouthwash are also recommended.

Key words: *Acanthospermum hispidum, Calendula* officinalis, ZI, herbal, oral gel, Mucositis.

THE IN-VITRO INVESTIGATION OF THE INTERACTION BETWEEN *ANANAS COMOSUS* CRUDE ENZYME AND SELECTED ANTIBIOTICS AGAINST *STAPHYLOCOCCUS AUREUS* AND *ESCHERICHIA COLI.*

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The uncontrolled and inappropriate use of antibiotics has resulted in the increasing prevalence of antibiotic-resistant pathogens leading to the emergence of new and the re-emergence of old infectious disease. Thus this research aims at developing an herb-drug combination as an alternative strategy using *Ananas comosus* (pineapple) crude enzyme to combat the problem of Antimicrobial Resistance (AMR). The crude enzyme were extracted by homogenization making use of sodium acetate buffer. The extract was then filtered and centrifuged at 10000rpm for 10 minutes to obtain a clear solutions. The concentration of the crude enzyme was also determined using Lowry's method making use of the U/Vis-spectrometry and the standard BSA, the concentration of the pulp extract was 6,2 mg/ml and the concentration of the stem and peel was 9,7 mg/ml. The enzyme activity of the crude enzyme was determined and the crude enzyme exhibited proteolytic activity as it digested gelatine at a range of temperature of 40^{o}C-50^{o}C and at a pH range of 6-7. The enzymatic activity was quantitatively analysed using the GDU technique for specific activity. The disk diffusion technique was used to determine the in-vitro interaction of the crude enzyme and the antibiotics and the plate were incubated at 45^{o}C which is the optimum temperature for the enzyme. The antibiotics used included Amoxicillin, Erythromycin and Doxycycline. The bacteria that was inoculated included *Staphylococcus aureus* and *Escherichia coli*. The results of the study concluded that the crude enzyme potentiates and synergies with the antibiotics studied and this is of great benefit to the pharmaceutical and medical field.

Keywords: *Drug resistance, Ananas comosus, Crude enzyme, Antibiotics, UV/VIS spectrometry, Gelatin digestion Unit, Disk diffusion assay***.**

ISOLATION AND EVALUATION OF POLYMER MUCILAGE OF *DICEROCARYUM ZANGUEBARIUM* AS A PHARMACEUTICAL EXCIPIENT

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Natural gums and mucilage are an important part of development of pharmaceutical dosage forms. The aim of this study was to isolate mucilage from *Dicerocaryum zanguebarium* and determine its functional and physicochemical properties. Using solvent based extraction method with 96% ethanol, the yield of mucilage was found to be 15.6%. Physicochemical characterization of the mucilage showed a swelling index value of 15.3%, loss on drying was 7.38%, a pH range of 5.1-6.5 and an average viscosity of 10.5Po. Results obtained from the micromeritic characterization and flow behavior showed that *Dicerocaryum zanguebarium* mucilage is a good candidate to be used as pharmaceutical excipient. An angle of repose value of 31.8 was obtained showing good flow properties of the mucilage powder. Compressibility index of 9.33% and Hausner's ratio of 1.102 indicate that the powder has excellent flow properties and can be easily compressed. Granules prepared from the mucilage showed good flow properties indicating successful binding ability of the mucilage extract. Granule properties such as angle of repose, moisture content, bulk and tapped densities, Hausner's ratio, Carr's index obtained indicate that mucilage of Dicerocaryum zanguebarium possesses comparable binding properties. The suspending properties of *Dicerocaryum zanguebarium* gum were evaluated at concentrations of (1.0,1. 5 and2.0%w/v). The highest emulsifying capacity of the mucilage (85.80%) was obtained at mucilage concentration of 2%w/v. The isolated mucilage exhibits properties that recommend it as a natural material that can be used as an additive in the pharmaceuticals and cosmetics industries.

Key Words: *Polymer mucilage, Excipient, Dicerocaryum zanguebarium*

EVALUATION OF STABILITY AND CONSISTENCY IN API OF EXTEMPORANEOUSLY PREPARED SILDENAFIL SUSPENSION

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Sildenafil is a potent and selective phosphodiesterase-5 inhibitor that is effectively used in the treatment of pulmonary arterial hypertension. Persistent pulmonary hypertension of the new born is a condition associated with increased pulmonary vascular resistance and pulmonary artery pressure, which may eventually lead to heart failure and death unless treated appropriately. It occurs in about 6.8 of 1 000 live births. The off label use of sildenafil was approved by the FDA in 2005 after a number of papers were published on its efficacy and safety (Namachivayam *et al.,* 2006; Barnett, 2006). Due to the inadequacy of data and evidence in stability in most drugs used in rare conditions common in children there is lack of licenced liquid formulations. In several countries, hospital and community pharmacists prepare the drug in an extemporaneous liquid preparation. The purpose of this study was to evaluate the stability of an extemporaneous sildenafil citrate oral suspension for 30days, according to the ASEAN guideline on stability studies of drug products. In this study two suspensions were made, one was syrup based and the other was aqueous based both without preservatives. Validated HPLC method was used to analyse the

stability and consistency of sildenafil. The chromatographic condition used a C18 column with a mobile phase consisted of Methanol, water and triethylamine (63:37:0.6) pH adjusted to 4%. The flow rate was performed at 1.0 mL/min, and UV detection was monitored at 245 nm. The results showed that the preparation was a greenish fairly cloud suspension with a sweet taste for syrup based and bitter taste for aqueous based. It was a viscous and weakly acidic mixture. The drug content was in the range between 99.23% and 99.9%, and the physiochemical stability met the general requirements throughout the study period. Therefore, the extemporaneously compounded sildenafil suspensions were physically and chemically, stable for at least 30 days when stored at 4° and 30°C. Furthermore, the in-use stability study showed that the preparations had acceptable attributes at least 14 days after the first-time use. This might provide an alternative option when the commercial suspension is unavailable.

Keywords: ASEAN guideline, Extemporaneous preparation, Sildenafil, Stability study, Suspension, off label

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EXTEMPORANEOUS PREPARATION OF PRAZIQUANTEL SUSPENSION FROM COMMERCIALY AVAILABLE TABLETS FOR THE TREATMENT OF HISTOSOMIASIS IN CHILDREN

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The lack of commercially available oral liquid dosage forms is a problem in Zimbabwe and other developing countries. Extemporaneous preparations are prepared mainly in hospital and community pharmacies to ease the problem of dosages in paediatrics and children. A pharmacist is often challenged to provide extemporaneous oral liquid preparation for children and paediatric patients.

Three Praziquantel aqueous suspensions for oral usage in children (30mg/ml) were investigated to determine their physicochemical stability under different storage conditions in amber plastic bottles with plastic closure caps. Formulations of Praziquantel suspension using sugar syrup and sugar-free bases were stored at 4^{o}C, room temperature (approximately 25^{o}C) and at 37^{o}C and the Praziquantel content was determined by reverse phase high performance liquid chromatography with UV/vis detector. Each sample was analyzed at different time points (0, 3, 14 and 28 days).

Praziquantel liquid suspensions were successfully formulated from Praziquantel 600mg tablets available commercially. Both sugar and sugar free suspensions were found to be stable under different storage conditions in amber plastic bottles with plastic closure caps over a period of 28 days. No physical changes such as color and smell changes were noticed in all the samples and this shows that the suspensions were also stable physically.

In conclusion, both sugar and sugar free Praziquantel suspensions can be stored in amber plastic bottles at 4^{o}C, 25^{o}C and 37^{o}C for a period of 28 days

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IN VITRO INVESTIGATION OF THE POTENTIAL ANTIBACTERIAL ACTIVITIES OF THE PERIPLANETA AMERICANA AGAINST SELECTED BACTERIAL PATHOGENS

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Currently bacteria and other pathogens continue to form resistant strains posing a challenge against existing antimicrobial synthetic agents hence the urgent need to develop novel antibiotics sources so as to salvage this menace. The trends of antimicrobial resistance are worsening by the day and driving research towards pre-antibiotic era. This has led to studies for the discoveries of new antibiotic compound originating from natural resources and has shown to be a promising research area. Insects have a long standing history of coexisting with a range of microorganisms, e.g cockroaches dwell in unhygienic places and hence tends to harbor and expose them to different types of microorganisms that are invasive and harmful in nature that are found in their habitants.Thus making them a good choice to replace bacteria-resistant chemical compounds. Cockroaches could be using immunological responses similar to that of vertebrates to fight against pathogenic bacteria that may serve as a threat to *it.* The study was aimed at investigating the antibacterial effect of the *Periplaneta americana* extract on susceptible and resistant strains of selected nosocomial bacteria namely *Pseudomonas aeruginosa, Staphylococcus aureus* and *Escherichia coli.* The *Periplaneta americana was* pulverized and mixed with different solvents (chloroform,75% alcohol and DMSO)for maximum compound extraction and was assayed on selected pathogens. The results of the study showed the maximum zone of inhibition 23mm against *Staphylococcus aureus*, followed by *Escherichia coli* 18mm and moderate effects were observed *Pseudomonas aeruginosa.* Minimum inhibition concentration fo r *E.Coli* and *S.aureus is 0.01% v/v* (10^{-2}) and 0.1%(10^{-1})for *P. aeruginosa* .Commercial antibiotics ciprofloxacin and vancomycin were used as controls and zone of inhibition compared with those obtained. Clinical Laboratory Standard Institute (CLSI) methods (2018) was used as reference guide for

interpretive categories and were used in determining the Minimum inhibitory of the highly active extract .DMSO extract was the most active against methicillin sensitive *Escherichia co*li and *Staphylococcus aureus* with zone inhibition ranges of 19-23mm,resistant effect was noted in *Pseudomonas aeruginosa*.

KEY :*antimicrobial,resitance,antibiotic, Periplaneta Americana,immunological,DMSO*

ANTIFUNGAL ACTIVITY OF *O. GRATTISSIMUM*, *M. UNDATA* AND *Z. CAPENSE* AGAINST SELECTED OPPORTUNISTIC PATHOGENS.

