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SCHOOOL OF INDUSTRIAL SCIENCES & TECHNOLOGY

SCHOOL OF ENGINEERING & TECHNOLOGY

COMPENDIUM OF HIT 400 CAPSTONE DESIGN PROJECTS ABSTRACTS 2015-2016

The document captures the abstracts of Capstone Design Projects done by students in the School of Industrial Sciences & Technology and School of Engineering & Technology for the academic year 2015-2016

School of Engineering & Technology

Department of Chemical and Process Systems Engineering

DESIGN OF A PLANT THAT PRODUCES 2TONS/DAY OF ACTIVATED CARBON FROM SAWDUST IN A FLUIDISED BED FURNACE

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Activated carbon is produced from sawdust by using steam activation in a high temperature furnace. Zimbabwe has some of the largest deposits of timber in southern Africa (about 500 000 tons per annum) such that most entrepreneurs venture into timber processing. The venture results in a lot of sawdust dumps that are of no economic use if they are left lying around. There is 10000 metric tons that go to waste each year. Research shows that it's feasible to produce activated carbon from the carbonisation of the sawdust in a fluidised bed furnace at 500℃ at 6$bars\ pressure$. The aim of this project is to carbonise 3.4 tonnes of sawdust per day to produce activated carbon. This is an economic way of disposing sawdust. The activated carbon produced will be approximately 2.04tonnes per day. Experiments are conducted to investigate the influence of various process parameters such as particle size, pyrolysis temperature and activation time on the quality of the activated carbon. Activated carbon production is growing and there is an increasing demand for it to be used for waste water treatment. In addition, the batch adsorption studies are done by using methylene blue. The aim of this study is to investigate that the sawdust carbon could be employed as a low cost alternative to produce commercial activated carbon. The project is also economically viable since it takes approximately 4years to payback an investor with a return on investment of 30.21 cents on a dollar

Keywords: Sawdust, Activated carbon, Methylene blue, Adsorption

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DESIGN OF A PLANT THAT PRODUCES 10T/DAY NICOTINIC ACID USING NICOTINE OBTAINED FROM TOBACCO WASTE

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Between 1980 and 2012 more than 3 million Zimbabweans were affected by pellagra with more than 100 000 deaths. As a result, recent research has focused on the development of chemicals that might be used to cure or prevent pellagra especially in developing countries like Zimbabwe. According to a research from the journal of internal medicine (Carlson. L. A. 2005.), nicotinic acid (niacin, vitamin B_3) is one of the major drugs used to prevent and treat pellagra (niacin deficiency). Therefore this project focuses on the design of a plant that produces 10ton per day nicotinic acid using nicotine obtains from tobacco waste. The design process has three main stages which include the extraction stage, oxidation stage, purification stage and crystallization stage.

Specifically, it takes tobacco waste as a starting raw material and converts it to nicotine before subsequently converting it to nicotinic acid and purifying the final product. By following this particular reaction path, the process avoids the more classic method of preparation by which nicotine is oxidized with potassium dichromate, a reaction with considerably more toxic reactants and waste. Along with this more sustainable reaction path, care was taken to ensure the process was as green as possible at each step along the way.

The entire system provides a green process to producing nicotinic acid in relatively high purity, around 97.7%. After analyzing the base-case design and economic analysis of this process, it has been found that this venture has a payback period of 2.2 years, with an ROI of 56.9% after the second year. The NPV after 10 years is $3 830 232.47.

KEYWORDS: nicotinic acid, tobacco waste, nicotine, pellagra

DESIGN OF A PLANT TO PRODUCE 1000 LITRES PER DAY OF KEROSENE FROM WASTE POLYETHYLENE PLASTICS

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Plastics have manoeuvred their way into our daily lives and waste plastic disposal and uncontrolled refuse now pose a tremendous threat to the environment. This project hence, focuses on the production of kerosene from waste polyethylene plastics thereby turning the problems into an

opportunity to make wealth from waste. The experimental work carried out proved that it is technically feasible to produce kerosene from waste plastics by pyrolysis. Use of a catalyst decreased the reaction time and increased the yield of kerosene fraction. The optimum temperature for pyrolysis was 425°C over a time frame of 51 minutes with a yield of 84.45%. The liquid product obtained had a specific gravity of 0.8123 g/cm^3, viscocity of 2.31and the flash point of the sample obtained lied in the range of 40°C- 45°C. Results of the mass balances were used to draw up raw material usage ratios in the design of the pyrolysis reactor and distillation column. Process control measures were implemented and HAZOP analysis was done on the pyrolysis reactor and also on the distillation column to ensure equipment operability and safety. An Environmental Impact Assessment of was carried out in order to mitigate the impacts of identified aspects. The project requires a total capital investment of about US$ 218 000. The production cost was US0.38/L and selling prize was US0.61/L.The sales volume of kerosene from plastic projected was considered viable with a payback of 4.20 years, return on investment of 24% and a breakeven point of 25%.

Keywords: Kerosene, waste polyethylene plastics, pyrolysis.

DESIGN OF A PLANT TO PRODUCE 20TONNES/DAY OF HYDROGEN USING HYBRID OF STEAM REFORMING AND PARTIAL OXIDATION OF ETHANOL

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Due to increase in rural electrification and low water level in Kariba dam which leads to shortages in electricity and demand of electricity in Zimbabwe increased. Currently in Zimbabwe most of the hydrogen is coming from electrolysis of water which requires a lot of electricity. Currently Sable chemical which is the major consumer of hydrogen in Zimbabwe is in huge debt because of high use of electricity which is directed mostly to hydrogen production by electrolysis of water. Sable chemical consumes 115megawatts to produce 240 000tonnes of ammonia fertilizer when operating at full capacity this means that for to produce a kg of hydrogen 3.45 kilowatt-hour at a cost of 3c per kilowatt-hour. Therefore this project aims at designing a plant that produces 20 tonnes/day of hydrogen from ethanol using a hybrid of steam reforming and partial oxidation. From research it has shown that it is possible to produce hydrogen at a low cost and low electrical usage. Experiments were done to determine the best temperature for steam reforming and 300°C was chosen, the optimum pressure for steam reforming and 1 atmosphere was the best, the best reacting ratio of ethanol to water was found to be 3 and also the temperature produced from partial oxidation which was found to be 340°C. Detailed mass balances were carried out, energy balances and process

description was also done this helps in the designing of a packed bed reactor and a packed scrubber. Process control and HAZOP analysis was done on the designed equipment to ensure that the plant will operate within the designed parameters. Site selection was done and Kwekwe was found to be the best after considering many factors such as transportation of hydrogen. Economic analysis was carried out to access the economic feasibility of the project and a payback period of 2 years and a return on investment of 50% which are acceptable financial indicators. The selling price of hydrogen is $0.60 per kg. The total required capital investment for this project including cost of EIA was calculated to be $2 354 842.43. It is conducted that it is feasible to design an economically viable and environmentally friendly process for the production of hydrogen from steam reforming of ethanol.

KEYWORDS: Hydrogen, ethanol, steam reforming, partial oxidation

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DESIGN OF A 15MW/DAY POWER GENERATING PLANT USING SYNGAS FROM THE GASIFICATION OF MUNICIPAL SOLID WASTE

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The utilisation of municipal solid waste (MSW) for energy production has been implemented globally for many decades. Zimbabwe however is still highly depended on landfills for MSW management. Zimbabwe has an urgent need for a better waste management strategy because of the concern for greenhouse gases (GHG) emission and scarcity of land. This study aims to evaluate the energy, economic and environmental impact of waste-to-energy (WtE) for municipal solid waste management. Energy is a critical issue for Zimbabwe, where a large number of people have no access to energy. Energy recovery from waste can play a role in minimizing the impact of solid waste on the environment with the additional benefit of providing a local energy source. Experiments were done to determine the heating value of MSW. Experiments were also conducted to determine the moisture content in MSW as this indirectly affects the heating value of MSW. The moisture content was found to be 29% which needed to be reduced to about 15% thus a drier was incorporated in the process. The presence of hydrogen sulphide was also investigated and this raised the need for gas cleaning in a cyclone and scrubber to ensure the use of a clean gas. A detailed process description was done. Mass and energy balances were also done and they provided a basis in the design of a gasifier, rotary drier and cyclone Aspects of temperature control, flow control was also done and HAZOP analysis were also done to ensure safe operation. Pomona dumpsite was selected as the plant site for the adoption of the gasification technology to produce syngas which can be used to

generate energy. A detailed economic analysis was done to access the economic feasibility of the project. This project has a payback period of 1.5 years and a return on investment of 68.2% which are acceptable financial indicators. The design done showed it is economically viable and environmentally friendly to generate electricity from MSW.

Keywords: Municipalsolidwaste (MSW), Gasification, Syngas, Energy

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DESIGN OF A 60m³ PER DAY EFFLUENT WATER TREATMENT PLANT USING NANOCOMPOSITE BIO-CHAR AS AN ADSORPTION MEDIUM – HARARE POWER STATION

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Environment issues are more than ever important in a modern society. With over 50 000 litres of waste water produced by Harare Power Station per day into the drain without pre-treatment, this document will critically review the impact of Bio-sorption technology using composite bio char material from paper mill sludge impregnated with MgO Nano crystals for higher adsorptions (787mg/g) as a sustainable water pollution control tool to the environment. The project seeks to determine the best technology to be used in the reduction of water pollution and recovery of essential elements such as phosphates by over 90% from industrial waste waters, industry of study being Harare Thermal Power Station. Other industries are however not an exception. With Kadoma Paper Mill releasing over 10 tonnes per day of waste paper mill sludge into the environment aiding to the already excruciating scourge of global warming, the aim is to make feasible contributions to the reduction of carbon dioxide through its sequestration into the bio char matrix. The Nano composite bio char besides being used as a bio sorbent can also be used as an energy source with fixed carbon composition of 44.14% and a gross calorific value of 22MJ/Kg. We also investigate and appreciate the Nano composite bio char production patterns under different conditions with the one produced at 700^0C producing the best adsorption results. FTIR spectroscopy was used in the characterization technique to observe different functional groups and the Nano crystals on the Nano composite bio char matrix. Techniques employed in the design of this system can potentially be used to build scalable, easily navigable, and extensible models of large-scale entities. Aspects of temperature control, flow control will also do and HAZOP analysis was employed to ensure maximum safety. A detailed economic analysis which yields 2.7 years of payback time on a profit

margin of 90% was done to assess the economic feasibility of the project work. The Return on investment is 37.6%.

Key words: *Nano composite bio char, Bio sorption, MgO Nano crystals*

DESIGN OF A PLANT TREATING 500m³ / day OF DAIRY WASTEWATER FOR REGENERATION USING A COMBINATION OF A MEMBRANE BIOREACTOR AND NANOFILTRATION: CO-CAPTURING BIOGAS AND BIOSOLIDS

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Zimbabwe has 0.98m^3 of fresh water per capita which is very low and worrying. The country also has an energy deficit of 60%. There is a lot of wastewater being deposited in water bodies from the dairy industry that can be collected and recycled to curb the water challenges while creating a green environment. This project is about an integrated wastewater management system that can recycle wastewater while also harnessing biogas via bio-catalysis. The process consists of a membrane bioreactor which combines first and secondary treatment, with Nano filtration as a tertiary treatment step. Experimental work was done and from this work, there was 99.8% removal of TSS, 93.9% COD reduction, 95% BOD_5 reduction as well 90% colour removal after membrane bioreactor treatment of the wastewater sample. The two major pieces of equipment, a membrane bioreactor, and a fixed film bio-digester were designed for this project on the basis of the experimental results and some research papers. Because of its unique design of packings with a biocatalyst (actizyme) embedded into it, a 78% yield of biogas was realised from the bio digester. The biocatalyst also facilitates production of H_2S free gas. A process control and HAZOP study were done on the designed equipment to ensure equipment operability and safety. An Environmental Impact Assessment was carried out for the identification and mitigation of identified impacts of the project to the environment. An economic analysis done showed that the project requires a total capital investment of about $ $ 177 072.70 with a payback period of 3.6 years and a return on investment of 27.4 %. The selling price of biogas was pegged at $1.05 per kg. From all the work done, it can be concluded that this is a technically and economically feasible venture that supports water sustainability while creating clean, renewable and sustainable energy.

Keywords: *Bio-catalysis, dairy wastewater, fixed film bio-digester, membrane bioreactor, biogas, Nano filtration, recovery.*

DESIGN OF A PLANT THAT CONVERTS 40 TPD COAL BED METHANE (C.B.M) TO METHANOL UTILIZING A TWO STAGE REFORMING PROCESS.

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A vast majority of industries depend on methanol and methanol derived products in their manufacturing processes. Zimbabwe annually uses US$ 5.2 million in the importation of methanol and methanol derived products, establishment of a methanol plant in Zimbabwe will eliminate the country's reliance on imported methanol.

The capstone design aim is cantered on designing a plant that produces methanol through operational energy reduction and insuring the module of the synthesis gas produced after stages of reforming is above two. The two stage reforming process is of integral importance to the process design. The pre-reforming stage acts as a purification step for the main reforming stage of partial oxidation. This is achieved by removal of sulphur and the splitting of higher hydro-carbons that are present in the CBM these impurities are major poisons of catalyst. The pre reforming reaction takes place at 550 ºC, a pressure of 1 bar with a steam to methane ratio of 4.5 to 1 and under the influence of nickel catalyst. Under these conditions a methane slip of 55% is achieved. This then allows the main reforming stage to receive an impurity free feed to convert which consists of 55% methane hence ensuring higher H_2 to CO ratios to be achieved in POX (partial oxidation). The two stage design of the SMR (steam methane reformer) and POX was simulated in Aspen Plus and the results obtained supported the feasibility of the design.

Equipment designed included the distillation column and the SMR unit. A Process instrumentation and control was done to control process variables and ensure no product variability. A HAZOP analysis of this equipment was also carried out to eliminate potential hazards to humans and the environmental.

A site selection process was conducted and Lupane was selected as the plant location site. An environmental impact analysis was carried out to ensure that the plant adheres to environmental laws. A detailed economic analysis to assess the profitability of the venture was done. The economic and financial viability of the project is evaluated using profitability indicators such as return on investment, payback period, and breakeven analysis. A total capital investment of US$ 3.8 million is needed; the venture has a payback period of 2.4 years, a return on investment of 41% and an internal rate of return of 45%.

Keywords: *methanol, coal bed methane, steam methane reformer, partial oxidation, HAZOP analysis*

DESIGN OF A PLANT TO PRODUCE 20TONS/DAY OF COPPER CATHODES THROUGH MAXIMISING ON CATHODE PURITY (CASE STUDY OF EMPRESS NICKEL REFINERY)

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ENR is currently the only operating base metal refinery in Zimbabwe. The company produces nickel cathodes and copper cathodes as the main products. The company is currently producing second grade copper cathodes due to the presence of impurities (Ni, Fe, Pb). This has resulted in the company selling the copper cathodes at a lower market value. This capstone design project has design a process to produce copper cathodes incorporating solvent extraction. LIX 984N is the copper solvent extraction reagents that best suites ENR conditions. Laboratory experiments conducted have proved that 93.8 % extraction efficiency can be obtained with 20volume % of LIX 984N. Extraction temperature of 35 °C was found to be optimum. Cobalt addition to the electrolyte has also proved to reduce the rate of lead anode corrosion with cobalt concentration of 300ppm being the optimum. The experimental results were then used to design two CSTRs and an electro winning cell. The total capital investment for the project is $ 1 633 250. The return on investment is 120.52% whilst the payback period is 0.83 years. The company has to sell 3615, 83tons of copper to reach the break-even point.

Keywords: *copper solvent extraction, cobalt addition, copper electro winning*.

DESIGN OF A PLANT THAT PRODUCES 250kg/day OF ZEOLITE-X SYNTHESIZED FROM FLY ASH

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Out of the five power generating stations in Zimbabwe four of them use coal for power generation. The combustion of the coal produces coal fly ash, bottom ash and flue gases. This project focuses on use of coal fly ash as a zeolite. From research done it has been found that the fly ash can be used to make zeolite which is a material that can be used as a catalyst, adsorbent, and detergent builder. The project focuses on the local production of 250kg/day of zeolite-X which brings financial benefits to the nation through reduction of importation of catalysts, adsorbents, and detergent builder. Experiments were done to determine the fly ash composition, effect of alkali fusion temperature,

effect of using NaOH solution, effect of using different NaOH to fly ash ratios, and effect of hydrothermal treatment. The results obtained were used in the design of stirred batch reactor and rotary kiln. 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 total project cost is $337 926.32 with a payback period of 2.8 years and a return on investment of 35.8% which are acceptable financial indicators. It was concluded that it is possible to design an economically viable and environmentally friendly zeolite manufacturing plant that uses coal fly ash from local power plants. Further optimization of the process to incorporate energy integration techniques in the plant to ensure efficient and more economical energy use is recommended.

Keywords: *coal fly ash, zeolite, batch reactor, rotary kiln*

DESIGN OF A PLANT TO PRODUCE 10T/DAY OF DOUBLE PLY TISSUE FROM RECYCLED WASTE PAPER SLUDGE (CASE STUDY FOR KADOMA PAPER MILLS (KPM))

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Currently Kadoma Paper Mills produces about 2 555 tonnes of sludge per year as waste and it is disposed to the municipality every day. KPM being the only company making tissue paper, it only produces 13 tonnes per day of E-white. At the moment there is high demand of E-White high quality tissue (HQT) since it is not locally manufactured and also being imported at high costs there is a need to come up with an economically feasible process that will produce this tissue grade from the readily available waste paper. This project came up with a design of a plant that treats the sludge and allow it to go through various stages with monitored consistency with the production capacity of the 10 tonnes per day .The sample product was tested for pH, tensile strength, deckle, and grammage. Various experiments to test the fibre consistency and also Aluminium Sulphate and DSR's retention effect to the short fibres were conducted at the laboratory and some at the KPM Company to analyse the feasibility of the process. Also moisture content tests and other compositions tests were done. The experimental results will be therefore used for the equipment design in the process. A hydrapulper and a Yankee dryer were designed and a HAZOP analysis was done for each equipment as well as the process control for each piece. A detailed economic analysis was done and showed a ROI of 47.03% with a payback period of 2.15 years with the unit price of the tissue to be $0.73 per kilogram.