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Development of more effective and less toxic antifungal agents is required for the treatment of candidiasis and cryptococcosis. Plants and their extraction preparations have been used as medicines against infectious diseases. In this research project, the following plants were used to determine their antifungal activity; *Occimum gratissimum (Chinyamupfukidzi mukonan'anga), Maytenus undata and Zanthoxylum capense.* Phytoconstituents in the plants were extracted with different organic solvents to investigate their antifungal activities *in vitro*. The extracts were screened for different secondary metabolites. *M.undata* had terpenoids, tannins and alkaloids whereas *O. gratissimum* had alkaloids and terpenoids. The plant extracts showed significant antifungal activity when compared to the activity of positive standard fluconazole*. O. gratissimum* showed a mean zone of inhibition of 23mm*, M. undata* had a mean zone of inhibition of 18mm and *Z. capense* had a mean inhibition of 20mm. *Z. capense* and *M. undata* had significant anticandidal activity and O. gratissimum had significant activity against *C. neoformans*. Greater inhibition was seen at 100% concentration of the extract. The MICs were as follows: for *O. gratissimum* 6.25-12.5mg/ml for the three pathogens, *M. undata* ranged from 3.125-25mg/ml for the different pathogens and *Z. capense* ranged from 6.25-50mg/ml for the different pathogens. Combining the 3 extracts had significant synergism against all three pathogens with an MIC of 3.125mg/ml and the combination of *Z. capense* and *M. undata* was more effective against the candida species.

Key words: *Antifungal activities, inhibition, MIC, synergism*

ANTIFUNGAL ACTIVITY OF THEVETIA PERUVIANA SEED EXTRACTS

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The aim of the present study was to investigate the antifungal activity of *Thevetia peruviana* seed extracts. The hexane extracts *of Thevetia Peruviana* were tested against two fungal species *Candida albicans* and *Candida krusei by* disc diffusion method. The result showed promising antifungal activity against the tested fungi. Among these, the hexane extract was found to possess a more potent inhibitory effect against *C.albicans* . Antifungal activity of the test extracts at different inhibitory concentration (12.5, 25.50, and 100 µl/ml) were used. The ability of the crude seed extracts of *Thevetia peruviana* to inhibit the growth of fungi is an indication of its broad spectrum antimicrobial potential which may be employed in the management of microbial infection. The maximum zones of inhibition obtained were 15.00 mm and 14.50 mm for C.albicans and C.krusei at 100μl/ml respectively .The results showed that *C.albicans* is the most susceptible to the antifungal activity of *T.peruviana.*The results also showed that as the concentration of the crude extract increased the activity also increased.

Key words: *Thevetia peruviana , hexane , disc diffusion , antifungal, Candida krusei, Candida albicans.*

DEVELOPMENT OF PAPER STRIPS INCORPERATING MANDELIN'S REAGANT AND IODOFORM FOR DETECTION OF KETAMINE AND ALCOHOL DRUGGED DRINKS.

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With drug facilitated sexual assaults nowadays fast becoming one of the most common and devastating problems in universities and many other social gatherings, the advent of drug detecting materials that can react with a number of drugs that are used for spiking purposes is of paramount importance. There are several drugs that might be used for drugging purposes for example benzodiazepines especially flunitrazepam, ketamine and alcohol are readily available to people who drug other individuals and therefore are frequently involved in spiking incidents. A number of identification tests in Zimbabwe are available but these are only carried out after a case has been presented hence the introduction of the strips is of importance since it focuses on prevention of getting drugged rather than identifying the presence of a drug after the damage has been done. Testing apparatus available in foreign countries are bulky, expensive, not easily portable difficult to operate. To develop paper strips, blotting paper was folded, dipped in wax ,dried, soaked in Mandelin's reagent (for the ketamine detecting strip) and iodoform (for the alcohol detecting strip). A green colour on the strip indicated the presence of ketamine from a concentration of 2mg/10ml of juice whilst a yellow colour indicated the presence of alcohol from a concentration of 5%. The ketamine detecting strip changed its colour to blue when exposed to sunlight and air and the alcohol detecting strip was more stable when subjected to different conditions but both strips only showed effective detection in seven days from the manufacturing date. The strips should be stored under cool dry condition, away from sunlight.

Keywords: *Spiking, Ketamine, alcohol, Mandelin's reagent, Iodoform*

INVESTIGATION OF APPETITE ENHANCEMENT PROPERTIES OF CHLOROCODON WHITEI USING ROOTS AND ROOT BARK

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Loss of appetite medically known as anorexia is caused by a number of factors such as illness, medication, pregnancy and depression. Whitei natively known as mungurauwe is found to have appetite stimulant properties and can hence be used in the treatment of low appetite. Chlororcodon whitei has been used in some countries in the southern Africa which include Zimbabwe and South Africa.

Aim

The aim of the study I to evaluate the ability of chlorocodon whitei which is known to improve appetite for its feasibility to be developed into a powdered encapsulated form. The other aim is to investigate its effects on appetite enhancement which were performed using laboratory mice

Design

A three armed study with six mice in each group was used. Each mice was given 1ml of fluid containing no addition for control purposes and each chlorocodon whitei extract and metoclopramide solution which was given for comparison purposes. Each test group was given relatively low doses for five days. The amount of food consumed by the mice and water was recorded. Ethanolic extraction was carried out for extraction of resins which antimetabolites are known to have appetite enhancement properties present. A further two day test of the amount of food consumed by the mice was carried out and the results were recorded. The capsules were made by pressing the male part in the clororcodon whitei powder until full the closing with the female part of the capsules.

Results

Statistics showed that there was a significant difference in appetite between the study groups. The mice feed with chlororcodon whitei showed an increase in appetite to a greater extent compare to the group of mice given metoclopramide.

Conclusions

It was proven that chloroocodon whitei powder can be incorporated in gelatin capsules which also enables masking of the taste of chlororcodon white powder which is a bit bitter. It has also been statistically proven that chlororcodon white enhances appetite in mice even at low doses over a longer period of time.

INVESTIGATION OF ANTIBACTERIAL EFFECTS OF *GYMNOSPORIA SENEGALENSIS* AND *PELTOPHORUM AFRICANUM* EXTRACTS AGAINST *STAPHYLOCOCCUS AUREUS.*

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Staphylococcus aureus is a leading cause of bacterial nosocomial infections and community-acquired infections in humans, associating with numerous skins infections such as impetigo, cellulitis and life-threatening diseases such as pneumonia, bacteraemia, infective endocarditis and toxic shock syndrome. Penicillin is the available current treatment for S. aureus infections. The increasing prevalence of methicillin resistant S. aureus (MRSA) and its ability to resist multiple drugs has caused a serious challenge for infection control. Patients subjected to broad-spectrum antibiotics and immunosuppressive therapies have higher risk of infection by this microorganism. Medicinal plants used in this study include *Peltophorum africanum* bark and *Gymnosporia senegalensis* leaves and they have both shown antibacterial effects against *Staphylococcus aureus.* Extraction of plant active constituents was done using 70% ethanol and distilled water. Percentage yields for *P.africanum* and *G.senegalensis* aqueous extracts were found to be 12.8% and 10% respectively. And that for ethanol extract were 20% and 14% respectively. Phytochemical screening was done and *P.africanum* was found to have many secondary metabolites than *G.senegalensis.* Paper disc diffusion method was used to determine the zones of inhibition of *S. aureus* by plant extracts. Zone of inhibition for S. aureus was found to be increased as the extract concentration were increased. Minimum inhibitory concentration tests were done using serialdilutions. The highest level of antibacterial effect against *S.aureus* was found in ethanol extracts. The plant extracts have shown to have significant antibacterial effects against S.aureas when combined. Therefore they have synergistic effects.

Keywords: *Staphylococcus aureus*, penicillin, resistance, medicinal plants, serialdilutions, disc diffusion.

EVALUATION OF ANTIFUNGAL ACTIVITIES OF *ZINGIBER OFFICINALE* AND *HHBISCUS SABDARIFFA* FOR TREATMENT OF ORAL CANDIDIASIS

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Oral candidiasis is an opportunistic infection of the oral cavity, it is caused by members of the fungal species *Candida*, most commonly by *C.albicans*. The aim of this study was to determine

the anti-fungal activities of *Zingiber officinale,* and *Hibiscus sabdariffa* against *Candida albicans*, as the current treatment being used has adverse effects. Increasing resistance to antifungals has become increasingly common, hence growing interest on the use of medicinal herbs or plants in the treatment of various diseases due to their promising results and fewer side effects. Ethanolic extract of plant materials of *Hibiscus sabdariffa* and *Zingiber officinale* were obtained by using 76 % ethanol for 7 days. The extracts were purified by using rotary evaporator to remove the solvent (ethanol) from the extract this was done at 40°C. Obtained percentage yield of *Zingiber officinale* was 5% w/w and of Hibiscus sabdariffa was 9.7% w/w. Phytochemical screening of the extract was done as described by literature. *Hibiscus sabdariffa* showed presence of tannins, saponins, flavonoids, alkaloids, terpenoids and anthocyanis whilist *Zingiber officinale* showed presence of saponins, flavonoids, alkaloids, and terpenoids. Minimum inhibitory concentration (MIC) of the extracts against *Candida albicans* was done by disc diffusion method and fluconazole was used as a positive control. Serial dilutions of test solutions (extracts and positive control) were made to come up with concentrations of 0.1%, 0.3%, 0.5%, 0.8%, and 1%. The MIC results obtained of *Hibiscus sabdariffa* at 1 % was 24mm, *Zingiber officinale* 23mm and fluconazole 24 mm. At 0.1%, the MIC results obtained of *Hibiscus sabdariffa* was 9mm, *Zingiber officinale* was 8mm and fluconazole 10mm. according to the results *Hibiscus sabdariffa* and Zingiber *officinale* posses antifungal activity as the inhibition diameter the showed at different concentrations against *C. albicans* was more less in the same range as that of the positive control, this could be attributed to by presence of various phytochemicals present in the plant extracts. With the findings of this study new pharmaceutical formulation can be explored.

Key words: *Hibiscus sabdariffa, Zingiber officinale,* MIC, *C.albicans*

ANTIMICROBIAL ACTIVITY OF THE ALCOHOLIC AND AQUEOUS CRUDE EXTRACTS OF *PARINARI CURATELLIFOLIA* BARK

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Antimicrobial activities of the dried bark extracts of *Parinari curatellifolia* (mobola plum) obtained from Ngomakurira, Domboshawa area in Zimbabwe were carried out using two different methods. Aqueous and alcoholic extraction was done. 99% ethanol was used for alcoholic extraction. A standard method for ethanolic extraction was used and a modified method was used for the aqueous infusion. The aqueous extract was obtained as a brown coloured infusion and the ethanolic extract was obtained as dark brown coloured oil which was liquid at room temperature. The oil percentage yield was 50% v/w. Phytochemical screening which targeted flavonoids and anthraquinone glycosides tested positive for both extracts for the presence of flavonoids but anthraquinones glycosides were only shown to be present in the ethanolic extract. The aqueous extract had no effect on *Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli* and *Candida albicans*. The alcoholic extract had an effect on *Staphylococcus aureus*, *Streptococcus pyogenes* and *Escherichia coli* with no inhibition on Candida albicans. The organisms' susceptibility varied with more inhibition to Staphylococcus aureus. The results obtained suggest that ethanolic extraction is a better method for *Parinari curatellifolia* dried bark extraction for antimicrobial activity purposes. The anthraquinones could be responsible for the observed antimicrobial activity of the ethanolic extract against *Staphylococcus aureus*, *Streptococcus pyogenes* and *Escherichia coli*.

Key words: Antimicrobials, crude extracts, *Parinari curatellifolia*

EVALUATION OF POTENTIAL APHRODISIAC ACTIVITY OF AQUEOUS *COMBRETUM MOLLE* EXTRACT IN MALE ALBINO RATS.

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Evaluation of the aqueous extract of *Combretum molle* roots on sexual behaviour of male albino rats was done in the study. The plant extracts at doses 50mg/kg and 100mg/kg were administered for 5 days. The general mating behaviour and libido were studied. The effect of the

extract on body weight and physical appearance was determined. The aqueous extract was compared with the standard reference drug sildenafil citrate. Oral administration of aqueous at doses of 50 and 100 mg/kg significantly increased the Mounting Frequency, Intromission Frequency and Ejaculation latency with reduction in Mounting Latency and Intromission Latency. It also significantly increased libido of the male rats. Clinical toxicity symptoms such as respiratory distress, salivation, weight loss, blood in stools, death, and change in appearance of hair as well as mortality prior to treatment with extracts were not observed at any period of the study. This aligns with the toxicity profile suggested by Jean David N'guessan 2012 et al. thus rendering support that short term use of the extract for this purpose is apparently safe. The results of the present study demonstrate that aqueous extract of *Combretum molle* roots enhance sexual behaviour in male rats. It also thus provides a rationale for the traditional use of *Combretum molle* roots as acclaimed aphrodisiac and for the management of male sexual disorders.

Keywords: *Aphrodisiac, Herbal medicine, Male sexual behaviour, Male rat, Combretum molle, Roots*

DESIGN OF A MOBILE PHONE DRUG AUTHENTICATION APPLICATION TO CURB THE PREVALENCE OF COUNTERFEIT MEDICINES.

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The intention of this project was to produce an effective mobile phone based application that if used appropriately, will stop infiltration, marketing and use of counterfeit medicines. Counterfeit medicines are pharmaceutical products whose standards of production, quality, efficacy, safety and authenticity are way below the established and are meant to fraudently imitate the original branded or generic drugs. The use of such drugs results in mortality, therapeutic failures, poor prognosis, adverse allergic reactions as well as drug resistance. Bar-code identification, mass serialization and radio frequency identification are some of the measures that pharmaceutical manufacturers have employed in order counter to this problem. The objectives of the project were to create internet based system that generates unique authentication codes that the user will enter into the android application and receive feedback on the medicines its authenticity. Php and

Java programming languages were used to code the application on the desktop interface and android studio used to build the android application for the user interface. An android application that operates using the internet was successfully made and after testing managed to verify drugs proving that it could be officially launched and used internationally as a way to prove the authenticity of the drugs. I highly recommend the expansion of the project from verification of medicines to other basic commodities that also facing the problem of counterfeiting as well as integration of the USSD code into the system in order to cater for those who do not have android and internet access.

Key words: *counterfeit drugs, mobile phone, authentication codes, authentication, internet*

EVALUATION OF ANTIBACTERIAL AND ANTIFUNGAL ACTIVITIES OF THE SEEDS DURANTA ERECTA.

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This study was carried out with the aim to evaluate the antibacterial and antifungal activities of the seeds *Duranta erecta*. The objective of the study was to assess the antimicrobial activity, determine the zone of inhibition of extracts on some bacterial and fungal strains and phytochemical profiling of the seed extracts. In the present study, the microbial activity of ethanol extracts and aqueous extracts of seeds of *Duranta erecta* was evaluated for potential antimicrobial activity against clinically significant bacterial and fungal strains. The antimicrobial activity was determined in the extracts using agar disc diffusion method. The antibacterial and antifungal activities of extracts (3.12,6.25,12.5,25.50,100 and 200 µl/ml) of *Duranta erecta* were tested against one Gram-positive—*Staphylococcus aureus*; one Gram-negative *Pseudomonas aeruginosa* human pathogenic bacteria; and two fungal strains *Aspergillus niger, Candida albicans*. Zone of inhibition of extracts were compared with that of different standards, ciprofloxacin for antibacterial activity and itraconazole for antifungal activity. The maximum zones of inhibition (14.66, 14.33, 13.33 and 12mm) were found against *C. albicans, Staphylococcus aureus, Pseudomonas aeruginosa and A.niger,* respectively at 200μl/ml concentration. C. albicans was the most sensitive organism to the seed extracts of *Duranta erecta*. Phytochemical

screening showed the presence of saponins, flavonoids, sterols and tannins which could be the ones which are responsible for the antimicrobial activity. These bioactive compounds are also known to act by different mechanism to exert antimicrobial activity hence could lead to the discovery of new classes of antibiotics with novel mechanisms of action.

Key words: *Duranta erecta,* disc diffusion, *Staphylococcus aureus, Pseudomonas aeruginosa, Aspergillus niger, Candida albicans*, saponins, flavonoids, sterols, tannins, ethanol.

EVALUATION OF ANTIDIARRHEAL ACTIVITIES FROM ETHANOLIC BARKS EXTRACTS OF CASSIA ABBREVIATA AND TODDALIA ASIATICA IN ALBINO RATS

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Globally, diarrhoea is a leading killer of children, causing more than 450,000 deaths each year in children under five and is responsible for millions of hospitalizations and clinic visits, (Armerine S, 2006). The current allopathic drugs used have several side effects manifested in kaolin and pectin that may cause in children paralysis of the intestines, meanwhile the ciprofloxacin also induce grey babies syndrome in premature and new-born infants (BNF, 2013). Therefore, the limitations in current medications may lead the evaluation of more potent plants extracts that are less toxic and have both antidiarrheal and antimicrobial agents such as *Toddalia asiatica* and *Cassia abbreviata.* However, I chose *Cassia abbreviata* (Murumanyama) and *Toddalia asiatica* (mugato) in my project because they are best well-known by traditional herbal medicines users for treating diarrheal (Tembo, 2004). The tests that were done in this project were phytochemical tests, MICs, and in-vivo antidiarrheal evaluation was done by inducing diarrhoea using castor oil and treat the albino rats using ethanolic extracts of *cassia abbreviata* and *Toddalia asiatica*. The results which I obtained in the MIC tests are of medicinal used since the plants ethanolic extracts of *Toddalia asiatica* and *cassia abbreviata* are effective against S. aureus and E. coli which possesses both antidiarrheal and antibacterial activities. The ethanolic barks extracts show the percentage inhibition of *cassia abbreviata* 65%, *Toddalia asiatica* 55% and combination of both is 70% respectively, this signifies that the both extracts of *cassia abbreviata* and *Toddalia asiatica* works effectively when they are combined against s. aureus and e. coli. Therefore, both plants extracts have antimicrobial activities. They plants are goods for medicinal used due the antidiarrheal and antimicrobial activities, therefore should be incorporated as antidiarrheal agents

Key words: *Diarrhoea, Cassia abbreviata, Toddalia asiatica, castor oil, ethanolic extract*

SAFETY AND QUALITY ASSESSMENT OF SEXUAL ENHANCEMENT HERBAL PRODUCTS SOLD IN HARARE

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This study aimed at evaluating the quality and safety of sexual enhancement herbal products sold in Harare. A total of 20 herbal samples for sexual enhancement were collected using the convenience sampling technique. The samples were assessed for adulteration with synthetic sildenafil using thin layer chromatography. Microbial quality was determined using total aerobic bacterial plate counts. The samples were also tested for the presence of *Salmonella typhi*, *Staphylococcus aureus* and *E.coli* using selective differential media and biochemical tests appropriate for each microorganism Two of the herbal products were found to be adultered with sildenafil. One other sample showed an Rf value of 0.72 which was close to that of sildenafil of 0.77. Only three (15%) of the 20 herbal preparations had bacterial contamination within the acceptable limit .Seventeen (85%) of the samples had bacterial contaminants which were above the limit. There was no microbial growth in one of the products which made the author to suspect that it could have been adultered with an antibiotic. It was then tested for antimicrobial activity and it showed marked activity against both Gram negative and Gram positive bacteria. Elleven samples (55%) were contaminated by S.*typhi*, seven (35%) by S.*aureus* and thirteen(65%) by E.*coli*. From this study it therefore shows that the herbal products being sold for erectile dysfunction in Harare are of poor quality and are likely to be contaminated with a variety of pathogenic microorganisms thus they pose serious health threats to the public. The quality assurance should therefore be thoroughly enforced and monitored in the production and distribution of herbal preparations.