Keywords: *Sludge-recovery, Retention, consistency, high quality tissue (HQT)*

DESIGN OF A PLANT TO PRODUCE 1500 KG/DAY GELATIN USING TENNARY WASTE SPLITS AND OFF-CUTS

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Environmental awareness became the periphery of sustainable development since 2007. Failure to address environmental health amplifies the burden of land, air and water pollution. The tannery is growing by 3.5% per year, the disposal of splits and off-cuts as waste is also increasing and this is contributing to the disturbance of ecological systems. Meanwhile the recycling of waste is a major concern at national and international levels. This waste could be used to create value-added products such as gelatin, currently imported in Zimbabwe and also solve the problem of waste disposal. This project focuses on the design of a plant to produce 1500kg/day gelatin from tannery waste splits and off-cuts. The feasibility of this project was tested through conducting series of laboratory experiments. From experiments the following information was obtained: percentage yield of gelatin 20.6%, extraction temperature 85°C, five hours extraction time, viscosity of gelatin 4.32 Pa.s, moisture content of gelatin 9.75%, and fat content of gelatin 10.7%. A detailed process description was done. Mass and energy balances were done and they provided a basis in the design of rotating shell batch reactor and horizontal tube evaporator. Aspects of temperature control, pressure control and level control was done and HAZOP analysis was also done to ensure safe operation of the plant. Decision matrix for Harare, Gweru and Marondera was done and Harare, Willovale was selected as the most appropriate site. A detailed economic analysis was done to access the economic feasibility of the project. This project has a payback period of 2.2 years and a return on investment of 45.2% which are acceptable financial indicators. The selling price of gelatin is $0.389/kg. In conclusion, it is feasible to design an economically viable and environmentally friendly process for the production of gelatin from waste tannery splits and off-cuts.

KEYWORDS: *Gelatin, tannery waste splits, off-cuts.*

DESIGN OF A PLANT TO PRODUCE 30 TONNES PER DAY OF PURE HYDROGEN GAS FROM PLASTIC SOLID WASTE: CASE STUDY SABLE CHEMICALS

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Sable chemicals currently facing challenges with the issue of the high costs of running their electrolysis to reduce hydrogen for their prime product, Ammonium Nitrate. The electrolysis plant has left the company in a huge debt to the Zimbabwe Electricity Transmission and Distribution Company (ZETDC) due to the high demands electricity of the plant during the electrolysis. The project presents considerations on using Municipal Plastic/ Solid Waste to produce hydrogen through gasification.

Three experiments were focused on. Ideal bed temperature was found to be 850°C. Optimum temperatures were 780°C for polystyrene, 835°C for polyethylene 845°C polypropylene and 795°C for polyethylene terephthalate. In the proximate analysis volatile matter was 95.40%, fixed carbon 2.89% moisture 0.67% and Ash 1.94%. Ultimate analysis had 79.54% carbon, 13.06% hydrogen, 0.18 nitrogen, 4.53% oxygen, 2.69% sulphur.

In the designed process shredded of the waste is fed into the gasifier. From the gasifier syngas is cleaned by a cyclone and is cooled by a heat exchanger for efficient sulphur and carbon dioxide respectively. The gas goes to a pressure absorption unit were the hydrogen is separated from the rest of the gas and before going to the storage tanks.

A prototype fluidised bed gasifier and cyclone were designed. The HAZOP study on the designed equipment was done to ensure equipment operability and safety. The control system of this equipment was automated utilising programmable logic controller technology PLC. An environmental Impact Assessment was done to assess the effect of by-products of gasification such as carbon dioxide.

Economic assessment showed the price of hydrogen being $455 per ton. The payback period to be 3.4 years and a return on investment of 29.06%

Keywords: *Municipal Plastic Solid Waste, Hydrogen, Gasification. Sable chemicals*

DESIGN OF A 2.3 TONNE/DAY LPG PRODUCTION PLANT FROM USED LUBRICATING OIL BY VISBREAKING

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The improper handling and mismanagement of waste lubricating oil is a serious environmental problem. Failure to address proper handling of used lubricating oil will amplify the land degradation and water pollution. Since almost all types of waste oil have the potential to be recycled safely, saving a precious non-renewable source and at the same time minimizing environmental pollution. There is need to take advantage of the used oil, by recycling it to produce liquefied petroleum gas. This project is centered on the design of a 2.3 tonnes per day LPG plant from used lubricating oil as raw material. From experimental work carried out at the Tribology Oil Laboratory Zimbabwe, it was ascertained that the optimum conditions for the *visbreaking* technology is temperature of 450^{0}C and pressure of 10 bars .From the experiments done, approximately 40 % of the used oil was converted into liquefied petroleum gas (LPG), 30 % of used oil into gasoline, 20% of used oil into naphtha and 10% of used oil into light gases. These experiments were used in mass balances to determine the amount or raw material needed and hence the size of equipment designed. A preliminary environmental impact assessment of the plant highlighted that the potential negative impacts such as soil erosion, destruction of the ecosystem by tree cutting and bush clearing, destruction fauna and flora and vegetation depletion can be easily mitigated. Process control, HAZOP analysis and Environmental Impact Assessment were done and the Chitungwiza industrial area was chosen as the best area to locate the plant. The chosen location offers all the following advantages in one package, availability of labour, easy accessibility to the plant and sufficient land available for expansion of 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, the return on investment (R.O.I) is 25 % after a total capital investment of $ 4 027 292.42. The selling price of the liquefied petroleum gas was projected at $0.80 per kg .

KEYWORDS: *Liquefied petroleum gas, used lubricating oil*

DESIGN A PLANT THAT RECOVERS 0.5TPD OF CARBON DIOXIDE FROM FOSSIL FUELLED POWER PLANTS USING MODIFIED ACTIVATED ALUMINA

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The ever-increasing concentration of CO_2 in the atmosphere associated with fossil fuel combustion has been linked to significant global climate change over the course of the last century. As a result, recent research has focused on development of materials and technologies that might be used to

capture CO_2 from fossil fuel emitting processes, especially from large point sources such as coal-fired power plants. Therefore this project focuses on the design of the process that captures carbon dioxide from flue gases using activated alumina. Experiments were done to determine the composition of flue gas, to synthesize alumina using the solvo-thermal method and to show adsorption efficiency of alumina towards carbon dioxide in the flue gas.The alumina was produced and the adsorbent showed a better selectivity to carbon dioxide. Mass and energy balances were also done and they helped in the design of scrubber and adsorption column. Aspects of temperature control, flow control, and HAZOP analysis were done to ensure safe operation. This project has a payback period of 2.43 years and a return on investment of 41% which are acceptable financial indicators. The selling price of carbon dioxide is $2.00 per kg. It is technically feasible, economically viable, and environmentally friendly to design process for the recovery of carbon dioxide.

KEYWORDS: *Carbon Capture and Storage (CCS), activated alumina, adsorption, CO_2*

DESIGN OF A 3 000 LITRES PER DAY WASTEWATER TREATMENT PLANT FOR THE REMOVAL OF LEAD IONS USING MODIFIED CORN COB CHAR: CASE STUDY CHLORIDE ZIMBABWE PLANT

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Chloride Zimbabwe being a leader in lead acid battery manufacturing faces the challenge of effectively treating their waste water which has lead concentration above limit of 0.5 parts per million (ppm). The remediation of lead ions in industrial wastewater was investigated by adsorption using bio char synthesized from underutilized agricultural waste, corn cobs which were pyrolysed at 450^0C for 1 hour using different modifiers. Experimental work was undertaken to determine the most suitable modifier. Activated Amine Silica composite showed the greatest affinity towards Pb with a 74.25% lead removal percentage and therefore was used as the impregnating agent. The selectivity order of the adsorbent modifier was Activated Amine Silica Composite > NH_3 > H_3PO_4 > Raw char. An optimum temperature of 40^0C and a pH of 9 was obtained. The competitive adsorption of two heavy metals, Lead and Arsenic was studied. Lead showed more aggression than Arsenic in the adsorption due to its lower firmly bound solvation shell, and consequently, its adequately smaller particle size. The quantitative information obtained from the experiments was used to design an adsorption column and a pyrolysis reactor. Environmental impact assessment was carried out for the plant from inception, construction, and operation and appropriate mitigation strategies were instigated. The total capital investment was calculated to be $376,326.72. A return on investment of 25.06 % and a payback period of 3.99 years showed high returns. It was concluded that it is possible to design the plant. Zimbabwe being an agro-based economy would benefit immensely from beneficiation of corn cobs.

Keywords; *lead, heavy metals, adsorption, corn cob char*

DESIGN OF A PLANT THAT PRODUCES 275 T/DAY OF PORTLAND CEMENT USING PULVERIZED COAL ASH

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The overall demand of cement in Zimbabwe has increased by 5.6% from 984 000 tons per annum in 2012 to 1 039 000 tons per annum in 2014 due to increased construction activities as its population increases. Local factories have a capacity of producing 940 000 tons per annum of cement providing a shortage of 99 000 tons per annum to the required amount of cement. Cement production processes are very energy intensive and causes a lot of carbon dioxide emissions to the atmosphere therefore this project aimed at designing a low energy consumption cement plant with reduced carbon dioxide emissions using pulverized coal ash. The plant has a capacity of producing 275 tons per day of Portland cement to meet the demand required. Experiments were done to determine the effect of clinker cooling on the strength of cement, effect of percentages of gypsum added on the settling time and compressive strength of cement. From the experiments 4% gypsum was used as an additive and a Portland cement with a compressive strength of 25Mpa and initial and final settling time of 60 and 120 minutes respectively was obtained. A detailed process description was also done. Mass and energy balances were also done and they helped in the design of a rotary kiln and a ball mill. Process control and HAZOP analysis was also done to ensure safe plant operation. Hwange was selected as the most appropriate site. A detailed economic analysis was also done to access the economic feasibility of the project. The selling price of Portland cement is $9 per bag. This project has a payback period of 1.94years and a return on investment of 51.46% which are acceptable financial indicators.

KEYWORDS: *Portland cement, Compressive strength, Gypsum, Setting time*

DESIGN OF AN INTEGRATED PLANT UTILIZING 1T/DAY CORNSTOVER TO PRODUCE BIOHYDROGEN AND BIOGAS

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High consumption of imported energy in Zimbabwe and other countries has increased the interest in bio-renewable sources of energy. This interest has fuelled research into crop residues as one potential alternative fuel source. Lignocellulosic biomass, such as corn stover, is a potential raw material for biofuels production. The production of bio hydrogen and biogas from corn Stover was investigated within a bio refinery framework. Initially, 1 tons/day corn Stover was hydrothermally liberated to a cellulose rich fibre fraction and a hemicellulose rich liquid fraction (hydrolysate). A 3 pre-treatment step at 80^{o}C for 15 minutes, 180^{o}C for 40 minutes and 190^{o}C for 10 minutes was done to achieve efficient conversion of lignocellulosic biomass to soluble sugars. Enzymatic hydrolysis and subsequent fermentation of cellulose yielded 0.3561g biogas/1g corn Stover, while dark fermentation of hydrolysate at 1atm, 5-6.5 pH and (40-60)^{o}C yielded 0.3116g bio hydrogen/1g corn Stover from sugars. The effluents from the bio hydrogen process were also used to produce biogas. More research was done using experiments by characterising the physical and chemical composition of the corn Stover so as to pave a way for easy production of the biofuels. The design of an integrated plant which produces bio hydrogen and biogas from 1 tonne /day was done and selection of equipment which would make it easy for production.

A fermenter and a hydrolysis reactor were 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. An EIA was carried out for the mitigations of the identified negative project impacts. The plant will be located in Norton along the Endeavour road near the Grain Marketing Board.

The project has a payback period of 1.34 years, a return on investment of 74.3% at a breakeven point of $58 846 units and an NPV of US$ 471 666. It was concluded that it is possible to design the plant and Zimbabwe's economy would benefit immensely from the project.

Keywords: *Bio hydrogen, biogas, lignocellulose, cellulose, hemicellulose, lignin, biofuel, biomass, fermentation, corn Stover.*

DESIGN OF A PLANT TO PRODUCE 5000 KG/DAY OF STRUVITE FERTILISER FROM HUMAN URINE

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Due to a rising demand of fertilizer in Zimbabwe there is need to supplement the current fertilizer supply by organic fertilizer. The demand of inorganic fertilizers for the year 2013 to 2014 farming season was projected at 345 000 tonnes per year for Compound D and Ammonium Nitrate (AN). *Herald of January 16, 2014*. Also as a concern to the environment, the use of inorganic fertilizers is being called to be reduced as it is causing adverse environmental effects. The disposal of wastewater, leaching and surface runoff of inorganic fertilizers containing Nitrogen is causing cancerous diseases to humans and eutrophication in water bodies. From the experimental results the quantity of Nitrogen, Phosphorous and Potassium obtained from an individual urine sample was 77,6g/l, 55.3g/l and 0g/l respectively. This project is addressing a solution to the disposal of human urine as municipal waste by the use of a designed plant to harness Nitrogen and Phosphorous as organic nutrients. The human urine is going to be used as major raw material and collected from urinary tracks in which the tracks will be directed towards a collecting tank constructed underground. Urine and Magnesium Oxide (MgO) are reacted to precipitates Nitrogen and Phosphorous to form Struvite [Mg (NH_4) (PO_4) * $6H_2O$]. The designed plant has major equipment which is the continuous stirred tank reactor, a separator, a drier and a granulator. This is brought about to benefit the agricultural industry in Zimbabwe and mitigate the so called environmental problems by synthetic agricultural inorganic fertilizers. This research has commercialized efforts and highlights the development of human urine utilization by precipitation. This has shown significantly lower costs on Struvite fertilizer production and at the same time offering better physical properties and lower environmental pollution. It is possible to produce 5000kg/day of granulated struvite bio-fertiliser. A detailed economic analysis of the project has a payback period of 1.8 years and a return on investment of 55.0% which means the project is economic feasible and the selling price of 50kg bag of struvite fertilizer has found to be 21kg.

Key words: *Magnesium Oxide, Precipitation, Struvite, Bio-fertiliser*.

DESIGN OF A PLANT FOR THE PRODUCTION OF 400KG/DAY NANO ZERO VALENT IRON (nZVI) FOR ENVIRONMENTAL POLLUTION CONTROL AND REMEDIATION

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Nano-sized Zero Valent Iron (NZVI) is considered as an effective adsorbent and ideal technology for various contaminant removals including in-situ remediation of heavy metal contaminated groundwater. It is used for environmental pollution control and remediation. The production of NZVI is done via the chemical reduction process whereby $FeCl_2 \bullet 4H_2O$ is reduced to Fe^0 using that is $NaBH_4$ as a reduction agent. Experiments were done to determine the optimum synthesis conditions of nZVI, the wet and dry nZVI particles moisture content, the optimum temperature for drying the nanoparticles and the copper removal percentage using iron nanoparticles. Atmospheric conditions

were adequate for synthesis process and the optimum drying temperature was 150℃. The effectiveness of nano Zero valent iron was also tested through its ability to remove contaminants like copper ions from contaminated water. nZVI managed to remove 89% of copper ions in 12 hours. A detailed process description was also done. The production process is divided into four unit operations which are synthesis facilitated by mixing, separating, washing and drying. Mass and energy balances were also done and they helped in the design of the reactor, rotary vacuum drum filter and the rotary vacuum drum drier. Aspects of temperature control, flow control and pressure control was also done as well as HAZOP analysis to ensure safe operation. Chitungwiza industrial area was selected as the most appropriate site. A detailed economic analysis was also done to access the economic feasibility of the project. This project has a payback period of 1.6 years and a return on investment of 60.9% which are acceptable financial indicators. It was concluded that it is feasible to design an economically viable and environmentally friendly processing plant for the production of nano zero valent iron.

KEYWORDS: *nano Zero-valent iron, contaminated water, heavy metals, adsorbent, remediation.*

DESIGNING OF A PLANT THAT PRODUCES 2000L/DAY OF OLEIN FROM TANNERY WASTE FLESHINGS. (A CASE STUDY FOR SUPERIOR HOLDINGS PRIVATE LIMTED)

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Superior Holdings private limited is one of the largest tannery companies in Zimbabwe that processes 22500kg of raw hides per day. During their Beam house operations, most of the wastes that are produced are fleshings which constitute approximately 28% of hide's weight that is 6300kg of waste fleshings per day. Presently, the fleshings are disposed as waste material. These waste fleshings create environmental problems and despite their considerable fat content they do not find any important use. By paying attention to the Zimbabwe Agenda of Sustainable and Socio-Economic Transformation (Zim-ASSET) blueprint under the value addition and beneficiation cluster, the 6300kg waste fleshings can be used as a raw material to produce 2000L/day olein (Glyceryl trioleate) thus 600000L/year and reduce the land burden through deposition. Olein is used in the manufacturing of fat liquoring oil for Retanning, lubricating oil and others. Work was done in this design and innovation capstone project to design a plant that produces olein for use as a fatliquor and lubricant, thereby reducing the amount of waste materials being disposed through a value addition system. A design of a stripping column and a bleacher as well as sizing of a decanter, and choosing the best

processing route for a cost effective production process of olein was done. Experiments proved that wet rendering process at 95^{o}C is a best route for extraction of the crude oil and the quality test experiments gave process monitoring information for saponification value of 194.48mgKOH/1g olein and iodine value of 63.03g of iodine/100g olein. Mass and energy balances were done and they formed the basis of the design of a stripping column, bleaching column, sizing of the decanter and provided information for site selection, HAZOP analysis and economic balance. Control systems and HAZOP analysis for the equipment were done to ensure safe operation and monitor product quality. Number 6 Barking road (Superior holdings site) was selected as the most appropriate site for the designed plant. The economic analysis of the project highlighted that $426 652 capital investment is required. By selling olein at $1.30 per litre, net profit of $389 601 can be realized and a payback period of 1.1 years at a return on investment of 91%. The break-even is reached when the plant sales 69 683 litres and in 5 years' time the company profit is estimated at $828 542.