THE INVESTIGATION OF ANTIBACTERIAL, ANTI-INFLAMMATORY AND ANALGESIC PROPERTIES OF *CARISSA EDULIS (MURUGURU)* TO ALLEVIATE THE SYMPTOMS OF TONSILLITIS.

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Tonsillitis refers to the inflammation of the pharyngeal tonsils that is the glands at the back of the throat, visible through the mouth. Streptococcus pyogenes is the main cause for tonsillitis. The current treatment for tonsillitis includes antibiotics, non-steroidal anti-inflammatory drugs, lozenges and andolex c sprays. Antibiotics are widely used in the treatment of tonsillitis and this has resulted in resistance of the bacteria due to lack of adherence by the patients, prescribing of the first line antibiotics and blind therapy. This has led me to investigate the anti- inflammatory, analgesic and antibacterial properties for Carissa edulis for further suggestions in the need of an effective as well as safe alternative therapy for the radical treatment of tonsillitis. Carissa edulis was extracted using ethanolic extraction. The anti- inflammatory activity of the extract was assessed by in –vitro egg albumin protein denaturation assay. Carissa edulis extract showed anti-inflammatory properties but slightly smaller than to that of the reference drug diclofenac sodium. Analgesic effect was assessed using the hot plate method and the maximum analgesia was found to be 44 seconds. The anti- bacterial properties were determined using MICs and Carissa edulis showed high anti- bacterial effects against Streptococcus pyogenes with a 23mm zone of inhibition which was almost similar to that of amoxicillin the reference drug which was 24mm. However further investigations were recommended on the analgesic effect in combination with other plant extracts so as to formulate a better product in the future.

Keywords: *Carissa edulis, Streptococcus pyogenes, Tonsillitis*

IN-VITRO DETERMINATION OF THE ANTIBACTERIAL AND ANTISEPTIC ACTIVITY OF THE HERBAL EXTRACTS OF *A. hypogea* And *C. anguria* ON BACTERIA CAUSING WOUND SEPSIS.

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Septic wounds are a usual observed dermatological sign in patients who have had burns, wounds and those that will have undergone amputation or surgery. Frequently, the injuries progress toward becoming mostly superinfected with *Staphylococcus aureus* and *Pseudomonas aeruginosa*. This condition influences the personal satisfaction of sufferers and the colour changes are distorting. The accessible treatment alternatives have various deficits including poor compliance with patients, resistance, high expenses and insignificant symptomatic alleviation. The purpose of the project was to find out the antibacterial activity of the active extracts from *A. hypogea* and *C. anguria* on bacteria that result in wound sepsis. The ability of *S. aureus* and *P. aeruginosa* to thrive in septic habitats has prompted the author to determine the antibacterial activity of the herbal extracts of *A. hypogea* and *C. anguria* against the two pathogenic bacteria.

This was done by carrying out minimum inhibitory concentration tests and paper disk diffusion method. Preliminary chemical profile of the herbal extracts was done using standard methods of phytochemical screening tests. The extracts were obtained by carrying out solid-liquid extraction. The assays demonstrated that the *A. hypogea* had an MIC of 50% on *S. aureus,* and an MIC of 50% on *P. aeruginosa. C. anguria* had an MIC of 50% on *S. aureus* and an MIC of 100% on *P. aeruginosa.* As the concentration of both extracts was reduced, the diameter of zone of inhibition decreased. Subsequent culture using a combined extract revealed that the combined extract was bactericidal against *S. aureus* and *P. aeruginosa.* The standard phytochemical screening tests revealed eight secondary metabolites (tannins, saponins, flavonoids, glycosides, terpenoids, alkaloids, phytosterols and anthocyanins) from the herbal extracts. The study revealed plausible development and use of novel as well as effective antibacterial agents from the herbs

Keywords: A. hypogea, C. anguria, antibacterial activity, MIC, paper disk diffusion assay, septic wounds, S. aureus, P. aeruginosa, antimicrobial, phytochemicals.

DEVELOPMENT AND IN-VITRO CHARACTERIZATION OF AN IN SITU GEL CONTAINING *ZINGIBER OFFICINALE* AND *CITRUS LIMON* EXTRACTS.

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Development of an oral in situ gel gastro retentive system containing crude extracts of *Zingiber officinale* (Ginger) and *Citrus Limon* (Lemon) was done to improve release and residence time of the herbal formulation. Extraction of *Z.offinale* and *C.limon* was done using solvent extraction and a yield value of 124.5ml and 115ml respectively. Percentage yield of 16.27 was obtained for Z.offinale and 15 for C.limon. A cold method was used in preparing 200ml of a pH sensitive in situ gel which undergoes a change from solution to gel upon reaching the small intestines. The change in pH enables the anionic carbopol 940 1%w/v polymer to transform into gel due to an alkaline physiologic stimuli. Propylene glycol, carbopol 940 w/v, crude extracts of Z.offinale and C.limon, methyl paraben and propyl paraben were added as preservatives in the formulation. The formulation was evaluated for gelation time, viscosity, gel strength, and pH. Viscosity of the formulation increased with increasing pH and lower temperature storage showed increased viscosity compared to room temperature storage. Gelation pH occurred between 7.5-8.5, between pH 5.5-6.5 no gelation occurred. The formulation exhibited good gelation strength and showed potential for use as a prolonged formulation delivery system in herbal preparations containing ginger and lemon extracts.

Keywords: In situ gel, *Zingerber officinae, Citrus Limon*.

ANTIFUNGAL ACTIVITY OF *CURCUMIN* EXTRACTS FROM TURMERIC AND *OLEUROPEIN* FROM OLIVE LEAF EXTRACT FOR THE MANAGEMENT OF *TINEA PEDIS* (ATHLETE'S FOOT).

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Tinea pedis is a common superficial fungal (dermatophyte) skin infection of the feet. It may present in several clinical varieties such as intertriginous, moccasin, vesicobullous, or a combination of these. It is often referred to as Athlete's Foot. *Tinea pedis* is most commonly caused by *Trichophyton rubrum,* a dermatophyte initially endemic only to a small region of Southeast Asia and in parts of Africa and Australia. *Curcumin* which is one of the extracts in the project acts in combination with other anti-fungal medications that are commonly prescribed to treat such conditions. It demonstrates anti-fungal activity against all *Candida* species, reverses drug resistance in Candida infections and also acts synergistically with photodynamic therapy in treating Candida infections. In pharmaceutical industry, the olive leaf extracts which is another extract used in the project are used as natural antimicrobial, and antioxidant in non-sterile pharmaceutical dosage forms instead of conventional chemical preservatives which have toxicity to human beings even at low concentrations.

The extraction method used in both extracts was solid-liquid extraction, zarrabal et al., 2009, with ethanol and water being the solvents employed. Fluconazole was used as a standard and the species studied was *candida albicans* instead of *trichophyton* rubrum due to its unavailability.
From the ethanol extractions of turmeric and olive leaf extracts, the percentage yields attained from crude extract were 16.25% w/w and 16.19%w/w respectively. Tinctures prepared gave 50%w/v and 49.52%w/v of turmeric and olive leaf extract respectively. Result of phytochemical screening of turmeric gave positive results on alkaloids, tannins, antraquinones, saponins, terponoids and glycosides while Olive leaf extract showed the presence of saponins, stérols, phenols, and flavonoids. The Minimum Inhibitory Concentration tests showed no growth in the petridishes containing the standard fluconazole and this implies that the antifungal activities of the extracts was less effective than that of the standard used at the same concentration, but there were growth observed in the petridishes with the extracts. Nevertheless the results shows that the plants used have antifungal activities as they inhibited growth of the microorganisms' *candida albicans*. The selection of the appropriate solvent is one of the most relevant steps in optimizing the recovery of plant secondary metabolites.

Key words: *Tinea pedis,* antimicrobial, phytochemicals and minimum inhibitor concentration

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EVALUATION OF FERTILITY PROPERTIES OF *ZIZIPHUS MUCRONUTS* ON FEMALE WISTAR RATS

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Infertility in females is a disorder caused by various factors e.g. failure to ovulate, uteral obstruction etc. Infertility is a source of stress that impacts the couple physically, psychologically, and socially, when fertility treatment fails to produce a pregnancy, the couple may experience decreased quality of life and increased stress, anxiety, and depression. Current chemotherapy available for infertility treatment which is due to failure of ovulation include drugs like clomiphene has some side effects associated with them including ovarian enlargement, vasomotor flushing, breast discomfort etc. hence more people are turning to alternative medicine. *Ziziphus mucronuts* (muchecheni) is one of the extensively used herb to deal with infertility in females, traditionally and in some communities today. The focus the project was to evaluate the fertility properties of *Ziziphus mucronuts (*muchecheni) and provide supporting scientific proof of the claims made about the herb. The crude extracts from *Ziziphus mucronuts* were administered the wistar rats also clomiphene was administered the other group for comparison. The rats were grouped into 3, the control, the positive control (given clomiphene) and the experimental group. Vaginal smear cytology is used to follow the phases of the oestrous cycle phases to determine when ovulation occurs. Data collected from experiments showed a significant difference between the three groups. However, between the experimental group and the positive control (Clomiphene) group there was no significant evidence to prove their difference. Using one-way ANOVA, the F value was 0.857 compared to the F critical which is 5.98. it then proves that the extract has the same effects as clomiphene.

KEY WORDS: *Ziziphus mucronuts, muchecheni, fertility, cytology, vaginal smear.*

EVALUATION OF THE ANTIDIABETIC POTENTIAL OF *SCLEROCARYA BIRREA* EXTRACTS

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The stem bark, roots and leaves of *Sclerocarya birrea (S. birrea)*, subspecies caffra are widely used in Zimbabwe and some African countries as folk medicine in the treatment and management of a variety of human ailments, including diabetes mellitus. Diabetes is one of the

non-communicable disease with a high morbidity and mortality rates with estimated 1500 000 deaths annually. The primary aim of the current project was to study the *in vitro* inhibitory effects of *S. birrea* stem bark extracts on the activities of selected diabetic related carbohydrate metabolizing enzymes that is α-amylase, α-glucosidase. Crude methanol and aqueous extracts of the stem bark extract of *S. birrea* were prepared by means of a sequential solvent extraction procedure and screened for inhibitory activities against fungal α-amylase, pancreatic α-amylase, using standard procedures for assaying the activities of these enzymes. The aqueous extract had a greater yield of 7.5% compared to the 3.5% of methanol extraction. The aqueous extract contained tannins, flavonoids, alkaloids and phenols, whilst the methanol extract contained tannins, flavonoids and terpenes. The aqueous and methanol extracts showed inhibitory activity against the fungal amylase and the pancreatic amylase. The methanol extraction had 90% inhibition on pancreatic amylase whilst it inhibited the fungal amylase by 80%. The aqueous extract had lower inhibition for the fungal and pancreatic amylases of 45% and 50% respectively. The crude extract of 5mg/ml gave a 65% inhibition of the glucosidase enzyme. The crude extracts showed inhibitory activity against the starch digesting enzymes *in vivo* using the *Bacillus subtilis* and *E. coli* on the starch hydrolysis test.

Key words: *Diabetes mellitus, S.birrea, alpha amylase , glucosidase*

EVALUATION OF ANTIBACTERIAL PROPERTIES OF FLACOURTICA INDICA AND LANNEA EDULIS EXTRACT AGAINST PSEUDOMONAS AERUGINOSA

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The present study was aimed at assessing the antimicrobial potential of extracts of Flacourtica indica and Lannea edulis against human pathogenic strains of Pseudomonas aeruginosa. The antibacterial activity was determined by agar disc diffusion and broth microdilution techniques. The results showed that the growth of the organisms was inhibited by the both ethanolic extracts of Lannea edulis and Flacourtica indica. The Flacourtica indica extracts showed significantly higher zones of inhibition. The minimum inhibitory concentration of the lannea edulis and Flacourtica indica extracts were 12.5% and 25% respectively. The phytochemical analysis was

carried out for the different plants. The qualitative analysis showed the presence of alkaloids, tannins and flavonoids were present in the Flacourtica indica extract and only tannins were present in Lannea edulis extract. The combination of the plant extract increased the antibacterial effect. The result of the present study indicates that Flacourtica indica and Lannea edulis have many medicinal values and can be widely studied to extract natural compounds which are beneficial to human beings.

DEVELOPMENT OF A DRUG DELIVERY SYSTEM FOR CHEMOTHERAPEUTIC DRUGS BASED ON MICROBUBBLES PRODUCED FROM LIPIDS EXTRACTED FROM *ZINGIBER OFFICINALE*.

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This present study aimed to produce a drug delivery system which release an alkaline drug at the stimuli of acidic environment like the microenvironment produced by highly proliferative tumorous cells which have a high metabolic rate. The drug delivery systems produced was based on a microemulsion Extraction was done through maceration of the *Zingiber officinale* tubers and exposing the biomass 70% methanol and 30% distilled water for 7 days. 112ml of the lipids was extracted using the solvent extraction method. Particle size and distribution investigations were determined using the optical microscope. In this project the microspheres were produced using Reverse Phase Evaporation coupled with sonication (using bath sonicator at 20kHz for 15 minutes) which produces Large Unilamellar Vesicles which have an encapsulation efficiency of 60%. The encapsulation capacity of this project was determined to be 53.1396 %. Remote loading or Active loading was used to load an amphiphilic amine into the vesicles which had an Ammonium Sulphate solution in them which produced a transmembrane pH gradient making is easy to load the drug which forms a complex in the micelles releasing ammonia. Dialysis method is the method that was be used for the analysis of drug release, making use of the changes in the pH of the release media (ethanoic acid) in 24 hours. The microbubbles and microspheres of the lipid and phospholipid mixture can be used as drug delivery systems for alkaline amphiphilic amine drugs like doxorubicin to alleviate the setbacks encountered by using the conventional drug delivery systems in chemotherapy.

Key words: amphiphilic amine, encapsulation efficiency, side effects, microspheres, *Zingiber officinale* tubers

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STABILITY ASSESSMENT OF AN EXTEMPORANEOUS PREPARATION OF HYDROXYCHLOROQUINE PAEDIATRIC SYRUP AND SUSPENSION FOR TREATMENT AND PROPHYLAXIS AGAINST MALARIA.

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The use of extemporaneous preparations can be considered as unlicensed drug use as they are inadequate drug stability data onto the preparations. This raises concerns about quality, stability, bioavailability, efficacy and safety of the formulations. The purpose of the study was to formulate extemporaneous Hydroxychloroquine syrup and suspension for treatment and prophylaxis against malaria and to test the chemical, physical and microbiological stability of the formulations. The syrup base was prepared by method of solution with the aid of heat and the suspension was prepared to use 2% SMC base. Hydroxychloroquine was added into the bases by the method of geometric dilution forming the medicated syrup and suspension. The container closure system used for packing the drug formulated products was 200ml amber bottles. Samples were stored at 25°C assayed at day 1, 7 and 14 for physical, chemical and microbiological stability. Chemical stability was defined at retention of 90% of the original drug concentration and was determined using Reversed Phase High Performance chromatography (RP-HPLC) using Hydroxychloroquine assay method in the British Pharmacopoeia. Microbiological stability was done using the method by *Rasha Saad et al. Ijppr.Human, 2016; Vol.5 (2):116-138* and stability was defined as microbial count of less than 200CFU/plate. Physical stability involved measurement of pH, sedimentation volume, viscosity, suspension and crystal growth. Hydroxychloroquine syrup and suspension were successfully formulated from commercially available Hydroxychloroquine tablets obtained at Trinity Pharmacy Harare. Hydroxychloroquine Sucrose syrup was chemically unstable during the two week test period but Hydroxychloroquine CMC Suspension was chemically stable during the two weeks of experiments. In conclusion at room temperature in amber bottles Hydroxychloroquine is chemically, physically and microbiologically stable in CMC Suspension and in Sucrose Syrup, Hydroxychloroquine is microbiological and physically stable but chemically unstable.

Keywords: *Hydroxychloroquine, RP-HPLC, Chemical stability, Physical stability and Microbiological stability, CMC, Sucrose, CFU*

AN INVESTIGATION ON THE ANTI-HYPERTENSIVE ACTIVITY OF *HIBISCUS SABDARIFFA* AQUEOUS CALYX EXTRACT IN SALT INDUCED HYPERTENSIVE RATS .

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The incidence of cardiovascular diseases, including hypertension, is on the increase worldwide. Medicinal plants played and continue to play paramount role in alternative management of hypertension. Very few scientific studies have, however, been done to validate the use of these phytotherapies. *Hibscus sabdariffa* is one of the many phytotherapies that has been employed for control of hypertension.

Background: *Hibiscus sabdariffa* is a tropical wild plant rich in organic acids, polyphenols, anthocyanins, polysaccharides, and volatile constituents that are beneficial for the cardiovascular system. *Hibiscus sabdariffa* beverages are commonly consumed to treat arterial hypertension.Therefore, aim of this study was to assess the potential antihypertensive effects of *H. sabdariffa* on pulse rate, systolic and diastolic blood pressure and comparison with the conventional synthetic antihypertensive drug, Nifedipine.

Method*:* Involved induction of hypertension on experimental animals(albino rats) through incorporation of a high-salt diet to their feed by adding 8% sodium chloride (NaCl) to accelerate the progression and severity of hypertension for 6 weeks. Weekly body weight, systolic and diastolic blood pressure was measured and recorded. The animals presenting high blood pressure measurement after six weeks of salt loading were randomly divided into groups of 5 rats each and introduced to placebo, nifedipine, aqueous HS calyx extracts(different concentrations respectively) whilst pulse rate, systolic and diastolic blood pressure measurements were taken and recorded for six weeks.

Results: The extract and drug treated groups showed a significant ($P < 0.01$) reduction in diastolic and systolic blood pressure when compared to the normotensive and hypertensive rats. There was no significant difference ($P > 0.05$) between the drug treated group and the extract treated group during this treatment.

Conclusion**:** This study further supports previous findings and the use of H. sabdariffa calyx extract in the treatment of hypertension. The graded doses of aqueous extract of *H. sabdariffa* leaves have significant blood pressure lowering effects in both normotensive and hypertensive rats.

Key words: *diuretic, nifedipine, orally, electrolytes, hypertension, blood pressure*, hibiscus sabdariffa calyx extract, *calcium channel blocker.*

MICROENCAPSULATION ADVANCED GLYCATION END PRODUCTS (AGE'S FROM DICHROSTACHYS CINEREA.

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Glycation of protein molecules in diabetes leads to the formation of the AGE's which are often reactive than the sugars they are derived from and are implicated in many age related chronic diseases like nephropathy, retinopathy, peripheral neuropathy and cardiomyopathy. Current medication include an investigational drug pimagedine as known as aminoguanidine, pyridoxamine and opb-9195 thiazolide among others but not really effective. This shows that there is a need for the development of effective drug substance that reduce diabetic complications. Studies on the ethanolic extract on the plant Dichrostachys cinerea showed that is has advanced glycation end products formation inhibiting properties. It has been suggested that mesquitol (one of the extracts) may serve as an important natural organic lead compound for future development of antiglycating agents with potent anti-oxidant activity (Alain Souza,Fidele Kpahé ;2011).