Key words: *Olein, tannery waste, fleshings, physical refining and dry rendering*

DESIGN OF A PLANT THAT PRODUCES 18 TPD OF PROPYLENE FROM ORGANIC MUNICIPAL SOLID WASTE

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Liquid fuels are in high demand throughout Africa not mentioning Zimbabwe. Due to strain on conventional sources for liquid fuels, alternative sources and new technologies to create liquid fuels are becoming more attractive routes. The project intends to use organic municipal solid waste as a raw material for the production of polymer grade propylene. It entails the problem statement, aim of the project, justification of the study and the objectives of the study. The conversion of organic municipal solid waste to propylene followed the following steps, sorting, soaking, anaerobic digestion at 55^{o}C, gas cleaning, steam methane reforming, methanol synthesis, dimethyl ether synthesis, propylene synthesis, and lastly purification of propylene.

Material and Energy balance results were used to come up with usage ratios in equipment designing. A bio digester and a distillation column were designed in order to show practicality in organic municipal solid waste to propylene process.

An economic feasibility was done on the project and was found to be viable. The project requires a total capital investment of $ 525 173.05. The selling price of propylene and ethylene were calculated

to be $ 242.65/ton and $484.30/ton respectively. The project had a break-even point of 746 units in tonnes, payback period of 1.62 years and return on investment of 61.6%. The NPV was found to be $ 2 442 798.85 for a plant life of 5 years, proving that the project is worth investing in.

Keywords: *Bio digester, HAZOP, anaerobic digestion, organic municipal solid waste, Environmental Impact Assessment, propylene*

DESIGN OF A PLANT THAT RECOVERS 1000 LITERS/DAY OF OIL FROM EMULSION EFFLUENTS VEGETABLE COOKING OIL (A CASE STUDY OF PURE OIL INDUSTRIES).

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Currently there is a problem of reducing the oil contaminant load to downstream waste water systems hence according to the Environmental Management Act (Chapter 20:27) the government of Zimbabwe is aiming at providing a sustainable environment and also regulating the disposal of waste (solid waste and effluents). Vegetable oil processing plants are normally the big contributors of oily wastewater. Vegetable oil industries such as sunflower, olive and soybean, discharge large volumes of oily wastewaters. These wastewaters contain a very high volume of oil-in-water emulsions as their basic contaminant *(Pushkarev et al., 1983)*.Therefore this project aims at designing a plant that recovers 1000 liters/day of oil from emulsion effluents of vegetable oils. Preliminary studies have revealed that it is possible to recover oil from emulsion effluents based on experiments done on the composition of the effluent, clarification of the effluent and lastly on the recovery of oil. During the clarification stage using a dissolved air floatation tank the removal of suspended solids was 80 % and the remaining 20% was removed by use of a decarbonator. The optimum temperature in the DAF tank was 40°C at atmospheric pressure. The recovery of oil a distillation column was used at a temperature of 300°C and a pressure of 1 atmosphere. A detailed process description was also done. Mass and energy balances were also done and they helped in the design of an evaporator and distillation column. Aspects of temperature control, flow control was also done and HAZOP analysis was also done to ensure safe operation. Harare was selected as the most appropriate site. A detailed economic analysis was also done to access the economic feasibility of the project. This project has a payback period of 6 months and a return on investment of 195 % which are acceptable financial indicators. The selling price of cooking oil is $1.20 per liter. It can

safely be concluded that it is feasible to design an economically viable and environmentally friendly process for the recovery of oil from emulsion effluents.

KEYWORDS: *Emulsion effluents, Decarbonator, Dissolved Air Floatation tank, Clarification, Suspended solids*

DESIGN OF A PLANT TO PRODUCE 280L/D OF ACRYLIC ACID FROM BIOMASS (GLYCEROL)

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Environment has become a major concern globally leading to the rise to the need to consider biochemical from renewable low cost and carbon based raw material. This research work focused on production of acrylic acid from crude glycerol replacing propylene as a raw material. Acrylic acid is a chemical intermediate used in production of adhesive super absorbent polymers etc. Therefore this project aims at designing a plant that produces 280L/day of acrylic acid from crude glycerol. Experiments were done to determine the effect of temperature on dehydration of crude glycerol to acrolein, the effect of temperature for oxidation of acrolein to acrylic acid and the effect of oxygen/acrolein ratio to acrylic acid yield. Maintaining an ambient pressure of 1 bar the optimum temperature for dehydration of glycerol was found to be 300^{o} C which attained 97.9% conversion of glycerol and 78.2 % yield of acrolein. For the oxidation process the optimu12m temperature was also 300^{0} C which attained 100% conversion of acrolein and 95.5% yield of acrylic acid. Also at oxygen/acrolein ratio of 12.5mol/mol resulted in 100% conversion of acrolein and 95.5% yield of acrylic acid .A detailed process description was also done. Mass and energy balances were also done and resulted in the design of fixed bed catalytic reactor and absorption column. HAZOP study was carried out on designed equipment in parameters like flow, pressure, temperature, etc. and also process control procedures done taking into consideration temperature, level and pressure controls. Mutoko was considered to be the most appropriate site for plant location. A detailed economic analysis was also done to access the economic feasibility of the project. This project has a payback period of 2.1 years and a return on investment of 49.3% which are acceptable financial indicators. The selling price of acrylic acid is $5.7 per kg. It is conducted that it is feasible to design an economically viable and environmentally friendly process for the production of acrylic acid.

KEYWORDS: *Acrylic acid, Crude Glycerol*

DESIGN OF A PLANT TO PRODUCE 20TON/DAY OF LIQUIFIED HYDROGEN FROM COKE OVEN GAS (HWANGE COLLIERY COMPANY

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Hydrogen is an important input in the manufacture on nitrogenous fertilizers in Zimbabwe. The most common industrial method to produce ultrapure hydrogen is by steam methane reforming (SMR), where hydrogen is first produced as a mixture mainly composed of hydrogen, carbon monoxide, methane, and carbon dioxide. Herein a rich and readily available source of hydrogen (coke oven gas) is to be utilized for the purposes of this design and innovation project. A purification step by pressure swing adsorption (PSA) is carried out using activated carbon and 5A zeolite as adsorbents. The design of this process obtained fundamental information about the adsorption and diffusion of the components of SMR-off gas and coke oven gas (COG), which is only available in the literature for a limited number of adsorbents. Experiments were done for COG characterization, adsorbent preparation, gas separation, and product hydrogen gas characterization and the results were outlined and analysed. A detailed process description was also done. Mass and energy balances were also done and they were taken into account in the design of equipment. A PSA unit for hydrogen purification using activated carbon and 5A zeolite was designed and a working prototype of an absorption column was developed. Process control and HAZOP analysis were carried out to ensure safe plant operation and for process optimization. The economic feasibility of the project was determined. This project has a payback period of 2.43 years and a return on investment of 41.21% highlighting the economic feasibility of the project.

Keywords: *Hydrogen, PSA, adsorption, zeolite, molecular sieve, coke oven gas.*

DESIGN OF A 1.5TON/DAY EGG TRAY MANUFACTURING PLANT THAT UTILIZES BAGASSE AS RAW MATERIAL

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The bagasse from the sugar factory is collected and cooked in a novel process of formic acid, acetic acid and water for 60minutes, at 110^{o}C to give a pulp yield of 50.4% after black liquor removal from pulp. The pulp will undergo ECF bleaching sequence prior to storage and chemical dosing to improve

on retention properties and strength. The pulp is then moulded into egg trays using Leotech moulding machine that makes use of vacuum pressure and then the moulded egg trays are dried in a continuous tunnel dryer which makes use of steam from the boilers. The boilers make use of bagasse to heat up the water instead of coal or any other fuel. This plant will be producing 1.5 tons of egg trays per day, utilizing a total of 7.8 tons of bagasse per day for both power generation and egg tray manufacturing. Mass and energy balance results were used to draw up material usage ratios in equipment sizing. Detailed process and equipment design of the major equipment was done. The HAZOP study on the designed equipment was done to ensure equipment operability and safety. The EIA was carried out for the mitigation of identified negative impacts of project. The total capital investment for the plant is $632,688. The plant produces 20 000 egg trays a day with a production cost of $0.08 per egg tray and selling prices of $0.11 per egg tray. It has a payback period of 4 years, a positive net present value of $13,593.33after 4 years and break-even at 68% from maximum capacity of 1.5tons a day. Estimated net profit is $ 159,719 per annum. This data approves the viability and profitability of this project.

Key words: *bagasse , black liquor , Leotech moulding machine , ECF bleaching sequence , HAZOP analysis,*

DESIGN OF A PLANT TO PRODUCE 13 TPD OF ULTRA HIGH MOLECULAR WEIGHT POLYETHYLENE FROM COAL BED METHANE

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Ultra High Molecular Weight Polyethene has a wide range of properties and these have made it a major component in the construction of machinery and equipment in the industrial sector and in the medical sector. However since the leading raw materials in ultra-high molecular weight polyethylene production are fossil fuels and petroleum oil, the depletion of world oil reserves causes a rise in ultra-high molecular weight polyethylene import prices. Due to high demand of use in ultra-high molecular weight polyethylene products, there is need to locally produce polyethylene from coal bed methane with the same properties as that produced from the existing raw materials. The research project aims to produce a 13TPD ultra-high molecular weight polyethylene using coal bed methane as a raw material, the economic benefits, environmental effects as well as technological benefits will be taken into consideration. The ultra-high molecular weight polyethylene making process starts with the steam reforming of coal bed methane to form syngas, followed by the gas to liquid conversion of syngas into hydrocarbons by the Fischer Tropsch process, cracking, distillation and lastly polymerization. Experiments were carried out and used in mass balance to determine the amount of raw material needed and hence the size of equipment designed. A detailed design was done on two major pieces of equipment; a plug flow reactor and Fischer Tropsch reactor. Hazard

operability has been analyzed in trying to monitor and mitigate deviations that may rise in the plant. A financial analysis for the project was carried out and the project proved to be economically viable with a payback period of 3.35years, the total capital investment was US$4 362 132.54. From the financial analysis, process and equipment design it can be concluded that it is possible to produce 13t/day polyethylene. The researcher recommends the in cooperation of nanoparticles since they have some novel properties which can increase the reaction rate and also increases the mechanical and chemical properties of the product.

Key words: *ultra-high molecular weight polyethylene, coal bed methane*

PROJECT TITLE: DESIGN OF A 14TON/DAY PLANT OF HIGH STRENGTH NANO BIO COMPOSITE POLYLACTIC ACID PLASTIC FROM SUGAR MOLASSES

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Plastic waste disposal is an environmental problem in Zimbabwe, with many challenges associated with it. Zimbabwe imports plastic material and pellets from other countries it being without petroleum. Due to high demand of use in plastic products especially pet there is need for use of alternatives that do not pollute the environment. This brings us to the use of bio plastics, especially in this case PLA. The project aims to design a process that produces PLA with zinc Nano crystals which is strong. The main objectives were to carry out a technical and economic feasibility of producing .The PLA plastic making process starts with fermentation of sugar molasses using lacto bacillus delbrueckii bacteria, followed by microfiltration which involves the separation of the liquid and solid, then Nano filtration, evaporation, lactide formation, polymerization, . The production of PLA was done experimentally. The experimental work was done to test the technical and economic feasibility. It was noted that at a temperature of 42^{0}C fermentation of lactic acid was at its highest, the concentration of lactic acid increased to 90g/l. It was also noted that the conversion of sugar to lactic acid was 90% and the conversion to PLA was 73.76 % at 195 ^{0}C. The properties of the PLA infused with Zinc oxide Nano crystals were better than PLA without zinc oxide Nano crystals. Mass balance results were used to draw up material usage ratios in equipment sizing. Detailed process and equipment design of the major equipment were done. The HAZOP study on the designed equipment was done to ensure equipment operability and safety. The EIA was carried out for the mitigation of identified negative project impacts. The PLA plant will be located in Msasa near ZFC. Economic analysis was carried out in order to see the economic feasibility of the project. The

project requires a total capital investment of about $3 518 400.88.The total manufacturing cost of the product was $0.51/kg and the product selling price is $0.77/kg. The projected sales volume was considered viable with a breakeven point of 1922 tons, 3 years 3monts 8 days' payback period and ROI of 31.35%.The NPV after 10 years was found to be $3 033 879.0 an indication that the project is worth pursuing.

KEYWORDS: *Polylactic Acid, Zinc nano crystals, bio plastics*

Industrial and Manufacturing Engineering Department

DESIGN OF A COPPER CONCENTRATOR PLANT

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Copper is a vital mineral in today's industry. The modern industrial era owes its existence to the use of copper wire. Zimbabwe sits on an estimated 5.2 million tonnes of copper, oxide and sulphide based ores, spread over 70 deposits mainly in the Lomagundi basins in North West parts of the country. With the closure of Munyati, Alaska, Shamrock and Mhangura copper mines the processing of the mineral has been put to almost a stand still forcing small scale miners to export the precious mineral in its unprocessed form. This has resulted in country losing opportunities that could be harnessed through beneficiation of the mineral to develop the economy by creating jobs, enhancing skills and diversifying the economy. Currently small scale copper miners in Zimbabwe lack the equipment and appropriate modern technologies to process the mineral and this has limited their ability to engage in value-addition and beneficiation. The aim of this project was to design a copper concentrator plant to process copper sulphide ores for Zimbabwean miners.The designer conducted informal interviews and used electronic papers and journals to gain deeper understanding of comminution technologies. In designing the plant the researcher used Autodesk Inventor 2015 to produce 3D CAD models and to perform simulations on various machine components. Flexsim 7.1 was used to conduct a discrete event simulation of the plant. The plant was designed with a throughput of 1.20 TPD copper concentrate. The plant comprises of a 4 TPD primary jaw crusher

with a 600mm x 400mm feed opening, a 3TPD gyratory crusher and a 2TPD ball mill. The ball mill operates in a closed circuit with a spiral classifier which then sends the fine ore for floatation in 1.2 TPD floatation cells. The designer fabricated a prototype ball mill and floatation cell. The plant can be made from mostly locally sourced materials and it can be used for both small to medium scale miners.

Keywords: *Mineral Beneficiation, Copper Concentrator, Comminution, Spiral Classifier*

DEVELOPMENT OF A PRODUCTION PLANNING MANAGEMENT SYSTEM IN A CHEMICAL PROCESS PLANT

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This project accesses the currently used production planning approach of Chemical Enterprises (CE) with the aim to improve the process. The company is faced with an assessment of the organisation's capacity to respond to demand opportunities. It is expected among other things that the production planning process can be improved since a trade-off between production and inventory costs are unknown. Currently the production planning is done by the production team manually using their experience and expertise. It uses due date priorities without taking into consideration costs related to production planning and other factors. As a result the constructed plans cannot fulfil customer demands. The aim of this project was to structurally improve the production planning approach and the customer service level to 99.5% through computerisation of the process and taking into consideration cost priorities. This research used more of quantitative research with a bit of qualitative research. To show how production planning approach and customer service can be improved, this research developed two alternative solutions that use real changeover and inventory costs with various dispatching rules. The quantitative and qualitative assessment showed that Mixed Integer Linear Programming out performed the other planning approaches on cost reduction and customer service level. For better management of the production planning process, the researcher developed a production planning management system that displays machine utilisation reports, enables customer order placement which automatically generates due dates, generates the plan and lastly the system generates production reports database. The best part is it is tailor made to solve specific problems at Chemical Enterprises.

Keywords: *Production Planning, Mixed Integer Linear Programming, Machine Utilisation*

A SYSTEMS DYNAMIC BASED SIMULATION MODEL TO SUSTAINABLE ENERGY SUPPLY IN ZIMBABWE

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Zimbabwe's electricity sector needs significant investment and reforms if satisfactory supply is to be accomplished. Power outages have been high and are still affecting firms (industry), famers, mines and households. Zimbabwe imports almost 50% of its electricity needs, with total current demand of over 2200MW compared to available capacity from internal sources of about1100MW. The local generation capacity is inhibited by lack of spares, maintenance, vandalism and antediluvian and obsolete equipment. The country has an overwhelming electricity debt to regional power utilities with Southern African Power Pool (SAPP) and other members cutting power supply. Zimbabwe's electricity is generated internally from hydro power (Kariba) and thermal power plants (Hwange). It is very necessary as a country to improve our total electricity capacity supplied so as to reduce the demand supply gap. As a nation, it is important for us to become self-dependent as this promotes ZIM ASSET. System Dynamic Modelling was used in this research as a demand and supply forecasting tool, and also as a policy lever. A conceptual simulation model designed by the author is very important in modelling electricity supply as it clearly outlines our current status and the forecasted demand for the next 12 years. The author used software denoted as STELLA. The model provided a conceptual framework of the whole electricity system. The results of the simulation showed a considerable growth in electrical supply if the country apply net metering of renewable energy and invest more in installing solar systems. Generally that is the solution for our electricity and we can further improve the solution by applying wind technology.

Keywords: *System Dynamic Modelling, Simulation Model, Conceptual Framework, Net meterin*

MYOELECTRIC CONTROL INTERFACES: A METADESIGN APPROACH

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Many amputees face the challenge of not being able to control their prosthetic devices and as such they suffer from high cognitive load and high energy expenditure. This research explored the idea of applying EMG signals in the control of prosthetic devices. The aim of this project was to develop a myoelectric control interface for the control of these devices. The interface which was developed was based on open source technologies as that could bring down the cost of the devices to the amputees. In this research, control of an actuator using EMG signals was achieved, thereby proving the viability of EMG signals as applied to the control of prosthetic devices.

Keywords: *Electromyography, Prosthetic devices, Cognitive load*

DESIGN OF A TWO AXIS SOLAR TRACKING PARABOLIC DISH FOR SOLAR WATER HEATER

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The purpose of this research was to design and develop a parabolic dish solar water heater for domestic and commercial hot water applications. The heater was designed to provide 800 litres of hot water at 95^{o}C per day at 75% efficiency. For effective performance the design incorporated an electromechanical sun tracking device which ensures the suns radiation is always perpendicular to the reflective surfaces of the solar collector. A prototype was developed and experimental tests were carried out which showed satisfactory results.

Keywords: *Parabolic Dish, Water heating, Solar tracker*

DESIGN OUT MAINTENANCE OF A BEARING LUBRICATION MECHANISM IN AN EXTRUDER BARREL (CASE STUDY NIBBLE SNACKS)

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This project was about design improvement of an extruder which produces snacks at Nibble Snacks. Through implementation of the barrel lubrication mechanism design would give maintenance personnel more time to focus on other maintenance programs rather than to spend more time attending extruder breakdown duties therefore leading to improvement of quality of products produced. The project contributed to the organization's ultimate goal of optimizing the production

process, by focusing more on value addition activities instead of non-value adding activities. The new design assisted in the reduction in machine breakdown and downtime during maintenance. This enabled local organizations to produce their products faster and giving them a competitive edge on the regional and global market in whatever type of business they would be involved in. The gathered information was analysed using graphs and pie charts. A final solution was chosen from three possible solutions and was developed into a prototype which was analysed for functionality. The results of the prototype analysis proved that the design is fully functional and is worth developing into a business venture.

Keywords: *Design improvement, Barrel, Tribology, Bearings, Maintenance*

DESIGN OF AN AIRBORNE WIND TURBINE FOR ELECTRIC POWER GENERATION

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This research work was carried out with the aim of generating electrical energy using a wind turbine located at 1.5 km above the ground level (airborne wind turbine). This was prompted by the realization that wind velocity in Zimbabwe is generally less than 3m/s. Also power densities of between 10 W/m^2 and 100 W/m^2 at the ground level and at fifty meter hub height is not economical for wind energy generation. It was found that at distances between 1km and 10 km above ground level wind exponentially increases in speed to at least 10m/s which are the required speeds for wind power generation. Global wind data from Archer and Caldera was used to estimate the distances/ altitude at which high velocity wind is found in Zimbabwe. The research methodology adopted followed the waterfall model in which all stages of design came after one another. Engineering tools such as AutoCAD, and Autodesk inventor were used to model and simulate the design. The results were a 1 kW turbine that is lifted from the ground by a lighter than air gas (helium) contained in a sealed envelope. Energy from the turbine is transferred to the ground via an aluminium flexible tether that is connected to the ground anchor. The anchor can rotate three hundred and sixty degrees to allow movement when wind changes direction.

Key words: *Airborne wind turbine, wind speed, power generation.*

DESIGN OPTIMISATION OF AN AUTOMATIC HEAVY VEHICLE WASHING SYSTEM

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Heavy vehicle machines in the construction and mining industry are the cardinal piece of equipment that keeps the target production volumes within reach. Nevertheless, maintenance of these machines through conventional cleaning methods comes at a cost as excessive water is required. This research seeks to come up with a design that will reduce the washing time and water consumption in heavy vehicle wash bay area. The researcher seeks to optimize the already existing designs incorporating a method of washing vehicles using high pressure sprays and moving within only the vehicle length. Data was collected using both qualitative and quantitative method based on a joint application methodology (JAD) approach to research pertaining previous washing bay design. A micro controller based machine that uses infrared sensors that detect the presence of a vehicle in the wash bay was designed. A motor driven trolley to start moving along the vehicle was incorporated. The design reduces waste of resources during vehicle cleaning thereby minimizing operational costs.

Keywords: *Maintenance, Wash bay, Micro controller, Infrared sensors*

DESIGN OF REAL TIME METER DATA ACQUISITION AND SUPERVISORY MONITORING SYSTEM

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One avenue through which today's plant monitoring problems can be addressed is through the reduction of human manual operation. The existing utility system only provides feedback in the morning in the form of tables. The plant operators have no way to track their utility usage on a more immediate basis. The data acquisition and monitoring system has some non-invasive smart meters for utility tracking with a visual basic interface. Utility data is measured using smart sensors. This data is then transmitted over cable connection through the plant router to the base station and visual basic interface. The project aimed to provide a clear picture of a plant's current usage, and through this data provide an estimate to utility consumption. The project also aimed to analyse data,

generate and sends reports to various departments by analysis of this current data. The goal of provided such data to a user is that they will optimize and reduce their plant utility usage.

Keywords: *Utility system, Usage, Smart sensors, Visual basic*

DESIGN OF AN AUTOMATIC GUIDED VEHICLE (AGV) FOR TRANSPORTATION OF SAND FROM THE MIXER TO THE FOUNDRY FLOOR AT SIRDC

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Nowadays the creations of Automated Guided Vehicle (AGV) model can be found from all over the countries as it gives many advantages in all manufacturing and industry processes. AGVs should be well developed to optimize its benefits to our own living. The aim of this project was to build a prototype of an AGV model that can move on a flat surface on four driving wheels and transport a load from one point to the other. The prototype is able to follow line on floor with an Arduino microcontroller as its main brain that control all the navigation and responses to the environment. The ability to follow line on floor is an advantage of this prototype as it aides the complicated task of loading sand and offloading using a hydraulic tipping mechanism. To follow the line, the microcontroller is attached to a sensor that continuously reflects surface condition. Therefore, this project involved designing and fabrication of the hardware and circuitry. The objective of this project was to develop automated guided vehicles systems that autonomously transport material from loading to unloading stations.

Keywords: *AGVs, Arduino, Hydraulic tipping*

DESIGN OF AN AUTONOMOUS OBSTACLE AVOIDANCE ROBOT EYES TO AID IN NAVIGATION

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Majority of the existing robot navigation systems which facilitate the use of laser range finders, sonar sensors, or artificial landmarks has the ability to locate itself in an unknown environment and then build a map of the corresponding environment. Stereo eye, while still being a rapidly developing technique in the field of autonomous mobile robots, are currently less preferable due to its high implementation cost. This project aimed at describing an experimental approach for the building of a stereo eye system that helps the robots to avoid obstacles and navigate through indoor environments and at the same time remaining very much cost effective particularly for the Zimbabwean Mining industry since the environment is risky. This project discusses the fusion techniques of stereo eye and sensors which helps in the successful navigation through different types of complex environments which results in the calculation of routes to take depending on the presence of obstacles in the work environment. The data from the sensor enables the robot to create a map of unknown environments and stereo eye systems models the three dimension model of the same environment.

Key words: *sonar sensor, stereo eye, fusion techniques, stereo eye systems models*

DESIGN OF A PRILL POT FILTER MONITORING SYSTEM: A CASE OF SABLE CHEMICAL INDUSTRIES

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The aim of this project was to design an automatic prill pot filter monitoring system to counter the problems associated with manual monitoring. This was prompted by the realization of major problems associated with manual monitoring such as under-utilization of human labour, risk of ammonium nitrate explosion due to unmonitored temperatures, health, and safety risks due to ammonia and ammonium nitrate fumes and spillages due to the lower reaction time of a human operator. The research methodology adopted followed the waterfall model which sequentially cascades from gathering requirements to the design and maintenance of the new system. The Engineering tools used to come up with the design included Autodesk inventor, Microsoft Visual Studio, Arena, MatLab, Mikcro C, Proteus and the Arduino development Kit. The resulting semi-automatic design was an integrated system consisting of a mechanical drive, the power circuit, a microcontroller based control circuit and a user interface in Visual basic. The system has the ability to automatically replace a clogged filter with a clean sieve, provide real time performance

information to a remotely stationed operator through Human Machine Interface (HMI), and generate a data log sheet with quality characteristics of different batches of Magnesium Oxide. The prototype successfully performed its desired functions upon testing and verification. Each of the five filter changes were carried out in less than 5 seconds to an accuracy of 0.25mm and no spillages were observed. Temperature and fluid level data was displayed in real time on the Visual Basic user interface. Further research work can be done to include an automatic cleaning mechanism.

Keywords: *Monitoring system, Visual Basic, Real time performance*

DESIGN AND LOCOMOTION ANALYSIS FOR A DAM WALL INSPECTION AND MONITORING ROBOT

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This project focused on the reduction of risk and cost on the inspection process of dam walls. This necessitated in the design of an economically feasible, environmentally friendly and ergonomic design of a locomotion model that could be coupled together with different machine vision sensors. Different locomotion models and adhesion principles were evaluated and the working principles of existing wall climber models were scrutinized to help come up with an optimum model for the inspection. Methods used included experiments, the generation of concepts, review of relevant literature and test analysis using Fluent, Arduino software, and Matlab. Experiments results were also embodied within the design to help come up with different concepts. Embedded were the selected principle that uses aerodynamic suction method and differential drive for adhesion. Simulations and design calculations were also included which help select part sizes. An economic analysis in the form of a keep or drop decision was made comparing the proposed design to the current scaffolding method. Finally a product life cycle analysis was conducted to forecast the environmental effects of the prolonged manufacturing of the robotic model and future alternatives we suggested to ensure that the robot leaves a very small carbon foot print during its life time.

Keywords: *Inspection, Dam wall, Locomotion, Robot, Aerodynamic*

DEVELOPMENT OF AN INTELLIGENT EYE FUNGAL KERATITIS SCREENING SYSTEM

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This project assesses the current eye fungal keratitis infection screening methods in use in the local ophthalmological industry in a bid to solve the challenges faced in infection detection. The current local methods for fungal keratitis diagnosis are mainly semi manual, which are not accurate and efficient in infection screening leading to diagnosis and prescription errors resulting in detrimental effects on the patient and loses due to compensations and lawsuits on the practitioners' side. Access to proper, affordable health services is an unbearable challenge in developing countries especially Zimbabwe. Therefore there is need to design an intelligent system based on machine vision for the screening of Eye Fungal Keratitis ocular infection to improve access to affordable and accurate ocular health care services. This project achieves this by making use of those techniques that mimic human senses like sight and feel and decision making algorithms but at a more advanced level. Machine Vision has been utilized in depth to provide tools and techniques for image acquisition; image processing (feature extraction i.e. colour, shape, size and texture) and image evaluation (decision making) to come up with the most suitable algorithms for real time fungal keratitis screening. A lot of literature has been reviewed for previous work undertaken in this field and a number of considerations and trials have been done that led to the design of the desired solution. However the system can be expanded for a comprehensive number of infections and the accuracy levels are achievable by increasing the number of various eye types in the training sets with consistent resolutions and pixels.

Keywords: *Eye Fungal Keratitis, Machine vision, Image, Acquisition, Processing, Evaluation*

DESIGN OF A MICROCONTROLLER BASED SELF-LEVELLING FIXED STAIR LIFT: PARIRENYATWA HOSPITAL CASE STUDY

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Stairs are a part of our lives and will remain so because of increasing demand for utilisation of space. This reality has affected health institutions, academic institutions, public buildings including shopping malls and even our homes in which we stay. The aim of this project was to design a self

levelling fixed stair lift so as to give a sense freedom to the victims of old age, disability and infirmity. Their dependence on caregivers to move up and down stairs is a major burden and this shortens their lifespan. There is also great need to relief caregivers and lift up the burden of being dependent upon. This paper brings to you the design of a stair lift to assist the mentioned categories in going up and down staircases whether in homes, public building, or institutions. The stair lift has a sitting platform that allows one person to sit take themselves up using push buttons that are being monitored by a microcontroller. The sitting platform rests upon a carriage which slides along an angle iron rail that is customized to suite the shape and details of the stairs onto which it is being installed. The lift will be constantly charging in landing positions and using dc power while in transit.

Keywords: *Self levelling, Stair lift, Microcontroller*

DESIGN OF AN AUTOMATED MATERIALS HANDLING AND BLENDING CONTROL SYSTEM FOR A PVC POWDER MIXING PLANT

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Blending is important in the production of homogeneous mixtures suitable for processing t required performance level. Blending PVC with additives is vital in order to improve the melt flow of the PVC, improve the mechanical properties of the resin such as tensile strength and resistance to flattening and most importantly to increase the temperature at which decomposition starts to take place. The project was a detailed design of the materials handling system of the automated blending system including a PLC program for the automation of the whole process. Already existing equipment in blending systems with particular attention on the PLC and HMI system were considered. Simulations were carried out and the blending machine programmed using a Programmable Logic Controller. The result was a fully automated materials handling system for the blending system.

Keywords: *Materials handling, homogenous mixtures, blending*

DESIGN OF BOILER FLAME FAILURE CONTROL SYSTEM

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With the increase in energy demand due to urbanization, energy management and conservation is critical. To meet these requirements, there is need to implement systems that allow the continuous production of energy without fail. The aim of the project was to design a control system that monitors and control boiler draft and burner flame to prevent boiler failure for continuous production. Techniques created in order to manipulate the project include, observations, interviews, plant records and literature review. Literature was reviewed on different areas that would affect the design, these areas include; types of actuators, sensors and drive systems Data presentation in form of tables and graphs was done and the designs which included possible solutions generation, calculations and prototyping were done as part of the methodology used. A system that monitors furnace conditions was then designed to prevent boiler failure. The researcher recommends adoption of the design as it is effective and environmentally friendly.

Keywords: *Energy demand, Continuous production, Boiler failure control*

OPTIMISATION OF A SINGLE SCREW PLASTIC EXTRUSION PROCESS FOR DIE INTERCHANGEABILITY IN HDPE PLASTIC RECYLING INTO LUMBER AND POSTS, A (CASE STUDY OF WESSEC SOL PVT LTD)

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This project proposes an optimisation methodology for the existing extrusion processes at Wessec Sol Pvt Ltd. Currently; production relies on dedicated machinery which is inflexible to an increase in product ranges which is negatively impacting on their profitability. The method suggested here employs the use of spring loaded dies which are easier to change and manipulate thereby reducing the time spent on non-productive operations such as die interchange. A model of the proposed system was designed and tested so as to check its conformity to the proposed production and flexibility rates. The project work culminated in the production of a prototype unit which was used to test the die interchangeability.

Keywords: Optimisation, Die Interchangeability, Flexibility, HDPE, Extrusion

LIMESTONE BENEFICIATION FURNACE

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This design project looks at the design of an Electric Arc Furnace which achieves melting at very high temperatures through use of an electric arc. In Zimbabwe, the Calcium Carbide manufacturing process is yet to be introduced. Calcium Carbide for use in Zimbabwe is being imported largely from South Africa Calcium Carbide Company (SACCC), which is the only calcium carbide manufacturing entity in Africa and from Asia, to a lesser extent. This has resulted in challenges of high importation prices of the calcium carbide as creation of a monopoly on the supply of the product which has adversely affected the supply lead times of the product. Research methods used in gathering pertinent information on the project include field interviews, experiments, electronic journals, and articles, published articles and textbooks. A furnace was developed and a prototype was fabricated which shows the basic operating principles of an electric arc furnace. The designer recommends the device for use in low volume productions which require very high temperature melting processes.

Keywords: *Electric Arc Furnace, Calcium Carbide, Beneficiation*

DESIGN OF A NETWORK-BASED REMOTE MONITORING SYSTEM FOR SOLAR POWERED LED STREET LIGHTING.

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The public lighting systems of cities and towns in Zimbabwe are failing to provide adequate lighting due to several reasons. Service providers are finding it very expensive to run and maintain public lighting systems thus leaving the community insecure. This is partly contributed by the apparently high cost of electricity from the main grid which goes for $0.14/Kwh as well as poor monitoring and control of the light fixtures as some are left switched ON during the day. The kind of light fixtures which are mostly Sodium Oxide lamps consumes a lot of energy leaving the electricity bill too exorbitant for municipalities. It was based on this premise that an integrated, smart remote monitoring system for solar LED street lights was developed. An energy saving smart lighting system with integrated sensors and controllers for real time reporting to achieve fault attendance within 24hrs was realized in the design. The communication system linking the remote light and the central

control room was able to transmit data almost instantly. The design has Radio Frequency transceivers (Zigbee modems) one at remote light post and the other in the control room. The integrated circuit which is coupled with solar power set at remote sight ascertains the state of the street lights and through the Zigbee transceiver. Through use of Light Dependent Resistor (LDR) which signals switching, the state can be viewed at the control room. The personnel in the control room through a customized visual studio user interface window can view which lights are ON/OFF and defective lights as well. Control personnel can also switch ON any desired street light from the control room. The rationale of this research was based on the cost savings (amounting to 90%) associated with the use of solar energy as well as constant monitoring of the street lights.

Keywords: *Public lighting, Solar Energy, Remote Monitoring.*

UTILITY MODELLING OF A REFRIGERATION AND AIR CONDITIONING SYSTEM

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Traditionally, load estimating in the design of refrigeration and air conditioning systems was done either by manual calculation or judgmental estimation based on experience of the air conditioning practitioner. While manual calculation is laborious, leaving estimates at the mercy of human judgment is liable to error due to the complex and dynamic nature of present day architectural designs. This research focuses on the development of computer software based on C++ programming to handle the intricate and dynamic nature of load estimation for refrigeration and air conditioning units in developing countries. Data was initially gathered pertaining to refrigeration equipment sizing methods. With the help of collected data, a program was then developed that can be used to model a refrigeration and air conditioning system. Load estimating through computer automation makes a positive impact in the dynamic nature of air conditioning application by increasing accuracy, efficiency, and speed of execution of the required calculations and simulations.