In this review, 930g of the organic crushed dicrostachys cinerea roots were immersed in 1000 mls of 70% ethanol for extraction. Phytochemical tests were done to confirm the presence of the flavonoids. The rats were grouped into 5 groups were group 1 served as normal control and received distilled water (NL), group 2 served as normal animals treated with plant extract, group 3 served as diabetic control animals treated with alloxan (DC), group 4 served as alloxan-induced diabetic rats treated with age albumin and group 5 served as alloxan-induced diabetic rats treated with 100 mg/kg BW aqueous extract of d.cineria roots. Diabetes was induced to the three groups of wistar rats using alloxan at a dose of 150 mg/kg BW interperonially. Fasting blood glucose tests were done at intervals for 35 days and it was confirmed that they were now diabetic. The renal function of the diabetic rats to which the age albumin had been administered, group 4 was compared against that of group 3 and there was no huge deviation which then led to the conclusion that glycation was occurring in this group as well. However a comparison of the hepatic function of these two groups against that of group 5 to which the plant extract had been injected showed that group 5 had better hepatic function probably due to less damage by ages as their formation was inhibited by the extract.

Key words; diabetic complications, advanced glycation end products, mesquitol, dichrostachys cinerea.

PHYSICAL, CHEMICAL MICROBIAL STABILITY OF PAEDIATRIC HYDROXYUREA FORMULATION

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Sickle cell anaemia is common in sub-Saharan Africa, which affects up to 3% of births. This condition is associated with very high child mortality due to acute and chronic organ damage. The 63rd session of UN General Assembly in December 2008 adopted a resolution on the "recognition of sickle-cell anemia as a public health problem. Hydroxyurea has become an accepted therapeutic option for many patients with Sickle cell anemia. Liquid hydroxyurea extemporaneous preparations are made for pediatrics with a precise and accurate dosing regimen within 2 mg/kg/d as there are no liquid formulations available in Zimbabwe. The objective of the study was to assay the physical and chemical stability of sugar based and non sugar based suspensions of pediatric hydroxyurea preparations. 10mg/ml suspensions were prepared and samples of each were stored in amber bottles at different temperatures of 4^0C and 25^0C. Samples were then assayed using the HPLC method for chemical stability over 60 days. Physical stability tests were also conducted which included pH, viscosity, sedimentation, crystal growth and microbial growth. Over the 60 days there was no change in colour or odor of the suspensions. The pH for both suspensions ranged from 4.68-4.94 which was within the theoretical value range of hydroxyurea. The sugar based suspension which was stored at 25 degrees crystallised as increasing temperature increases solubility and supersaturation. The sugar based suspension also had a higher viscocity than the non sugar based suspension. At least 90% of the hydroxyurea concentration remained in the suspensions after 60days in both the conditions. From this study therefore it can be concluded that the suspensions were stable for at 60 days at both the temperatures. It is recommended that the suspensions also be stored in amber bottles as the hydroxyurea is photosensitive.

Key words: *hydroxyurea, sickle cell anaemia, HPLC, suspensions, stability.*

EVALUATION OF ANTIASTHMATIC ACTIVITY OF *KIRKIA ACUMINATA* EXTRACTS AND *BERCHEMIA DISCOLOR* EXTRACTS.

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The prevalence of asthma and other allergic diseases like seasonal allergies and animal allergy has increased during the past two decades due to changes in environmental factors such as food and lifestyle. Asthma is a condition that attack anyone and its prevalence is high in children than adults. It is a hypersensitivity reaction that occurs mostly due to the presence of an allergen and is characterized by airway inflammation, airflow limitation, hyper-reactivity and airway remodeling. The present study has been designed to evaluate the anti-asthmatic activity of the barks of *kirkia acuminata* and *berchemia discolor* in vivo as well as to evaluate their anti-inflammatory activities in vitro. Extraction of *kirkia acuminata* was done using maceration method and that of *berchemia discolor* using decoction technique. Phytochemical screening was done using standard test found in British pharmacopeia and alkaloids, quinolones, flavonoids and steroids among others were found to be present. Anti-asthmatic activity was carried out on milk-induced leukocytosis and eosinophilia in albino rats. Both Aqueous and ethanolic extracts *of kirkia acuminata* and *Berchemia discolor* respectively were found to decrease blood eosinophilia and leukocyte count by 80% and 85% respectively which resulted in the conclusion that they can be considered being useful in the management of asthma. Different concentrations of plant extracts were prepared by serial dilutions. The plant extracts were incubated with egg albumin under controlled conditions, absorbance was measured and the percentage inhibition was calculated which was found to increase with increased sample concentration also leading to the conclusion that the plants exhibit some anti-inflammatory properties. Further studies to evaluate other pharmacological activities of the plant species are recommended.

Key words*:* hypersensitivity, inflammation, anti-asthmatic, leukocytosis, eosinophilia

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A COMPARATIVE STUDY OF THE ANTIBACTERIAL PROPERTIES OF THE ESSENTIAL OILS OF *ZINGIBER OFFICINALE* AND *ALLIUM SATIVUM* AGAINST *STAPHYLOCOCCUS AUREUS*

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Staphylococcus aureus infection is a leading cause of *staphylococcal* bacteremia in adults and children in hospitals all over the world. Furthermore it is the leading cause of skin and soft tissue infections such as abscesses, furuncle and cellulitis. *Staphylococcus aureus* can travel through the bloodstream and infect almost any site in the body particularly heart valves causing endocarditis and osteomyelitis. *Staphylococcus aureus* is the leading cause of infant death in developing countries. It cause *S aureus* enteritis, an inflammation that is usually caused by eating or drinking substances contaminated with *S aureus* endotoxin. The toxin settles in the small intestine and causes inflammation and swelling. This in turn can cause abdominal pain, cramping, dehydration, diarrhoea and fever. *Staphylococcus* infections also include impetigo, food poisoning and toxic shock. Penicillase resistant penicillins remain the antibiotics of choice for the management of methicillin susceptible *S aureus*. According to WHO studies in 2016, a total of 80% *S aureus* infections were reported worldwide and there has been an increase of 40% in the number of antibiotic resistant *S aureus*. This study was therefore done to find an alternative approach to treatment of *S aureus* infections by comparing the antibacterial properties of the essential oils *of Zingiber officinale* and *Allium sativum* against *Staphylococcus aureus* using ciprofloxacin as a standard. The aim was to determine whether these essential oils were effective enough to become possible alternative to *Staphylococcus aureus* infection treatment. The plants were selected based on their availability, accessibility and antibacterial properties. Plants were collected and were prepared for extraction. Hydro-distillation was the method used to extract the essential oils by the Clevenger apparatus. The essential oils of *Zingiber officinale* and *Allium sativum* produced percentage yields of 3.5% and 1.7% respectively. These values were within the theoretical range given in literature. Mueller Hinton agar was used as the medium for *staphylococcus aureus* inoculation. Streak plating method was used for inoculation to avoid formation of single colonies. Serial dilutions of the oils were done and the minimum inhibitory concentration was obtained. The study reviewed that the essential oils produce the same antibacterial properties as ciprofloxacin with Allium sativum having greater inhibition capacity than both ciprofloxacin and *Zingiber officinale*.

Key words: *staphylococcus aureus*, *Zingiber officinale*, *Allium sativum,* ciprofloxacin, antibacterial

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INVESTIGATION OF THE ACUTE TOXICITY, ANTI-INFLAMMATORY AND ANTI-OXIDANT ACTIVITY OF TYPHA LATIFOLIA EXTRACT

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Synthetic anti-inflammatory and analgesic medicines have been reported to cause internal bleeding, ulcers, high blood pressure, fluid retention, kidney and heart problems. Some contain toxic substances at small doses hence the major aim of this experiment was to investigate the acute toxicities associated with *Typha latifolia,* its anti-inflammatory activity and anti-oxidant activity.10 female albino rats were grouped into 2 a group of 5 each. One group received 5000mg/Kg *Typha latifolia* powder, both the test and control groups where allowed full access to food and water. The test group was monitored hourly for the first 6 hours after taking the cattail powder then once daily for 14days. Anti-inflammatory activity was demonstrated using the red

blood cell membrane stabilisation method using prostaglandin induced cell lysis and protein denaturation inhibition method. The respective haemoglobin content and protein denaturation were estimated using the UV-VIS spectrophotometry and the relative percentage inhibition calculated. The antioxidant capacity of *Typha latifolia* extract was evaluated using 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay. During the period of observation of the acute toxicity, there were no sign of toxicity such as tremor, convulsion, change in step, excessive grooming, salivation and diarrhoea. Their behaviour was rather strengthened compared to the control group. At the end of 14 days, no death was recorded and no adverse effects identified indicating that the lethal dose 50 (LD_{50}) is higher than 5000 mg/kg. The haemoglobin content of the test samples containing different concentrations of the extract was lower than the control sample. There was Inhibition of haemolysis in all the extract concentrations and the maximum inhibition 50,81% was seen with a concentration of 80% extract. all the samples demonstrated protein denaturation inhibition with a maximum of 56.6% with a concentration of 100% extract. The extract's free radical scavenging activity expressed as inhibitory concentration IC50 obtained was 76%, The DPPH scavenging activity was 3.76. *Typha latifolia* extract was found practically non-toxic or non-lethal after an acute exposure. It poses significant anti – inflammatory activity and less of anti – oxidant activity. Therefore, *Typha latifolia* extract can be a source of oral medicine for reducing inflammation and detoxification.