Keywords: *Refrigeration system modelling, Load calculation, C++ programing*

DESIGN OF A SOLAR POWERED INTELLIGENT CITY PARKING SYSTEM

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The increase in the number of cars in Zimbabwe particularly in urban areas such as Harare and Bulawayo has resulted in the need to develop an efficient, time and cost effective parking system. The present car parking management systems in use have not seen much technological innovations. This in turn has resulted in high parking demand which in turn causes congestion when motorists are looking for free parking spots. Currently, the parking authorities use a manual system which is manned by marshals who use a hand held device which generates receipts to bill the customer. The alternative 'smart park' meter still requires manual actuation and physical verification by the city marshals. The proposed system integrates huge electronic displays on road intersections that inform drivers of the status of each street in terms of vacant parking slots before the driver gets into any particular street. Radio Frequency Identification (RFID) is used to identify the vehicle and infrared sensors to detect vehicle presence on each parking slot. This triggers a real time clock which calculates the time spent on each parking spot. Results shows that this parking system enables drivers to avoid driving into a congested street in which there are no parking slots which therefore improves fuel economy by 15%. Also with this system, the client pays for the actual time spent in the parking lot and does not have to carry cash but rather the bill is paid off when renewing the road licence. Considering the acute shortage of electricity in Zimbabwe the system is designed to used off grid solar power with a power bank so that even on days when there would be no sunlight it would continue to operate.

Keywords: *Intelligent Parking, Automatic Billing, Radio Frequency Identification*

DESIGN OF A HYBRID VAPOUR ABSOPTION REFRIGERATION SYSTEM CUSTOMISED FOR RETAIL INDUSTRY IN SUB-SAHARAN AFRICA (A CASE STUDY OF OK ZIMBABAWE)

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The solar powered absorption refrigeration technologies are attractive alternatives not only to serve the needs for refrigeration, ice making and coagulation purposes, but can also leverage the demand for energy conservation and environment protection. However the solely use of absorption systems may not adequately meet the refrigeration loads. This research work is centred on the design of a hybrid absorption refrigeration system. A detailed review on the past efforts in the field of solar absorption cooling systems was done. A retail outlet in Zimbabwe has been taken as a case company

to elicit right information concerning refrigeration requirements at commercial level and validate the extent to which the results of adopting hybrid absorption systems in retail industry can be used to represent all other companies of the same sort in Sub-Saharan Africa. A hybrid solar based absorption refrigeration system which can replace conventional vapour compression was developed and this design is recommended for adoption at a commercial level.

Keywords: *Energy conservation, Solar absorption, Hybrid refrigeration*

DESIGN OF A CARBON DIOXIDE CAPTURE AND STORAGE SYSTEM

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Concerns over climate change are driving innovation in technologies for stabilizing the carbon dioxide (CO_2) concentration in the atmosphere. This paper sought to provide a practical assessment of prospects for an improved, low cost CO_2 capture and storage (CCS) system for use at power plants and other industrial facilities. This will aid to mitigate emissions of greenhouse gases linked to global climate change. The power sector is the highest contributor of the carbon dioxide emissions being at 40%. In Zimbabwe there are quite a number of power plants, thus there is need for a carbon dioxide capture and storage device. The research seeks to explore a new technology for capturing CO_2 directly from ambient air at collection rates that far exceed those of trees or other photosynthesizing organisms, and that has a cost that would allow its widespread use in managing the anthropogenic carbon cycle. Vital information on existing systems and adopted concepts was obtained through literature review. Experiments were done to measure emission source parameters and analytical test validity of proposed concepts and project parameters. Software for process design and modelling including COMSOL Multiphysics®, Autodesk Product Design Suite® were used in simulating and testing projects designs. The final design is a combination of an adsorber with membranes embedded in the unit. An extraction fan creates a pressure difference to enable CO_2 permeation on the membrane. This design can be custom designed for entrepreneurs as a waste management approach. The captured CO_2 can be used in pharmaceuticals, health care, laboratories, and pulp-paper, food, and beverages industries.

Keywords: *Climate Change, Mitigation, CCS, Adsorbent, Membrane*

Electronics Engineering Department

DESIGN AND IMPLEMENTATION OF A MATLAB BASED RED LIGHT TRAFFIC LIGHT VIOLATION SYSTEM

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At a typical intersection the system processor is connected to the traffic lights so as to be able to determine which side is currently in the red phase. Next we install the vehicle sensors, these simply inform the processor when a vehicle has passed over them. For this project we in-cooperated an ultrasonic range finder in order to see if the vehicle was within camera focus range. On a PC we install software called matlab which we shall use for image processing and character recognition. Once a vehicle crosses a red traffic light it sets off the sensors .the processor then activates the front and rear cameras to capture the offenders vehicle in the act. The processor also sends a serial communication trigger to the PC matlab software the software then processes the images that were captured by the cameras. The image processing software retracts the license plate numbers and compares them with a vehicle registration database. Once a match has been found, a ticket is issued via email.

ENERGY-EFFICIENT AUTONOMOUS FLYING ROBOT

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Major challenge is faced on news reporting at some events; this is due to lack of resources and avoiding wastage of the available ones. The goal was to develop a small, robust and highly maneuverable autonomous flying robot for news reporting gathering information at area of interest. Currently, similar platforms are controlled at low frequencies due to hardware and software limitations. This causes uncertainty in position control and instable behavior during fast maneuvers. Flying platform offers a 2.4 GHz control frequency and at 495 Hz motor update rate, in combination with powerful brushless DC motors in a light-weight package. The minimalistic design approach this system is based on a small number of low-cost components. Its robust performance is achieved by using reliable highly optimized algorithms.

DESIGN AND IMPLEMENTATION OF A DENSITY BASED FUZZY LOGIC TRAFFIC CONTROL SYSTEM

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Nowadays congestion in traffic is a serious issue. The traffic congestion can also be caused by large Red light delays, etc. The delay of respective light is hard coded in the traffic light and it is not dependent on traffic. Therefore for simulating and optimizing traffic control to better accommodate this increasing demand is arises. In this project the optimization of traffic light controller in a City using microcontroller was done. The system tries to reduce possibilities of traffic jams, caused by traffic lights, to an extent. The microcontroller used in the system is PIC 18F4520. The system contains IR transmitter and IR receiver which are mounted on the either sides of roads respectively. The IR system gets activated whenever any vehicle passes on road between IR transmitter and IR receiver. Microcontroller controls the IR system and counts number of vehicles passing on road. Microcontroller also store vehicles count in its memory. Based on different vehicles count, the microcontroller takes decision and updates the traffic light delays as a result. The traffic light is situated at a certain distance from the IR system. Thus based on vehicle count, microcontroller defines different ranges for traffic light delays and updates those accordingly. The system records vehicle count in its memory at user predefined recording interval on real time basis. This recorded vehicle count data is displayed on an LCD display.

TOUCH SCREEN BASED DC DRIVE DC DRIVE DC DRIVE

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DC Motor offers a solution to systems that requires good speed regulation, frequent start-stop, braking and reversing. In Zimbabwe there is no single company which manufactures variable speed drives to supply local market or to export so as to compete with international players like Siemens, SSD Parker and LS so that we can bring in the much needed $US into the local economy. Most DC Drives are manufactured in Europe. Zimbabwe is restricted from buying machine parts from European Union due to economic embargo imposed on the country and also from dwindling foreign currency reserves, so there is need for innovative designing locally so that we could keep our industries running. A touch screen based DC Drive was designed and prototyped. It was designed to meet the tough requirements needed in industries. Speed was controlled and well regulated by this proportional controller. Also, to be provided was motor protection via current and temperature monitoring and the drive would effectively stop the system if one of the parameters is out of safe range.

DESIGN AND IMPLEMENTATION OF AN INTERNET WEB BASED DEVICE CONTROL SYSTEM

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The Web based home control system is an Internet of Things (IoT) project which utilises internet to control different types of home gadgets remotely by web browsing. It is cost effective as it usually utilises existing infrastructure. In this project a Web server is created to control the different devices

via the Microcontroller and the respective device relays. Current status for each individual device can also be view remotely from the web page anytime as it is real time. IP Address assigned to the local host server is used to server remotely enabling authorised remote users to control the devices. The device to be controlled was interfaced with the relay interfacing board. The ON/OFF control of the device from the web page and its status monitoring from the web page was successfully accomplished. The main benefits of this project include its lightweight design, automatic configuration, and utilization of widely available and tested network protocols of TCP/IP and HTTP.

MICROCONTROLLER BASED POWER OPTIMIZATION AND AUTOMATIC CHANGE OVER

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A Microcontroller based power optimization and automatic changeover system was developed in this project. Under normal operation the system will run on solar energy. But because of the differences in the weather conditions sometimes cloud cover will block direct reception of the sun rays. This results in depletion of the voltage associated with solar energy. When this happens the battery backup will supply voltage to the load. Because the system is set to optimise power by using the most cost effective and natural source of energy, it will only switch over to AC mains supply when the battery level has gone below a set threshold. Because of the unpredictable supply of electricity from supply authorities, failure of the system to detect a local voltage supply will result in switching of the generator ON

SMART SHOPPING TROLLEY USING RFID

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The aim of this project was to design and implement a smart shopping trolley using RFID as main wireless technology. Arduino Mega 2560 made RFID reader on smart shopping trolley to detect RFID tags on products such that upon unique identification the products were categorized according to product name and price using information recorded on PHPmyAdmin WampServer shopping mall database with the use of Arduino Wifi Shield and this information total price and smart shopping list update is displayed on the TFT display which was interfaced to its own Arduino Mega 2560.The smart shopping list was sent using Bluetooth technology from an Android Application made using MIT(Massachussets Institute of Technology) App Inventor Integrated Development Environment(IDE.

GSM BASED SWITCHING CONTROL SYSTEM

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This project presents the design and implementation of a GSM based switching control system, due to the rapid technological changes in the digital systems this has led to a significant change in human lifestyle. Technological developments have enabled the creation of mobile devices with technical features previously only conceived in PC architectures or similar devices. With this evolution comes the need to integrate these devices with others, so they can take actions and monitor interaction on mobile devices, as is exposed. Any equipment that can be controlled wirelessly is more easily maintained and it responds faster comparing to manually operated equipment, it also increases safety as well as speed of operation in times of failure or damage. This change involves that remote systems are not limited by network protocols with limited features]. The aim of the project is to develop a cost effective solution that will provide controlling of electrical appliances remotely in the absence of home or office owner. The main aim of the prototype development is to reduce electricity wastage and to increase the life span of appliances. GSM module was used for receiving short message service (SMS) from an authenticated mobile number that automatically enable the controller to take any further action such as to switch ON and OFF the home appliances such as light, air-conditioner ,inverter, fridge etc.

DESIGN AND IMPLEMENTATION OF AN FPGA BASED VOICE ACTIVATED ACCESS CONTROL SYSTEM

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This project the reviews the method of implementing an FPGA Based Voice Activate Access Control System which activates door control mechanisms (opening and closing) based on 'learned' spoken voice commands. It uses a Voice module which captures and stores the voice commands. The FPGA interfaces the Voice module to the relay drivers and a local GSM which sends an SMS to a remote GSM mobile phone in case of Emergency specifying the location (GPS coordinates) where the emergency has occurred. The phone uses an android application Automate. It to detect a signal condition on its USB to send a pre-defined SMS. The phone makes us of the internet to get its location from Google Maps.

DOUBLE SECURITY ACCESS CONTROL SYSTEM

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This project aims to design a system with duplicate security access control for use at an Aircraft Maintenance Organisation (AMO). The system combines RFID technology with fingerprint detection to accomplish the task. When the fingerprint module at the entrance of the (AMO) captures the person's fingerprint, the system requests for the person's RFID tag or card. When the RFID reader detects a number, the system scans the database for a match. If both the card and fingerprint belong to a registered person, access is granted; otherwise it is denied.

DESIGN AND DEVELOPMENT OF AN ANDROID MOBILE CONTROLLED EXCAVATION TIPPER.

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A robot is usually an electro-mechanical machine that is guided by computer and electronic programming. Many robots have been built for manufacturing purpose and can be found in factories around the world.. I am developing the remote buttons in the android app by which we can control the robot motion with them. And in which we use Bluetooth communication to interface controller and android. Controller can be interfaced to the Bluetooth module though UART protocol. According to commands received from android the robot motion can be controlled. The robot tipper can be moved in all directions using the android app.

DESIGN OF A WEARABLE ELECTROCARDIOGRAM FOR REMOTE HEART MONITORING USING INTERNET

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An AD8232 based heart monitor was developed for this project. It uses Bluetooth to transfer the measured data to a mobile phone. The AD8232 sensor is connected to the microcontroller PIC16F876A which is responsible for converting the analog signal to digital data which is then transmitted via a Bluetooth module. The transmitted data is received by a mobile phone application connected to the device. The mobile application which was developed for android enabled mobile phones processes the data and displays it on a graph. The same application on user request sends the data to an online database for storage and later retrieval by their health service provider. The database is hosted online to enable remote monitoring. The Bluetooth module used is HC06 which has a maximum range of 10 meters therefore the user is supposed to have their phone in this range whenever taking ECG measurements.

PLC BASED MAXIMUM DEMAND CONTROL SYSTEM

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MD is the peak demand/usage of electricity and is therefore the greatest demand of the load on the Power station during a given period. The demand charge reflects the peak rate at which electrical energy is consumed and is higher when there is more electrical equipment running. Electric utilities charge high penalties because they must have sufficient capacity to serve the instantaneous demand for all customers at any time. One isolated peak power use can result in the company paying heavy penalties on the Bill despite low energy consumption for the same billing period. A PLC based system

to control MD during each 30Min billing interval was designed targeting a refrigeration plant. Glofa GM7 PLC was used and programmed in ladder logic using Windows based GMWIN software. A PLC program that predicts demand at the end of each thirty minute period block based on the rate of energy usage and time remaining to get to the end of the period block was created. The PLC switches off contactor relays for loads KM1-KM1O according to given priorities when set target is about to be exceeded. The controller was synchronized with the 30M synchronizing reset times used on Enermax Meters. A hardware implementation of the controller was developed and both the hardware and software components of this system were tested and found to meet the objectives. The user was able to control the MD for each 30Min demand block. This system ensures that the MD peaks are eliminated from the bill thereby avoiding the penalties charged for them and reducing operating costs. It was concluded that the PLC based MD control system has predictive control and is very well suited for such applications.

CONTROL UNIT OF A BIODIESEL MANUFACTURING PLANT

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The biodiesel manufacturing control system is used for controlling the manufacturing process of biodiesel. Temperature sensor is used for temperature control, controls the heater, making sure that the process is done within the required temperature. PH is also measured after the reaction process is done to check the quality of the product produced. There are samples taken that are used for research purposes. Once the process is done the results are stored and the tank is emptied and waits for another batch to be introduced to the system and the process is done all over again.

DESIGN AND IMPLEMENTATION OF A PIEZO-ELECTRIC BASED POWER HARNESSING (HARVESTING) SYSTEM WITH PREMISE, STREET AND TRAFFIC LIGHT CONTROL.

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The project was aimed at the designing, implementing and testing of a prototype for electric energy generation from collecting wasted ambient power coming from the mechanic vibrations using low cost (Piezoelectric Energy Harvesting PEH) Transducers. This design was based on a previous comparative analysis among all the existing auto-harvesting circuits of similar PEH. The prototype was specifically designed for applications where it is required to connect multiple transducers in order to obtain greater power levels. The system was aimed at providing an alternative means for electricity generation which is usable for low power everyday usage applications like street and premise lighting as well as traffic lighting. The system was interfaced to a PIC 18F452-I/P microcontroller through a software protocol developed using C programming language. The prototype also proved that, though achieving power levels of a few watts, its application in the autonomous powering systems field is a real possibility.

ENHANCED BIOMETRIC ATM AUTHENTICATION SYSTEM

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Now a days ATM systems are not secure because, there are some hackers which are capable of accessing ATM accounts of the people seeking ATM facility. In order to put ATM accounts of people to a more secure side we are introducing our new idea of finger print module to verify the actual user more precisely. So in this way the hackers will not be able to hack the personal accounts of different people. In this project we are using a fingerprint module along with C++ programmed interface on PC. In which the different finger patterns of different people are captured and stored by the module itself. The code generated by the module will be monitored by a processor consisting all the codes of users in the form of (account id, fingerprint, pin) data. Whatever the service needed by the users will be offered in a very efficient way. If the user inputs a wrong pin or fingerprint they will be denied access and be blocked. This system can be taken and placed in any operating system and immediately begins to work because of C++, given the system has a fingerprint scanner

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MICROCONTROLLER AND SCADA BASED SUBSTATION MONITORING AND CONTROL SYSTEM

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In the 20th century the use of electricity and electrical gadgets has grown and the demand requires an efficient power supply mechanism. Power Generation stations, transmission lines and distribution systems are the main components of an efficient power system. Smaller power systems (called regional grids) are interconnected to form a larger network called national grid, in which power is exchanged between different areas depending upon surplus and deficiency. This requires knowledge of load flows, which is impossible without monitoring. The major factors that influence the operation of a power system are the changes in load and stability. Stability is also affected by the occurrence of faults; Faults need to be intercepted at an easily stage and corrective measures like isolating the faulty line must be taken. As the power consumption increases globally, unprecedented challenges are being faced, which require modern, sophisticated methods to counter them. This calls for the use of automation in the power system. The Supervisory Control and Data Acquisition (SCADA) and Microcontroller are an answer to this. SCADA refers to a system that enables on electricity utility to remotely monitor, co-ordinate, control and operate transmission and distribution components, equipment and real-time mode from a remote location with acquisition at date for analysis and planning from one control location. Microcontroller on the other hand is like the brain of the system with the joint operation of the SCADA and the Microcontroller, it is possible to control and operate the power system remotely.