Key words: *Typha latifolia*, acute toxicity, anti-inflammation, anti-oxidant and UV-VIS

IN-VITRO EVALUATION OF THE HYPOURICEMIC LIKE EFFECTS OF MALIC ACID FROM *Malus Domestica*

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Hyperuricemia is a condition affecting 3.6 % (8.4 million people) of the total world population (Bridgit Kioko et al, 2015). Hypouricemia can precipitate into gout, deposits of uric acid in joints as mono sodium urate crystals which are not soluble in aqueous environment. The crude extract containing Malic acid used to test the dissolution rate of the urate crystals microscopically at x400 magnification. 10 samples prepared 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% crude extract with 0% and 100% acting as the controls. The rate of dissolution increased with increase in extract percentage with average count of crystals 102, 71, 61, 60, 57, 37, 23, 20, 15 and 8 respective microscopically viewing at x400 magnification specific to urate crystals. Malic acid which is 2hydroxybutadioic acid was identified using ph test showing extract having pH of 5.04, 5.06, 5.04 from 3 sample having average of 5.04 , in which literature shows ph of 5.04 of apple juice. Phenolphalein indicator used to confirm ph also with colourless result and with colourless and pink colour for control of HCL and NaOH respectively. The thin layer

chromatography used to confirm presence of malic acid in the extract using bromocresol green stain. The rf value showed 0.46 with 0.01 difference from the theoretical value of 0.45. There Is 92 % reduction of crystals from the sample by the apple crude extract in the in-vitro analysis showing potential use of malic acid in reduction of uric acid crystals and favour renal excretion of the soluble form.

Key: *malic acid, microscopic analysis, uric acid crystals, thin layer chromatography, thin layer chromatography, 2 hydroxybutadioic acid*

EVAULATION OF ANTIMICROBIAL AND ANTI-INFLAMMATORY PROPERTIES OF *Lantana camara* and *Cucuma longa* EXTRACTS USE IN MANGEMENT OF INFECTED PRESSURE ULCERS.

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Pressure ulcers are defined as localized damage to the skin and underlying soft tissue, usually over a bony prominence or related to a medical or other device. Such injury can present either as intact skin or an open ulcer and may be painful. The plants used in this study are *Lantana camara* and turmeric. The method used for extraction was solvent extraction. The solvents used for both plants are ethanol and methanol. The methanolic and ethanolic extracts of *Lantana camara* and turmeric were put under investigation for microbial susceptibility testing using agar disc diffusion methods and anti-inflammatory activity using carrageenan induce paw edema model. The solvent extracts were found to be effective against the selected pathogens used (*Staphylococcus aureus and E. coli)* with highest mean inhibition diameter of 19.45mm for ethanolic and 19.33mm for methanolic turmeric extracts at 100mg/ml while 18.67mm for ethanolic *Lantana camara* extract at 100mg/ml was recorded against staphylococcus aureus. The minimum inhibitory value was ranged from 10-100mg/ml. It was found that the MIC value for both *Staphylococcus aureus and E. coli* was 25mg/ml for ethanolic and methanolic extracts of *Lantana camara* and turmeric. The percentage yield of the plant extracts were 16.68%w/w, 16.12%w/w for ethanolic and methanolic turmeric extract and 13%w/w, 13.2%w/w for ethanolic and methanolic *lantana camara* extracts.11 secondary metabolites were tested these include flavonoid, anthocyanin, diterpenes, phenol, steroids, terpenoids, saponins, alkaloids, tannins, coumarins, and anthraquninos. These

metabolites are believed to facilitate the antibacterial and anti-inflammatory of the solvent plant extracts. The anti-inflammatory activity of the ethanolic extract of both turmeric and *Lantana camara* was found to be more effective with percentage edema inhibition of 95.91% in 200mg/ml turmeric extract, 95.90% in *Lantana camara* extracts at 200gm/ml and 97.96% combined 50-50mg/ml turmeric and *Lantana camara* after 4 hrs. The results obtained from this experiment approved the claims made by researchers about the medicinal use of these two plants.

KEYWORDS: Pressure ulcers, *Lantana camara*, turmeric, antibacterial, anti-inflammation.

APPENDIX

Harare Institute of Technology
HIT
success through innovation

HIT 300 – Design & Innovation Project Course for Engineering programmes

Course Outline

Title: Design and Innovation Project

Project Code: HIT 300

Duration: notional hrs

Weighting: 20 notional credits

Lecturers: All Academic members of Department

1.0 Preamble

The HIT 300 project is done in the third year in the first semester. The second semester is wholly dedicated to an Industrial internship, and therefore the HIT 300 project must be completed by then. This makes the HIT 300 project a one semester project characterized by a lot of hard work and input from the students. HIT 300 is a follow up project from HIT 200, and instead of group work, this is an individual work where the student works alone and is expected to solve a real problem. The problem has to be challenging. The project must not only be informative but also applied. The engineering or technology concepts learnt thus far should be applied. The candidate must demonstrate not only engineering, technology & design concepts but how the concepts can be put in real life application. The project topic must be supported by literature. The candidate must present facts found and interpret them. From the facts drawing of reasonable conclusion showing careful planning and flow of ideas should form the basis of the HIT 300 project. The project should show innovation and demonstrate an obvious improvement from HIT 200 in terms of the engineering or technology aspects covered.

2.0 Aims

(a) Stimulate students to demonstrate understanding and ability to apply the fundamental principles of the technology or engineering programme content learnt in the previous two years of the programme

(b) Enhance hands- on aspects to the students

(c) Inculcate in students the habit of conducting projects that are need based

(d) Develop technopreneurs and innovative citizens

3.0 Objectives

By the end of the course students should be able to:

(a) Apply principles and techniques learnt in their respective technology or engineering discipline , design, construction, process control and improvement of machines and equipment of processing plants.

(b) Apply skills to rehabilitate and show innovativeness in existing process manufacturing facilities.
(c) Be able to scale up and commercialise manufacturing or production processes
(d) Solve real life technical problems
(e) Start their own high tech business enterprises

4.0 Project Content

The project content consist of project chapters, model or prototype production and project write up

4.1 Project Document Chapters

4.1.1 Chapter 1: INTRODUCTION

The student is expected to give an outline of the problem statement. Aims of the project and justification are to be given in this chapter. It should be spelt out in this chapter the need to carry out this research and the problem area to be tackled.

4.1.2 Chapter 2: LITERATURE REVIEW

The chapter should mainly contain literature review of the project. Basically this is done to give a theoretical background to the chemical processes involved. A comprehensive understanding of the technology or engineering concepts involved is done at this stage. Comparisons of the best technology are also done. As a conclusion to Literature Review, the best production process to be carried out is done at this stage.

4.1.3 Chapter 3: RESEARCH METHODOLOGY

The chapter includes the research methodology and design of experiments. It encompasses all the approaches to be employed to enable student to design the process or the equipment. Algorithms to be followed are part of this chapter. Included are all the means of data gathering and processing to be done. All the experiments are to be formulated here. It is required that a HIT 300 project carry at least three experiments.

4.1.4 Chapter 4: EXPERIMENTAL RESULTS AND ANALYSIS

The chapter should contain results of experiments and the analysis of the results. All results are to be clearly tabulated in this chapter. A proper results analysis should be done. Ultimately there should be a link between the results obtained and the future work to be done, this must clearly be evident.

4.1.5 Chapter 5: PROCESS DESIGN

In case of a project aligned to engineering, this must cover process design to include mass balances and energy balances for the chosen equipment. These should be directly related to the experimental results obtained and also facilitate the following chapter where designs are done. The calculations done should therefore clearly lead to equipment design; they should not be a hanging part of the document but a link. Students must then come up with equipment list and process flow charts.

4.1.6 Chapter 6: EQUIPMENT DESIGN

Students must show detailed understanding of the engineering or technology design aspects and mechanical design of the equipment. The students can select at least one major equipment of choice and carry out a thorough design of it. They should demonstrate understanding of choice of material of construction, stress calculations and pressure vessels fabrication.

4.1.7 Chapter 7: PROCESS CONTROL AND HAZOP ANALYSIS

Process control aspects are to be shown in this chapter. Students should come up with HAZOP analysis of the chosen equipment.

4.1.8 Chapter 8: ECONOMIC ANALYSIS

Economic analysis should be covered in this chapter using the profitability indices. It should clearly show that a profit is generated in carrying out this project; otherwise it is not worth doing it.

4.1.9 Chapter 9: CONCLUSION AND RECOMMENDATIONS

This chapter should cover design results discussion, conclusion and recommendations

4.1.10 References

All sources of information used should be listed in the references. Students must use the Harvard reference system.

4.2 Model or prototype production

A HIT 300 project must be backed up with the production of either a model or a prototype for the production process or of the designed equipment.

4.3 Report writing

The report should:

- Have a minimum of 60 pages and maximum of 80
- Have a font size 12, Times New Roman
- Be presented in one and half spacing

In the preliminary pages or front pages of the Design Project, the following materials are presented:

- The title page
- Abstract
- Declaration
- Copyright
- Dedication
- Acknowledgments
- Abbreviation

- Table of contents
    - List of tables
    - List of figures

4.3.1 The title page (I)

It is considered as page (i) but is left unnumbered. Titles are single spaced and are written in upper case. If the title is more than one line it should break in a logical place for easy reading. The title page shows:

- Title of project
- Name of writer
- Purpose of the project
- Name of the Institute & Department
- Year

4.3.2 Copyright (II)

This is a form that grants the Harare Institute of Technology permission to produce copies of the Research and Development Project and also reserves the authors' publication rights.

4.3.3 Declaration (III)

This serves as official acknowledgment and acceptance of the research project as satisfactory. It is signed by your supervisor(s)

4.3.4 Dedication (IV)

This serves as a tribute or recognition to a specific individual or individuals.

4.3.5 The Abstract (V)

The abstract is used by potential readers to determine at a glance, the contents of the capstone design project. You should present it as a precise and well written summary. Your abstract should contain:

- A clear statement of the problem/ problems being solved.
- The purpose of the project.
- A summary of the methods used in the design of major equipment such as heat exchangers, distillation columns etc.

- A statement of source and type of physical data collected and its use. A summary of experimental work undertaken and the type of data collected and its use in the design.
- A summary of the findings, conclusions, recommendations and suggestions for further research. Your abstract should not be more than a page in length.

4.3.6 Acknowledgements (VI)

In this section you thank persons to whom you are indebted for guidance and assistance in making your study successful. You must present this section on a separate page.