The project focuses on substation monitoring measuring voltage, current and temperature. It also controls power breakers switching the 'ON' and OFF. This is displayed on a SCADA system. When current goes above 5Amps the breaker trips and a buzzer rings. This calls for attention on reducing the load or increasing the supply current. When temperature goes above 30 degrees Celsius a fan starts running so as to cool the room. When the breaker 'ON' is switched the load is supplied with

energy, when the phase change button is clicked from the keyboard, the phases change. Also phases are monitored by power supply on the SCADA.

KINEMATIC CONTROLLED WHEELCHAIR FOR THE PHYSICALLY DISADVANTAGED PEOPLE.

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Nowadays the number of people who are physically disadvantaged is on the increase due to many causes. Being physically disadvantaged may arise from birth, aging and when involved in an accident that will result in the motor capacity of the body being damaged. It is estimated that about 2% of the world's population needs a wheelchair. Wheelchairs are there in the market but these chairs range from the man (traditional) powered chairs to the sophisticated chairs with on board PC (which are motorized). This project's objective was to give the user something that is simple and natural to aid physically disadvantaged people to move. It consisted of a glove that had to be worn, it had Hall Effect sensors on the tips of the fingers which the user actuated using the magnet placed on the thumb. It also have obstacle avoidance capability, which when an obstacle is detected the wheelchair stops for about 30 seconds. This window offers the user time to survey his environment and then send a signal that can avoid the obstacle. If the user sends no signal or a signal that results in a collision the wheelchair will remain stationary. Wireless communication was utilized using the 315 MHz RF receiver and transmitter. The RF transmitter was connected to the glove. The receiver was connected to the wheelchair which controlled the motors movements.

FPGA BASED INTEGRATED CAR SECURITY SYSTEM (JUNE 2016)

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An integrated car security system was developed which operates in two modes, the ARMED and DISARMED mode. The modes are activated by voice command when the doors are either locked (for ARMED mode) or unlocked (for DISARMED mode). The appropriate vibration, tilt and motion sensors were used to detect the respective parameters of interest. Voice recognition was incorporated to start the ignition. An appropriate module for voice recognition was selected to communicate with the FPGA via UART. If any of one of the inputs from the sensors which trigger the alarm is detected, an SMS notification will be sent to the cellphone of the owner using an android phone located inside the vehicle.

DESIGN AND CONSTRUCTION OF A COST EFFECTIVE PULSE WIDTH MODULATION SOLAR CHARGE CONTROLLER

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A Pulse Width Modulation solar charge controller was designed in this project. Pulse width modulation (PWM) is a powerful technique for controlling analog circuits with a processor's digital outputs. In this paper the charge controller was simulated using proteus professional software and PIC16f877 microcontroller was used. The microcontroller has in built (pwm) modules so system complexity and number of electronic components is reduced. The charge controller senses the battery voltage through one of the port A PIC pins. A voltage scaling circuit comprising a potential divider is used for voltage measurement. The charge controller reduces or increases the charging current in tandem with the battery voltage level measured. It does so through varying of duty cycles of the PIC generated pulses. An LCD display the measured voltage, charging current and power. The rate of electrochemical activity within any battery is largely dependent on temperature. To maintain the best optimum temperature for the battery charging task and prolonged battery life an extractor fan is used to help regulate the temperature

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WEB-BASED SOLAR PLANT ENERGY MONITORING AND CONTROL SYSTEM

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Monitoring and control are important aspects when efficient energy management is to be achieved. Monitoring is to keep track of how the system is behaving. Control is there to facilitate corrective measures. This project was aimed at developing a web-based remote monitoring and controlling system for a solar energy plant.

DESIGN AND IMPLEMENTATION OF A PLC BASED PID CONTROLLED WATER RECLAMATION SYSTEM

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Water is one of the essential resources thus the need to conserve it is of utter importance. The project focuses on the waste water treatment from various pollutant industrial systems to forms that allow it to be reused. Focus is thus made on the control of the critical parameters of water which are, conductivity and pH in the most stable systematic way. The project was based on a Programmable Logic Controller (PLC) which was the main part of the control hardware with a highly robust and efficient system. The system was made up of pH sensor and conductivity sensor that provide feedback thus allowing the dosage of an acid or a base to maintain the pH at a required value. The control system, was based on Proportional Integral Differential algorithm that ensures stability by reducing overshoot, transition time and error using the three control parameters. The system also included a SCADA system that allows easy on time system view and manipulation so that the whole setup can be controlled at a control room.

LINE FOLLOWER BASED ROBOT PATIENT DOORSTEP DELIVERY SYSTEM

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A line follower robot that can locate a patient's room was implemented in this project. The LFR was able to avoid obstacles in its path .The project made use of three sensor arrays that is the IR Obstacle detector sensor transceiver with the receiver attached to the robot and the IR line sensor both from the IR family. Upon entering, the room number using the keypad the robot will be set in motion at the same time being subject to IR interrupts from the IR transmitters, which could be detected by IR receivers attached to the left and right side of the robot. When the interrupt had been received, the robot will exit the line following routine, turn to the path of the direction of the interrupt, and return to the forward line following routine. When the white end has been reached, the robot would stop and deliver items using a DC motor, the patient could press the push button, and the LFR would return in reverse mode until it gets back to the control room. For both forward and reverse line, following an obstacle in the path of the robot could be detected and a buzzer could sound and alarm the control room and observations were made on the PC using IP camera attached on the robot.

INDUSTRIAL HAZARD DETECTION MONITORING AND CONTROL SYSTEM

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The following document details the research and development of an Automatic Solar tracking system. Fossil fuels are a relatively short-term energy source; consequently, the uses of alternative sources such as solar energy are becoming more wide spread. To make solar energy more viable, the efficiency of solar array systems must be maximized. A feasible approach to maximizing the efficiency of solar array systems is sun tracking. Proposed in this report is a system that controls the movement of a solar array so that it is constantly aligned towards the direction of the sun. Solar modules are devices that cleanly convert sunlight into electricity and offer a practical solution to the problem of power generation in remote areas. The solar tracker designed and constructed in this project offers a reliable and affordable method of aligning a solar module with the sun in order to maximize its energy output. Automatic Solar Tracking System is a hybrid hardware/software prototype, which automatically provides best alignment of solar panel with the sun, to get maximum output (electricity).

DESIGN AND IMPLEMENTATION OF A MATLAB BASED FACE RECOGNITION SYSTEM

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A MATLAB based face recognition system for surveillance was developed in this project. It utilizes the bag of features (SURF) and Sum of Absolute Differences (SAD) algorithms to allow the user to control execute the successful detection, training and testing and recognition of the biometric face

input. An application was developed using MATLAB software which provides the user with an interface to set the desired point of operation from the three which were START OVER, ADD DATABASE and USE EXISTING DATABASE. The application communicates with the program the choice of the user which then is bases of the next stage. The first button will create a new database for the user allowing the user to add new training set images which can then be labeled and validated into the training set by the user. The second button will add to the already existing database and will allow the same operation of labeling and validating of image sets. Then the system will move on to live video face recognition platform where it will then show the recognition by sending the array of the name of the recognized individual. If the individual is not found in the database it would return an UNKNOWN label for the individual being detected by the camera. Research was carried out on the algorithms for face extraction and face classification as well.

PAY-AS-YOU-GO HOME SOLAR SYSTEM

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A pay-as-you-go home solar system was developed in this project. It uses the GSM technology in mobile phones and mobile money technology to allow the user to purchase credit for the energy harnessed and stored by the solar system. An application was developed using Android studio software which provides a platform for interpreting a mobile money transaction into a command that is sent as a sms message to the GSM module

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MICROCONTROLLER/ARDUINO BASED ROBOTIC GAS ANALYSER

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Carbon monoxide (CO) gas is a compound produced by incomplete combustion of various carbon-based fuels and substances. The slow accumulation of this poisonous gas can cause headaches, nausea, vomiting, vertigo and confusion which are harmful for workers. Rapid accumulation may be fatal through Carbon Monoxide Poisoning and cause death. The purpose of this design is to develop a carbon monoxide monitoring system for mines and industries that have confined areas in which workers are required to attend to. The system includes a carbon monoxide detector which is capable of measuring concentration of the gas. When it reaches the predetermined levels, the alarm system will notify the worker/s as well as the nearby people and at the same time prevent hazardous gas to spread inside the vehicle through the automatic activation of fan which introduces Oxygen into the area. This detection is done through the use of an automated Android controlled rover to avoid contact between user and the toxic environment.

IOT AND PROCESS PARAMETER CALCULATION IN BREWING

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Internet of Things generally refers to network connectivity and computing capability extended to objects and sensors. In process automation industry, operator interface is usually a Human Machine Interface Unit (HMI). HMI plays a significant role in creating a friendly visual environment between the user and the technology. HMI is the window to the automation control system. This paper looks at a system fusing industrial instrumentation, cloud computing and HMI design, forming a multi distributed system. HMI was designed using PROCESSING IDE for monitoring and control of the beer maturation and cold storage process. The data on HMI was then posted on cloud. The idea is to employ sensors to gather data display it on HMI and send it on cloud. The main purpose of the dilution calculator incorporated in the HMI was to find best beer dilution rate of high gravity per brand depending on the required quality specification of residual extract, original extract, alcohol content, color and expected haze after filtration. Temperature control and data logging was achieved using Arduino YUN. The Yun has a Wi-Fi module built on board, allowing it to connect to a wireless router, or act as an access point.

DESIGN AND IMPLEMENTATION OF A GSM BASED AUTOMATIC ENERGY METER SYSTEM WITH BILLING

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The aim of the project was to design a GSM based automatic energy meter with instant billing with a facility of repayment. The system measures energy consumption through the current and voltage sensor. If a unit of 1KWh has been consumed, the unit value stored in the EEPROM of the microcontroller is decremented by 1. If the units' value reaches a threshold of 2, buzzer will ring and notifies the user that units are running out. The user can recharge the system through a keypad of the system or through the mobile phone which communicates with the system through a GSM interface. The system has a display unit which displays the RMS voltage, energy consumed and the available units the user has.

HAND GESTURE CONTROLLED WIRELESS ROBOTIC WHEELCHAIR

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This paper presents the design and development of a Hand-gesture controlled wireless robotic wheel chair based on the MEMS technology. This project is useful to the physically disabled people, that is by only using his or her hand movement or his or her hand gesture using Acceleration technology, one can be able to perform his or her daily activities unassisted. Tremendous leaps have been made in the field of wheelchair technology. However, even these significant advances have not been able to help quadriplegics navigate wheelchair unassisted. It is wheelchair which can be controlled by simple hand gestures. It employs a sensor which controls the wheelchair hand gestures made by the user and interprets the motion intended by user and moves accordingly. In Acceleration

we have Accelerometer sensor. When we change the direction, the sensor registers values are changed and those values are given to microcontroller. Depending on the direction of the Acceleration, microcontroller controls the wheel chair directions like LEFT, RIGHT, FRONT, and BACK. The aim of this project is to implement wheel chair direction control with hand gesture recognition. Connectivity between the transmitter and the wheelchair receiver module is possible in the range of 10 meters.

DESIGN OF AN AUTOMATED REAL TIME RADIO FREQUENCY IDENTIFICATION INVENTORY MANAGEMENT SYSTEM

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Managing inventory is a major hurdle for most modern businesses, for organizations and individuals. There are various methods available and finding one best suited for a particular application is paramount to the success of a business. It is in the retail industry where this need is keenly experienced. Several billions of dollars are being lost by the retail industry worldwide due to loopholes in the inventory management methods worldwide, but this does not need to be the case, thanks to developments in technology. In a world where the Internet of things is changing how we interact with systems and collect data, modern businesses leaders need to have constant access to the state of their inventory. Radio Frequency Identification technology has been employed to uniquely identify individual products (stock). This feeds relevant information to a database on on a local server, synced with a cloud server. An application on the local server manages the database systems and interacts with the physical hardware that detects the inventory. This, unlike most methods utilized in inventory management today is easy to use and requires limited human intervention. It also occurs in real time providing the results instantly to users on the front end of the database.

RFID-MICROCONTROLLER BASED AUTOMATED TOLL COLLECTION SYSTEM

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With an increase in the number of vehicles that are being imported in Zimbabwe, there is need to create reliable and efficient systems. The operation of tollgates, whereby motorists have to stop at a toll plaza, pay hard cash, wait for change and have the barrier manually lifted becomes unsuitable. The system designed herein is an automated tollgate collection system. It eliminates the human aspect in the operation of the tollgate plaza and it is a prepaid system. Since there is no human involvement, it eliminates corruption at toll plazas and creates transparency. This project can be implemented in urban areas where less than a dollar is charged for the toll in an economy such as Zimbabwe where coins are scarce. Money is charged electronically, therefore there are no “change” issues. Clients do not have to carry hard cash with them. RFID tags are attached to the windscreen of vehicles. When a vehicle approaches a tollgate, the tag on the screen is powered up the reader which is located on the tollgate. Passive RFID is used. The tag identity number is read and client

information associated with the identity number is pulled from a database. Necessary deductions are made from the account of the client depending on the class of the vehicle. The tollgate barricade opens to allow the vehicle through. This is through the use of the stepper motor. Infrared sensors are mounted on both sides of the barricade. These consist of a transmitter and a receiver a side. They are used for object detection. When the barrier is open and a vehicle is blocking the transmitter-receiver pairs, the microcontroller ensures that the barrier does not close. When the vehicle has passed, the infrared sensors communicate to the microcontroller that the vehicle has passed and the microcontroller instructs the stepper motor to close the barricade. Using information from the database, an SMS message is sent to the owner of the vehicle through the use of an online service called infobip, the main highlight being status of current balance.

LP GAS DETECTOR

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In Zimbabwe , it has become a common practice to employ combustion apparatus such as furnaces , home gas stoves , heaters or LPG kits in cars, industries which utilizes a combustible gas without any due knowledge of dangers poised when the gas is not detected and controlled on time. This result in explosions and uncontrollable fires and life loss, property loss and worse still, affecting the environment. This project is to provide a solution by which instrumentation and software program detect and controls any LPG leakage. The project is a micro controlled Liquid Petroleum Gas (LPG) detection system which automatically facilitate the means to detect the leakage and fore worn the users that the gas has leaked through an sms, a buzzer and a display message on the LCD.

DESIGN AND IMPLEMENTATION OF A MICROCONTROLLER BASED AUTOMATIC TRANSFER SWITCH.

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This project reviews the methods of implementing change over system and proposes a better and cost effective approach to achieve the same. The main aim of the project was to come up with a system that can accommodate as many sources of standby power to ensure near permanent availability of power to critical loads. Some of the approaches which have been employed to implement change over systems include manual change over switch box, automatic change over system with electromechanical relays and change over system with automatic transfer switch. Each of these methods has some challenges that make it undesirable. Among these challenges are time wastage, possibility of fire outbreak, noise generation, frequent failures, product damage, high component count to mention but a few. This contributes to the high cost of these methods. The approach used in this project makes use of Microcontroller reduce the component count, space as well as improve the speed of the system. The system also has some desirable features like liquid crystal display [LCD] which makes the system user friendly, an alarm system for indicating standby system failure, over-voltage and under-voltage level monitoring. The microcontroller is programmed

to continuously monitor the status of utility power and switch over to standby power as soon as there is loss of utility power, over and under voltage in the order solar, generator and back to utility power when it normalizes.

AUTOMATIC SOLAR TRACKING SYSTEM

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The following document details the research and development of an Automatic Solar tracking system. Fossil fuels are a relatively short-term energy source; consequently, the uses of alternative sources such as solar energy are becoming more wide spread. To make solar energy more viable, the efficiency of solar array systems must be maximized. A feasible approach to maximizing the efficiency of solar array systems is sun tracking. Proposed in this report is a system that controls the movement of a solar array so that it is constantly aligned towards the direction of the sun. Solar modules are devices that cleanly convert sunlight into electricity and offer a practical solution to the problem of power generation in remote areas. The solar tracker designed and constructed in this project offers a reliable and affordable method of aligning a solar module with the sun in order to maximize its energy output. Automatic Solar Tracking System is a hybrid hardware/software prototype, which automatically provides best alignment of solar panel with the sun, to get maximum output (electricity).

CONTROL AND MONITORING SYSTEM FOR BACKUP POWER GENERATORS

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Telecommunication's service providers and banking service providers share one common attribute, data centers. Downtime or outage duration refers to that period of time that a system fails to provide or perform its primary function in data centers. This journal was prepared to demonstrate how to minimize down time in data centers through controlling a backup power generator via a real time web application that can be accessed by any internet capable device and monitoring status of the backup power generator through Short Messaging System (SMS) alerts using an ARM1176JZF-S microprocessor on a Raspberrypi model B module, a Global system for Mobile Communication (GSM) commander module and a DSE 7110 engine auto start control module.

AUTOMOBILE SPEED CONTROLLING SYSTEM USING RADIO FREQUENCY

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Nowadays people are driving very fast; accidents are occurring frequently, precious life is lost by making small mistake while driving (school zone, blind spots, and high accident zones) and high speed chase in in busy zones. So in order to avoid such kind of accidents and control their vehicle speed in such kind of places, the highway department has placed the signboards. But sometimes it may to possible to view that kind of signboards and there is a chance for accident. So to intimate the driver about the zones and the speed limit automatically, is done by means of using RF technology. A cost effective automobile speed controller was designed that monitors the speed limits in restricted speeding zones, which can run on an embedded system. The project is composed of two separate units: handheld car controller unit and receiver (speed calculation and control) unit. Once the car plate number or signal is received from the controller, the vehicle's embedded unit automatically checks the vehicle speed, to reduce the speed.

DESIGN AND DEVELOPMENT OF AC VOLTAGE VARIABLE SPEED

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Many industrial processes require some sort of variable speed driving for their smooth operation. Traditionally that is has been the dc machines that were widely used throughout the industry. But now there are ac machines that can now do the job. Since, because of the advancements made in the design of control and power conversion circuitry .The advancements in technology have enabled the motor parameters such as speed, frequency range, temperature, voltage, current, demand torque, power factor correction, auto breaking, built in protection system and so forth. It is for this reason that a project to design a system that can employ one of these methods to vary and control a three phase ac motor has been taken. This project controls the speed of a three phase motor by varying its voltage by use of high speed power mosfets. It also measures its operating frequency and gives a read out. In general, such ac drives often feature a cost advantage over their dc counterparts and, in addition offer lower maintenance, smaller motor size, and improved reliability.

DESIGN AND IMPLEMENTATION OF A MICROCONTROLLER BASED AQUARIUM ECOSYSTEM (JUNE 2016)

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The design in this project showcases the implementation of a microcontroller based aquarium ecosystem. The aquarium, consisting of the microcontroller, LCD display, solenoid valve, relay, float switch, fluorescent lamp, filter, pH sensor, turbidity sensor, water level sensor, water flow rate sensor, and the LDR (Light Dependent Resistor), performed the following functions in the, lighting, water filtration, temperature monitoring and control, water circulation and cleaning the aquarium ecosystem. Water replacement depends on the alkalinity or acidity of the aquarium's water which is measured by the pH sensor and the turbidity measure's the cloudiness of the water. The design incorporates an energy supply that powers up the entire system of the aquarium. The system

operates with the aid of the microcontroller which the is heart and the brain of the system, relay, solenoid valves and its sensors that help control the whole functions of the system.

The design also benefit the fish farmers, aquarist by maintaining the Cleanliness of the aquarium and monitoring and the maintaining the required set of conditions for the system and required optimum condition for high yields of fishes. The aquatic animal culture usually consists of fish but can also consist of snails or crayfish. The fish waste provides as a food source to the plants and the plants clean the water for the fish to continue to use

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AUTOMATED CLEANING IN PLACE CONROLLER FOR ROAD TANKERS

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The food and pharmaceutical industries anywhere in the world require to exercise extreme cleanliness when it comes to manufacturing their products. In these particular industries storage tanks and pipe work are frequently cleaned to avoid cross contamination of products. Road Tankers that ferry milk for instance need to be thoroughly cleaned after each offload of its contents into silos for processing. The cleaning process involves connecting the road tanker to a cleaning plant via a pipe work through which the cleaning solutions pass from the tanks to the road tanker being cleaned. Different cleaning solutions are used depending on the type of soil being removed. The chemical solutions used for cleaning for this project are acids detergents and cold water for rinsing. The pumping of these different chemical solutions was automatically controlled, resulting in a timed sequence of releasing the chemical contents into the road tanker. Parameters such as conductivity and temperature of the cleaning solutions were monitored and controlled before and during a CIP (Cleaning in Place) process. These industrial CIPs however are very expensive to import and since the trend in Zimbabwe is to minimize production costs it is thus necessary to implement home grown solutions which are less costly

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TELE-NURSE ASSISTANT ROBOTIC SYSTEM

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There has been a sharp rise of deaths caused by contagious ailments like as Ebola, swine flu (H1N1), bird flu, Zika virus and severe cholera both to the general population and the medical personnel. Thus there is need of advancing robots in assisting patients and reduce nurse to patient interaction especially in early stages of patient quarantine where the rate of contracting viruses is high. A medical robotic system that is controlled by a computer can be designed where it uses the Radio frequency modems for communication and data transfer. On the computer is an application designed to control the robotic vehicle to manoeuvre in any direction both its arm and chassis. The robotic vehicle carries on it sensors to test patient temperature, weight, environmental ambient temperature and air condition. When a command is sent from the computer, the robot controller will receive and determine what it is intended to do either to move the robot in a particular direction or initiate sensors to test their environment, and then gives back the feedback to the computer. The

feedback data can comprise of the position of the arm on the robot chassis, sensory values and if the robot is operating in arm or robot mode.

DESIGN AND DEVELOPMENT OF A RADIO FREQUENCY ROAD ALERT COMMUNICATION SYSTEM

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Nowadays people are becoming more reliant on the use of automated systems to ease their tasks or specific jobs in and out of hazardous environments. Consumer electronic devices are becoming popular as they make life easy and if they are nonhazardous there is no need for them not to be used. Most road accidents in Zimbabwe are as a result of human error. According to statistics 93.4% of all accidents recorded during the 2014/2015 festive season were as a result of human error. About 5 people die on our roads every day while 38 others are injuries. A radio frequency embedded system that increases awareness of motorists by alerting them on the status of that area, and the rules that apply there. The embedded alert system playbacks pre-recorded audio alerts and displays the alert message as vehicles pass through high accident probable points which include natural road terrain, high human and animal activity. For transmitter 1.A speed limit of 40 km/h is recommended and if car is over speeding the sound message is sent and also displayed on the LCD. And 60 km/h for transmitter 2. If car speed is above stipulated, alarm is sounded while the speed is continuously checked.

DESIGN AND DEVELOPMENT OF P-V DIRECT VARIABLE FREQUENCY INVERTER FOR WATER PUMPING APPLICATION

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In this paper is the design and development of a Photovoltaic Direct Variable Frequency Inverter for water pumping application. The system works by powering a single phase AC pump motor with variable frequency Alternating Current thus controlling the motor speed and output power based on the available voltage from the solar array. The system utilizes voltage frequency ratio to maintain constant torque as output power varies with sunlight. Input voltage from the solar array is boosted by the DC-DC boost converter. The boosted DC voltage is then modulated into pure sine wave AC using Sinusoidal Pulse Width Modulation. The purpose of the system is to provide an efficient and more affordable means to pump water for irrigation whilst utilizing an abundant renewable resource i.e. solar energy. P-V Direct systems are more cost effective as compared to conventional battery based solar systems

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VEHICLE AUTHENTICITY APPLICATION AND CASHLESS PAYMENT SYSTEM

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While paper money, (cash and cheques) are still being used in some parts of the world, electronic or cashless payment mechanisms are gaining consumer acceptance in several economies due to the high use of mobile phone technology. The cashless payment systems include online system, smart card payment, prepaid and chipknip systems. All these offer greater security in payment and positive cash flow, and efficient collection of revenue. Hard cash is at high risks of theft, counterfeit and it is becoming difficult to get, considering the current situation of Zimbabwe, where most of the citizens are public transport users. Public transport has several advantages that include affordability, environmental friendliness and convenience. However, public vehicles also come with disadvantages. There are several recorded cases of passengers who were robbed by malicious operators of inauthentic or unidentified vehicles. Unnecessary delays and inconveniences are also caused by these inauthentic vehicle operators. This project was designed to reduce the use of hard in public transport payment and it also enhances easy revenue collection through the use of RFID technology. A vehicle authenticity application was designed for public transport users to know the status of a vehicle before they board it by accessing a web database linked to the Android application.

FPGA-BASED MATTER INTERACTION BEHAVIOR SIMULATOR

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Computer based software simulators are a fundamental tool for gaining the understanding of science in schools. This system uses an FPGA board as the CPU for simulating the particles since it is hardware based. This implementation includes 10 different particle types. The Cellular Automation model is able to satisfactorily mimic certain particle dynamics similar to the expected behaviors in the real world, although it lacks the concepts of momentum and inter-particle forces. The idea was to create an educational science kit for enhancing the learning of science in primary schools. The interaction of the chosen particles is by simulation for educational purposes without physical experiments.

SOLAR MAXIMUM POWERPOINT TRACKING CHARGE CONTROLLER

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The aim of this project was to design and develop a Solar Maximum Power Point Tracking Charger .A low-power low-cost highly efficient maximum power point tracker (MPPT) to be integrated into a photovoltaic (PV) panel is proposed. This can result in a 25% energy enhancement compared to a standard photovoltaic panel, while performing functions like battery voltage regulation and matching of the PV array with the load. MPPT uses a simple Arm controller in order to be cost

effective. Furthermore, the converter has to be very efficient, in order to transfer more energy to the load than a directly coupled system. This is achieved by using as switched topology. A much higher conversion efficiency at lower cost will then result, making the MPPT an affordable solution for small PV energy systems

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TEMPERATURE AND RELATIVE HUMIDITY CALIBRATION CHAMBER

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Quality management calls for effective and efficient delivery of products and services in all organizations and industries such as meteorology, bio medical and many others. Data that is collected across the country from all meteorological observation stations , if it is inaccurate will result in a bad forecast being made and this may cause severe damage to Agriculture sector, aviation and many other economic sectors. Calibration therefore plays a significant role in ensuring that sensors give accurate data as per WMO standards minimizing damage to property and loss of human life. This project is aimed at designing a low cost temperature and relative humidity calibration chamber. The design is microcontroller based. The standard temperature and relative humidity sensors are interfaced to the micro controller using Mikro C language. The temperature in the chamber is raised by a fan-heater. To lower the temperature a fan is used to blow out the heat. Humidity in the chamber is raised using a simple humidifier in which a water heater is immersed in a water container. As the water is heated gradually moist air (steam) is raised. The design can calibrate both digital and analogue temperature and relative humidity measuring instruments. A comparison is made between the standard and the instrument under test and hence the error or uncertainty value of the instrument under test is calculated.

DESIGN AND IMPLEMENTATION OF AN ANT BASED HEALTH SYSTEM

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Record keeping of your health status has been a problem, but with the invention of technology has come to the acknowledgement of keeping your status in a mobile device or a cloud service or database where you can retrieve the information at a later date without losing the information. In this pretext the Ant+ based Health system is implemented by use of low power transmission protocol, where it measures the Heart rate, weight, height. and by use of these parameters you can deduce your Body to Mass Index as well as fat content. The Ant+ protocol since its introduction has been growing considering the number of devices manufactured with the protocol.

School of Industrial Sciences & Technology

Department of Biotechnology

INVESTIGATION ON THE POTENCY OF NEWCASTLE DISEASE VIRUS (NDV) STRAINS USED IN ZIMBABWE AS POTENTIAL THERAPEUTIC AGENTS AGAINST CHRONIC LYMPHOCYTIC LEUKEMIA (CLL) CANCER.

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Virotherapy is an emerging treatment of cancers in which oncolytic viruses are used to destroy cancers and stimulate immunity against cancers. In this study, the potency of Komarov and I-2 viruses as potential therapeutic agents against Chronic Lymphocytic Leukemia (CLL) was in BALB/c mice. Lymphomagenesis was induced in mice and CLL was diagnosed and staged by lymphocyte counts, hematocrit counts, weighing of mice to observe cachexia and lymph node and spleen examination. The NDV strains were propagated in embryonated eggs and treatments were done through intravenous injections of the virus daily. Statistical analysis of the data collected of masses and lymphocytes counts were done using the One-way analysis of variance (ANOVA). For the I-2 strain, the null hypothesis (HO) of Hypothesis 1 was rejected which meant that the I-2 strain had anti-cancer properties against CLL and for the Komarov strain the alternative hypothesis (H1) of Hypothesis 2 was rejected which meant that the Komarov strain had no anti-cancer properties against CLL.

Keywords: *Virotherapy, Oncolytic viruses, Lymphomagenesis, Chronic Lymphocytic Leukemia*

INVESTIGATING BIOFLOCCULANTS PRODUCED BY *KLEBSIELLA PNEUMONIAE* BACTERIA FOR TREATMENT OF HARARE BREWERY WASTE WATER.

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This project was carried out to produce bioflocculants from a local isolate of Klebsiella pneumoniae so as to investigate their effectiveness as compared to that of aluminium sulphate on sorghum brewery waste water. The local isolate of Klebsiella pneumoniae was subcultured on supplemented on basal media and incubated for 48hours after which capsule staining of cells was done to confirm the presence of capsules which possess the flocculation activity. Two protocols for the production of bioflocculants were adopted resulting in the production of broth B bioflocculants and broth A bioflocculants. Broth B had more carbon and nitrogen sources as compared to Broth A. two experimental analyses to measure the activity of bioflocculants as compared to that of aluminium sulphate on brewery water were done. In the first experimental analysis, the activity of crude and partially purified bioflocculants from broth A and B respectively with and without calcium chloride and that of aluminium sulphate on Harare brewery waste water was measured using a spectrophotometry at a wavelength of 550nm. The absorbance readings obtained were then used to calculate flocculation activities. A comparative analysis of the respective flocculation activities of the broth A and broth B bioflocculants on the waste water proved that broth B bioflocculants had higher activity. Therefore in the second experimental analysis, the flocculation activity of only Broth B bioflocculants was compared to that of aluminium sulphate on the waste water. In this analysis, the flocculation activity of a combination of aluminium sulphate and broth B crude and partially purified bioflocculants with and without calcium chloride on Harare Brewery waste water was also measured at a wavelength of 550nm. In the first analysis hand vortexing was used for mixing during flocculation whereas a magnetic stirrer was used in the second analysis. Therefore flocculation activity in the second analysis was higher than in the first analysis. A BOD test to confirm the flocculation activities of the bioflocculants and aluminum sulphate was done in the second experimental analysis. Waste water flocculated by bioflocculants had a BOD value accepted by the EMA regulations, whereas that flocculated by aluminum sulphate had a BOD outside these specifications. Partially purified bioflocculants were characterized using the phenol-sulphuric acid reaction and a positive result was obtained. From the flocculation and BOD test results obtained it can be concluded that bioflocculants produced by *Klebsiella pneumoniae* can be used to flocculate Harare brewery sorghum waste water. These bioflocculants have higher flocculation activity as compared to aluminium sulphate.

Keywords: *bioflocculant; Klebsiella pneumoniae; aluminium sulphate*

EVALUATION OF THE ANTIBACTERIAL ACTIVITY OF PHYTOCHEMICALS IN *COMBRETUM MOLLE* AGAINST METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* SPECIES.

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Methicillin resistant *Staphylococcus aureus* is a gram positive bacterium that has developed resistance to a wide range of antibiotics leading to an increase in nosocomial infectious diseases. The evaluation of phytochemicals in *Combretum molle* against methicillin resistant Staphylococcus aureus (MRSA) was done in an effort to find novel, effective and safe antibacterial agents which can fight antibiotic resistance. Phytochemicals from *C.molle* were extracted using solvent extraction method. Terpenes, alkaloids, anthracenes, phlobatannins, amino acids, quinones, tannins and saponins were found to be present in the plant after phytochemical screening analysis using different types of reagents for each test. To determine the antibacterial activity of the plant extract, disc diffusion method was used. The methanol extract indicated a high antibacterial activity with zones of inhibitions ranging from 20-23mm diameter. Vancomycin served as a positive control with diameter of zones of inhibition ranging from 15mm-16mm. The minimum inhibitory concentration of the extract ranged from 1.25mg/ml-2.25mg/ml which was determined by modified broth dilution. The results were considered significantly different when $p<0.05$.This therefore shows that Combretum molle contains phytochemicals which are effective in inhibiting the growth of multidrug resistant Staphylococcus aureus and the mechanism of action between the treatments could be different. It also concludes that medicinal plants contain therapeutic compounds which can be used in drug design.

Keywords: *Methicillin Resistant Staphylococcus aureus, Combretum molle, phytochemicals*

AN EVALUATION OF THE EFFICIENCY OF *AZOSPIRILLUM* BIO-FERTILIZER FOR THE GROWTH OF MAIZE (*ZEA MAYS*)

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The effect of *Azospirillum* as a biofertilizer in maize was investigated over a period of 7 weeks. The bacteria was purified and characterised by subculturing on Congo red media and the soil prepared by sieving, washing and sterilisation to remove organic matter and microorganisms. Five seeds of Seedco 513 were used for planting each pot and inoculation done after germination applying different amounts into their respective treatments using a pipette. There were 6 treatments i.e. maize without a source of nitrogen, maize planted with 40ml of *Azospirillum* and 4 other treatments with both *Azospirillum* and ammonium nitrate at different application rates. Root length, shoot length, number of leaves, biomass and total nitrogen content, were measured over the whole period. It was observed that the treatment without a source of nitrogen suffered chlorosis and stunted growth whilst the inoculated treatment grew healthy as well as treatments with chemical fertilizers. Plants with *Azospirillum* had more biomass (77%) and total nitrogen content (75%) than the control treatment which had 23% and 25% respectively. The root and shoot growth measurements were higher in the inoculated treatment as compared to the control treatment. However, comparisons of the 40ml inoculated treatment with treatments combined with ammonium nitrate showed no significant differences in all growth parameters. *Azospirillum* is effective in promoting the growth of maize. However, more experiments are required for a full maize growth cycle to determine the amount of yield that can be produced.

Keywords: *Azospirillum,* biofertilizer

ISOLATION OF *STREPTOMYCES* SPECIES FROM ZIMBABWEAN AGRICULTURAL SOILS FOR POSSIBLE PRODUCTION OF VITAMIN B12

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The project seeks to isolate *Streptomyces* species from local (Harare) agricultural soils for possible production of vitamin B12. Three soil samples from were collected from agricultural farms. The places where the soil samples were collected are Chitungwiza, Belvedere and Kuwadzana. The method of isolation of the *Streptomyces* species was through culturing the soil samples on enrichment and selective media. After growth of the media, seven isolates were obtained and the isolates were sub-cultured in Glycerol yeast extract agar in order to obtain a pure culture. The isolates were given laboratory reference numbers: 1CX, 1CY, 1AX, 1BX, 1BY, 2AG and 2AS. These *Streptomyces* were then characterized by cultural, microscopic and biochemical tests. All of the isolates were found to be aerobic, Gram-positive, filamentous and non-motile. They were able to express catalase, oxidase and urease. All the isolated species were also able to hydrolyze starch, casein and utilize tested carbohydrates as sole carbon sources and to produce melanin pigments. However, a wide range of variation was shown by the isolates in some other biochemical tests. These include: organic acids formation, production of H2S on Triple sugar iron agar, gelatin liquefaction, peptonization and coagulation of milk. Based on the morphology, colour and biochemical analysis the isolates were identified as *Streptomyces* species. These characteristics show that these were *Streptomyces* species according to the Bergey's Manual of Systematic Bacteriology for *Actinomycetes*. Five isolates of *Streptomyces* were recovered from soil samples collected from different areas in Harare since isolates (1BY and 1AX) and (2AS and 2AG) shows the same characteristics. As members of genus *Streptomyces* according to Bergey's Manual of Systematic Bacteriology for *Actinomycetes* four out of five species were presumptively identified as *S. lydicus* (2AS and 2AG), *S. calvus* (1CX), *S. oliveceuscleroticus* (1CY) and *S. rimosus* (1BY and 1AX). Isolate 1BX did not match any of the species in the Bergey's Manual of Systematic Bacteriology for *Actinomycetes* and may be regarded as a new species. The five isolates were accessed for their ability to produce vitamin B12 by microbiological assay using *Lactobacillus* species and only three isolates were able to produce vitamin B12. These isolates were *S. lydicus*, *S. calvus* and *S. oliveceuscleroticus*.