4.3.7 Table of Contents (VII)

You present an outline of the components of your design project. These components include, the preliminaries and these are typed in lower case. They are arranged as follows:

- Title Page (i)
- Abstract (ii)
- Declaration (iii)
- Copyright (iv)
- Dedication (v)
- Acknowledgements (vi)
- Table of Contents (vii)
    - List of Tables (viii)
    - List of Figures (ix)
    - List of Appendices (x)
- Abbreviations

After the preliminaries you then list chapters and chapter headings and sub-headings giving the page(s) where these are located in your design project. Lastly you present the back pages materials, which are references and appendices. For typing you should ensure that:

- Chapter numbers and preliminaries' pages are typed in Roman numerals.
- Chapter titles and chapter numbers are typed in upper case.
- Sub-headings of each chapter are typed in lower case and are single spaced.
- Margins are 4.0cm on the left, 1.0 on the right hand side, 2.5cm at the top and 4.0cm at the bottom of the page.
- Numbering of the pages should be at the centre bottom edge.
- Appendices are presented in Arabic numerals and typed in upper case. (Appendix vii)

4.3.8 List of Figures (VIII)

Anything other than tables should be considered as a figure. You should write the figure number, title and reference page. Type these in lower case.

4.3.9 List of Tables (IX)

You should show the table number, its title and reference page. This should be done in lower case.

Abbreviations

All terms abbreviated in the project document should be specified in this category

5.0 Project assessment

The course will be taken over a semester and will be examined by oral and written presentation of the project.

5.1 Oral presentations

The presentation will be evaluated on the following basis:

- Organization – systematic, logical and integrate
- Clarity – easy to follow and understand
- Presentation skills – good voice, projection, eye contact, confident and good results.
- Visual aids- readable, understandable and pertinent
- Content – Relevance of the information presented to the solution of the problem
- Conclusions – defensible and rationale provided
- Ability to answer questions effectively

Coursework is made up of three presentations:

a. 1st presentation - Covers the introduction chapter and all aspects concerning problem identification, justification and expected outcomes.

b. 2nd presentation – Covers up to experimental results. This clarifies the work done so far and paves way to subsequent design work.
c. 3rd presentation – Covers the design aspects, model or prototype, conclusions and recommendations

5.2 Written report

Report writing is a key skill in presentation of information. As such students should show a mastery of this. Assessment of the written report will be upon the following basis

- Typography – spelling and grammar
- Information flow – coherence and cohesion of information
- Referencing – knowledge of referencing skills, (the Harvard System)
- Content – relevance of information in the document toward solving the problem
- Adherence to set rules - following the prescribed procedure

Final report assessment is based on the guidance given in Table 1.0:

Table 1.0: Final report assessment

Performance Task	**Performance Criteria**	**Score** Total 100
Abstract	Cover all elements Coherence Concise	5
Problem Identification	Wealth creation Political needs Problem solving	5
Literature Survey	Journal Internet Textbooks Questionnaire	5
Research Methodology	Laboratory work Pilot plant study Modelling	15

Experimental Results and Analysis	Reaction kinetics Scaling up	15
Process Design	Mass balance Energy balance Technical composition	10
Equipment design	Chemical engineering design aspects Mechanical engineering design aspects Material selection Stress, strain calculations	15
Process Control and HAZOP analysis	Selection of sensors Monitoring devices HAZOP studies Environment Safety	10
Economic Analysis	Payback period Engineering cost factors Cost indices	10
Conclusion and Recommendations	Design results discussion Innovativeness Value creation Problem solving	5
References		5

NB Three copies of the spiral bound document should be submitted.

5.3 Overall assessment

The project will be evaluated in reference to Table 2.0:

Table 2.0: Assessments components

Work Component	**% of Final Course mark**
First presentation	10%
Second presentation	20%

Final presentation	30%
Model or prototype development	20%
Final written project report	20%
Total	**100%**

5.4 Assessment forms

The project will be assessed at each stage according to the following forms:

HARARE INSTITUTE OF TECHNOLOGY
SCHOOL OF ENGINEERING & TECHNOLOGY

HIT 300 PROPOSAL PRESENTATION ASSESSMENT FORM

Project Title:_____

Student's Name:_____ Student Number:_____

Panelist:_____

Criterion	**Total possible score**	**Mark awarded**
Organization	5	
Clarity	5	
Presentation skills	5	
Problem identification	5	
Objectives	5	
Innovation aspects	15	
Project feasibility	5	
Research design	15	
Visual aids	5	
Conclusions	10	
Answering questions	25	
Total marks awarded	**100**	

NB: Maximum marks are awarded for the following:

1. **Organization**-systematic, logical and integrate
2. **Clarity**-easy to follow and understand
3. **Presentation skills**-good voice projection and eye contact, comfortable and confident
4. **Visual aids**-readable, understandable and pertinent
5. **Conclusions**-defensible and rationale provided
6. **Answering questions**-ability to answer questions effectively

Panelist's Signature:_____ Date:_____

Chairman's signature_____ Date:_____

HARARE INSTITUTE OF TECHNOLOGY
SCHOOL OF ENGINEERING & TECHNOLOGY

HIT 300 PROGRESS PRESENTATION ASSESSMENT FORM

Project Title:_____

Student's Name:_____ Student Number:_____

Panelist:_____

Criterion	**Total possible score**	**Mark awarded**
Organization	5	
Clarity	5	
Presentation skills	5	
Experimental results analysis	25	
Process design	20	
Visual aids	5	
Conclusions	10	
Answering questions	25	
Total marks awarded	**100**	

NB: Maximum marks are awarded for the following:

1. **Organization**-systematic, logical and integrate
2. **Clarity**-easy to follow and understand
3. **Presentation skills**-good voice projection and eye contact, comfortable and confident
4. **Visual aids**-readable, understandable and pertinent
5. **Conclusions**-defensible and rationale provided
6. **Answering questions**-ability to answer questions effectively

Panelist's Signature:_____ Date:_____

Chairman's signature_____ Date:_____

HARARE INSTITUTE OF TECHNOLOGY
SCHOOL OF ENGINEERING & TECHNOLOGY

HIT 300 FINAL PRESENTATION ASSESSMENT FORM

Project Title:_____

Student's Name:_____ Student Number:_____

Panelist:_____

Criterion	**Total possible score**	**Mark awarded**
Organization	5	
Clarity	5	
Presentation skills	5	
Chemical engineering design	15	
Mechanical engineering design	10	
Process control	10	
Economic analysis	10	
Visual aids	5	
Conclusions	10	
Answering questions	25	
Total marks awarded	**100**	

Model or prototype	**100**	

Panelist's Signature:_____ Date:_____

Chairman's signature_____ Date:_____

HARARE INSTITUTE OF TECHNOLOGY
School of Engineering & Technology
HIT 300 Project Report Assessment Form

Name of Student:_____

Name of Assessor:_____ Name of Moderator:_____

Signature of Assessor:_____ Signature of Moderator:_____

Date:_____ Date:_____

Performance Task	**Comments**	**Score**
Abstract [5]		
Problem Identification [5]		
Literature Survey [5]		
Research Methodology [15]		
Experimental results and analysis [15]		
Process Design [10]		
Equipment design [15]		
Process Control and HAZOP analysis [10]		
Economic Analysis [10]		
Conclusion and Recommendations [5]		
References [5]		
TOTAL [100%]		

Mark Moderated by External Examiner:_____ Date:_____

Title Page Sample

HARARE INSTITUTE OF TECHNOLOGY

DESIGN OF A 190 TONNES/DAY DRIER FOR THE AGGLOMERATION OF CHROME ORE FINES

BY

MARY JONES H2020067S

SUPERVISED BY

PROFESSOR P. RALPH

PROFESSOR M. LIVINGSTONE

THIS DESIGN AND INNOVATION PROJECT WAS SUBMITTED TO HARARE INSTITUTE OF TECHNOLOGY IN PARTIAL FULFILMENT OF THE BACHELOR OF TECHNOLOGY (HONOURS) DEGREE IN CHEMICAL AND PROCESS SYSTEMS ENGINEERING

2013

Copyright Sample

Declaration Page Sample

DECLARATION

I, Waza Mumba hereby do declare that this work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Student's Signature: …… Date …….

(Waza Mumba)

Supervisor's Signature: ……. Date …….

(Professor P. Ralph)

Dedication Sample

DEDICATION

Firstly I would like to dedicate this piece of work to my mum and dad (Mr. and Mrs. Chaza) for the love and care they have given to me.

Abstract Sample Page

ABSTRACT

This report aims at documenting the design of a fractional distillation column to separate crude oil into its various fractions. It covers the process design, mechanical design and equipment costing.

Chapter 1 introduces the project, stressing out the design problem, its significance and the methodologies used in going about with the project.

Chapter 2 covers the literature aspect of a fractional distillation column. It presents a brief summary of what a fractional distillation is, the type of trays, reflux and reflux considerations.

Chapter 3 contains the process calculations and design aspects of the project, with equations, tables and graphs and enhances understanding of the design. A bit of extra literature is provided for some parts designed such that readers will appreciate the way the equipment should function.

The process economics and estimated costing of the plant are given in chapter 4, whilst chapter 5 discusses the design results, and chapter 6 the recommendations and the conclusion which are therein presented.

Acknowledgements Sample

ACKNOWLEDGEMENTS

Firstly I would like to thank the Lord God almighty for his mercies, for seeing me through this design and innovation project and throughout my life.

Secondary I would like to thank my supervisor Eng. M. Murambatsvina for his guidance through which I managed to come up with the dissertation and his time he set aside to supervise me.

Thirdly I would like to thank mum and dad for their encouragement and support. Special appreciation goes to all my friends for the encouragement and technical support.

Lastly my sincere gratitude goes to all lecturers in the Chemical and Process Systems Engineering Department, without them it would have been impossible for me to acquire the knowledge and be able to undertake this project.

Table of contents sample

List of figures sample

List of tables sample

List of Appendices

References sample

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