Keywords: *Streptomyces, actinomycetes, cobalamin*

A STUDY ON THE EFFECT OF ARBUSCULAR MYCORRHIZAL FUNGI AS A BIOFERTILIZER ON *SOLANUM TUBEROSUM* (IRISH POTATO) IN ZIMBABWE.

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A study was carried out to determine the effect of Arbuscular Mycorrhizal fungi (AMF), *Glomus mosseae* on the growth of *Solanum tuberosum* (Irish potato) and attempt to determine the suitable application method of the microbial fertilizer with the aim of developing it as a plant growth promoting bio-fertilizer thus reducing the need for high amounts of inorganic fertilizer. A pure culture of the fungi was obtained from Mycoroot in South Africa, cultured on Potato Dextrose agar (PDA) to check for viability of the cells. In one experiment, a known amount of seed was then inoculated by soaking in 30ml of AMF inoculum for 4 hours. The seeds were then allowed to germinate by sawing in germination trays with prewashed sand soil. Another set of seed was sawn in the prewashed sand without mixing with the AMF and this was later split into the control and another treatment inoculated at the seedling level after germination. The plants were transplanted into pots with prewashed sand, watered and growth responses were observed over a 4 week period. The effects of AMF on number of leaves, root and shoot length were measured each week on the inoculated plants and compared to the non-inoculated. In addition, an analysis of the plant nutrient content (Nitrogen, Phosphorus and Potassium) was done to check on the ability of the plants take up soil nutrients under the set conditions. It was observed that plants inoculated with AMF before planting had better average root (4.74 cm) development than those inoculated at seedling level (3.52 cm) and those growing on inorganic fertilizers (2.3cm) after 4 weeks. Significant differences were obtained for root length at a 95% confidence interval, however they were no significant differences on shoot length and leaf number. There were significant difference on biomass and plant absorbed nutrients with the inoculated plants having better values. It was concluded that AMF has positive effect on root and biomass development hence has potential to be used a bio-fertilizer. However, more research is required to ascertain the effect of AMF on yield over a full crop cycle.

Keywords: *Arbuscular Mycorrhizal fungi, Glomus mosseae, biofertiliser*

DEVELOPMENT OF A QUANTITATIVE REAL-TIME PCR (QPCR) METHOD FOR THE DETECTION AND IDENTIFICATION OF *TOBACCO MOSAIC VIRUS* (TMV) IN *NICOTIANA TABACUM*.

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Tobacco mosaic virus (TMV) causes significant economic losses in production of commercial flue cured tobacco in Zimbabwe. TMV is transmitted mechanically or by any other means that result in the virus coming into contact with injured cells in host plants. Methods such as enzyme linked immunosorbent assay, double stranded RNA analysis, symptomatology and reverse transcriptase PCR have used for detection of TMV. A study to develop a real time quantitative PCR method for the detection and identification of TMV was carried out. Total RNA was extracted from infected plants using TRIzol reagent and cDNA was synthesized using Revert Aid M-MuLV reverse transcriptase enzyme. TMV specific primers and probes were designed using *Oligo Architect* design tool. Four

tenfold serial dilutions of TMV commercial standards were used to produce a standard curve which was used to quantify TMV viral copies in the samples. Amplification was observed for the standards and the samples. The samples were estimated to contain 10020 and 10030 viral copies of TMV/µl. The method can be used to provide a faster and quantitative assay for TMV detection which can be used to provide information on disease severity.

Keywords: *Tobacco Mosaic Virus, qPCR, primers and probes, detection, RT-PCR and ELISA*.

PRODUCTION OF PECTINASE IN SOLID STATE FERMENTATION OF AGRO-WASTE BY *ASPERGILLUS NIGER*

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The production process of fruit juices produces waste in the form of peels, seeds, pulp and oils. Conventionally this waste is bio-transformed anaerobically into humus but wealth can be derived from this waste through value addition and produce products such as pectinase. The project was aimed at comparing the effectiveness of agro-waste as a substrate for the production of pectinase in a solid state fermentation with *Aspergillus niger*. were collected and sampled. Equal amounts of agro-waste's (orange, banana, sugarcane and wheat bran) were subjected to solid state fermentation for a fifteen-day period at a constant temperature. Wheat-bran was used as the control as it is the primary carbon source used in industry for production of pectinase enzymes. Enzyme activity was assayed at 5day intervals. The crude enzyme solution was purified by precipitation and dialysis and characterized by determining effect of temperature, pH and substrate concentration. Vmax and Km were determined by using the double reciprocal plot. Orange bagasse had an average activity of 107 U/ml followed by sugarcane with an average activity of 33U/ml and banana bagasse with an average activity of 34U/ml and wheat-bran with an average activity of 28U/ml. The values were proven to be statistically different with a p-value of 0.01 by Anova statistical tool against the control. A post hoc test was carried out to determine substrate efficiency in enzyme production the results obtained showed that a combination containing orange bagasse would produce a significant amount of enzyme activity with a p-value of 0.005. The enzyme produced was characterized using effect of pH, temperature and substrate concentration. They were found to have an optimum pH of 4.0 an optimum temperature of 35°C, a V_{max} of 51µmole/ml and a K_m of 7mg/ml this indicates that further purification would be needed to enhance the kinetics of enzymes. It is concluded that agro-waste used in the study, can be used to substitute wheat-bran as a substrate. Gel electrophoresis is recommended to differentiate the pectinases obtained. pectinase enzyme production. Enzyme stability tests are recommended for purposes of formulation.

EVALUATION OF BARVAR-2-PHOSPHATE AS A POTENTIAL BIO FERTILIZER FOR THE GROWTH OF MAIZE (*ZEA MAYS*)

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This project was carried out to investigate the effectiveness of Bavar-2 phosphate as a potential biofertilizer in maize (*Zea mays*) production under Zimbabwean conditions. A local maize variety, *ZM 401,* was grown under four different treatments: Treatment 1 had the Bavar-2 phosphate biofertilizer, Treatment 2 had a combination of Bavar-2 phosphate and Compound D, Treatment 3 had Compound D and Ammonium Nitrate, and the Control, had no added fertilizer. Standard application rates for all the fertilizers were used. A Block Design was used as the experimental design, and each block had 5 replicate bags, each with 3 plants, so as to ensure good statistical calculations. All the treatments were grown in black loam soil in small planting bags and exposed to field experimental conditions. Growth parameters per plant monitored were the number and length of leaves, density and length of roots, and the length of the shoot. Measurements were taken from the day of germination up to 21 days. The results confirmed *Zea mays'* need for fertilizer. Plants inoculated with Bavar-2 phosphate in combination with Compound D had the longest roots, shoots and leaves compared to the other treatments. It was hypothesized that Bavar-2 phosphate had a role in the development of roots in maize. Using SPSS, an Analysis of Variance (ANOVA) test was carried out on these results at 0.05 significance. The significance in the differences of the length of the roots obtained from the treatments when Bavar-2 phosphate was used in combination with compound D, as compared to the Control, was 0.05. This suggested that the use of Bavar-2 was most effective as a supplement to Compound D in the growth and development of the roots of *Zea mays*. The results from this study may recommend the use of Bavar-2 phosphate as a supplemental biofertilizer in the growth of maize, and perhaps in potatoes and other tubers as well.

Keywords: *Bavar-2 phosphate, biofertiliser*

PRODUCTION OF ANTIBIOTICS FROM SOIL ISOLATED ACTINOMYCETES AND EVALUATION OF THEIR ANTIMICROBIAL ACTIVITY AGAINST MULTI-DRUG RESISTANT *STAPHYLOCOCCUS AUREUS*

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The emergence of Multidrug-resistant *Staphylococcus aureus*(MRSA)and its increasing prevalence has become a public health concern. There is need to search for novel antibiotics that can act against this bacteria. Zimbabwe can be a potential good source of Actinomycetes that can produce the targeted antibiotics. In this project ten isolates that had been cultured from Harare Institute of Technology and Seke soils were screened for antibiotic activity. Forty percent of the isolates showed antimicrobial activity on MRSA and fermentation was done in MYE broth. The secondary metabolites were extracted and inhibitory tests were done which confirmed that the antibiotics worked against the MRSA. Purification and structural analysis of the bioactive compound need to be done and extensive research work should be carried out with more soil samples.

Key words: *Actinomycete, Novel antibiotic, Multidrug- resistant Staphylococcus aureus*

INVESTIGATION OF THE EFFECTIVENESS OF A TRADITIONAL PLANT (*ALOE FEROX*) FOR TREATING BABESIOSIS/REDWATER DISEASE

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Babesiosis/redwater disease is one of economic importance in Zimbabwe. The impact of redwater disease on livestock is severe which eventually leads to death. Babesiosis is caused by the *Babesia* species which parasitizes the red blood cells in the animal. Commercial drugs that are used to treat redwater do so by destroying the parasites directly hence they are intramuscularly injected in the sick animal. *Aloe ferox* is a plant that is traditionally used by small holder farmers to treat babesiosis/redwater because it is readily accessible, cheap, easy to prepare and it is orally administered to animals. An investigation was done on the effectiveness of *Aloe ferox* for treating babesiosis. Sensitivity tests of the *Aloe ferox* juice extract against *Babesia bigemina* were carried out *in vitro* using the parasitized blood, at the Central Veterinary Laboratory in Harare. In 20 test tubes, 1ml of the parasitized blood was placed and different volumes, 1µl, 10µl, 100µl, 200µl, 300µl and 1000µl of the *Aloe ferox* juice extract, the tryponil drug and the water as a control were added respectively. The decrease in packed cell volume and parasitaemia results were recorded at 3hr intervals of incubation at 37°C for 24hrs with exception of time at 12 and 15hours and analysed. At the volume of 300µl and the 21 to 24hr time interval there was visible mortality caused by the *Aloe ferox* juice extract. Thus, in the *in vitro* investigation the *Aloe ferox* juice extract juice proved to be effective for treating redwater. Packed cell results showed that the *Aloe ferox* extract was not toxic to the red blood cells. Further phytochemical and pharmacological investigation need to be done that could lead to identification of new active compounds that are in the *Aloe ferox* plant.

Key words: *Aloe ferox,* babesiosis, redwater disease, parasitaemia

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PRODUCTION OF (L) + LACTIC ACID FROM *LACTOBACILLUS LACTIS, LACTOBACILLUS BULGURICAS* AND/OR *STREPTOCOCCUS THERMOPHILUS* USING CHIBUKU SPENT GRAINS

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Spent grain from Chibuku breweries was tested to produce lactic acid using bacteria combinations of *Lactobacillus bulguricus, Streptococcus thermophilus* and *Lactobacillus lactis.* Eight combinations

including a control were formulated and exposed to 40^0c for120hrs in makeshift bioreactors. The spent grain was first pre-treated with mineral acid (HCL) to hydrolyse the cellulose under high temperature of 121°C for 30 min. Graphs were plotted with glucose concentration against time as well as lactic acid concentration and pH against time. Generally the graph for lactic acid concentration showed a positive sigmoid curve to show the production of lactic acid. They were a decline in glucose concentration and pH to show that glucose was being used and an acid produced respectively. All combinations proved to be scientifically viable in lactic acid production. A combination of *Lactobacillus lactis* alone had the highest production of lactic acid which had an average of 1.06mol/dm^3. The amount proved also to be economically viable. Adoption of this combination for large scale production of lactic acid is necessary. More research into LAB effect on biochemical production of lactic acid using spent grain is needed and genetic manipulation of those like *lactobacillus lactis* which have already been studied is crucial.

Key words: *Lactic acid bacteria, Chibuku, sorghum beer*

IN SILICO INVESTIGATION OF *CANINE KOBUVIRUS* AS AN IMPORTANT PATHOGEN OF ACUTE GASTROENTERITIS

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Acute viral gastroenteritis is a leading cause of mortality in infants and the immuno-compromised. It can be caused by the *Canine kobuvirus* of the family *Picornaviridae,* normally found in dogs and primarily transmitted to humans through the faecal-oral route. An *in silico* investigation of the *Canine kobuvirus* was carried out with the aim of providing more knowledge about the structure and functions of the virus' structural and non-structural proteins. Since there are no 3-dimensional structures of the proteins present, homology models of the virus proteins were predicted using M4T, Intfold, RaptorX and Phyre2 automated servers. Following model validation, conformational flexibility of the predicted structures was analysed by molecular dynamics simulations using CABS-flex web server and most of the structures proved to have a good conformational flexibility with the exception of VP1 and VP3. Antigenic sites were also identified on the immunodominant viral protein (VP1) using Ellipro and BCPred severs. These sites indicate residues that are highly solvent accessible implying binding potential to other molecules. Hence, they are important in vaccine, drug, and immunodiagnostic design. The function of the protein 2B was then determined using evolutionary relations with ProFunc and PROSITE severs and it was found to be a protein kinase involved in phosphorylation of serine and threonine residues for inducing functional change. All these *in silico* findings successfully provided more knowledge about the virus that can further be used as a benchmark for wet- lab analysis.

Key words: *Canine kobuvirus, Acute viral gastroenteritis, bioinformatics, in silico*

EXTRACTION AND CHARACTERISATION OF SECONDARY METABOLITES FROM *PRUNUS PERSICA* (PEACH) AND EVALUATION OF THEIR *IN-VITRO* ANTIMICROBIAL EFFECTS

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The use of plants for medicinal purposes is widespread, yet the therapeutic potential of plants remains poorly documented. *Prunus persica* (peach) of the family *Rosaceae* is among such plants. Some bacterial and fungal diseases have shown resistance to the antibiotics currently available on the market. Peach leaf extracts have been found to contain phenolic substances that inhibit bacterial growth in this work. The leaves were dried and ground then the best extracting solvent was used to extract secondary metabolites from the plant material. Standard chemical tests for plant secondary metabolites were used to test for the presence of phenolics, steroids, glycosides ant tannins and results showed that they were all present. Bacteria were grown on plate count agar then used to prepare suspensions respectively. The suspensions were aseptically inoculated on Mueller Hinton agar and discs impregnated with peach extracts, penicillin (positive control), and distilled water (negative control) respectively were carefully placed on the inoculated agar and the plates were incubated. The results showed bacterial inhibition around the discs with peach extracts and those with penicillin. There was no bacterial inhibition around the discs with distilled water. The peach extracts generally showed weaker inhibition compared to the penicillin. Statistical analysis for the zone of inhibition diameters showed that the peach extract inhibition was statistically significant. Secondary metabolites from peach leaves were successfully extracted and characterised. The extracts successfully inhibited the growth of the bacteria. However, purification and concentration of the phenolics in the extracts would result in better inhibition. Further study can be done on determination of the minimal inhibitory concentration. Recombinant gene technology can also be used to produce peach trees that yield higher concentrations of phenolics, resulting in better bacterial inhibition by their leaf extracts.

Keywords: *secondary metabolite, Prunus persica, antimicrobial effects*

EXTRACTION AND DETERMINATION OF SOLANESOL CONTENT IN TOBACCO (NICOTIANA TABACUM) KRK26

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Solanesol is an important compound used in the production of coenzyme Q10 and Vitamin K2 analogues. A study was done to investigate the solanesol content in *Nicotiana tabacum* leaves variety KRK26 using high performance liquid chromatography (HPLC). Solanesol was extracted from the top, middle and bottom leaves using the Heat Reflux method. Solanesol crude extract was analysed using a standard reverse phase high performance liquid chromatography with a Zorbax

eclipse XDB C18 column (4.6mm x 150mm s-micro) with mobile phase mixture of acetonitrile-methanol (95:5, v/v), oven temperature at 25°C and UV detection at 210nm. Average weight of crude extract obtained through heat reflux extraction for top, middle and bottom was 0.0056g, 0.0435 and 0.0385 respectively. Concentration of solanesol calculated was beyond the linear range of the relative standards of between 0.01 mg/ml and 0.5 mg/ml hence it could not be determined. Extraction of solanesol from KRK26 is a feasible process however further method development and validation is required to acquire accurate and precise results within the intended linear range. Extraction of solanesol serves as alternative use of tobacco and value addition for countries such as Zimbabwe who are dependent on the leaf for generation of revenue through export of the golden leaf.

Keywords: *solanesol, high pressure liquid chromatography, tobacco*

EVALUATION OF THE NUTRIENT COMPOSITION AND MICROBIOLOGICAL STATUS OF TRADITIONALLY FERMENTED MAIZE MEAL IN ZIMBABWE

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This study was carried out to evaluate the nutrient composition and the microbiological status of traditionally fermented maize meal at household level in Zimbabwe. Whole meal was fermented according to the traditional way of spontaneous fermentation. About 100g of whole maize meal was measured into a beaker and left to ferment at room temperature (30oC) for 3days in 900ml of distilled water. The nutrient composition of the fermented sour porridge was compared to the raw unfermented maize meal using the AOAC methods at the Standard Association of Zimbabwe. There was an insignificant drop in nutrient composition using the paired t-test of SPSS at 95% confidence interval ($\alpha \leq 0.05$) with the p value being 0.057. The pH values dropped by 17.2% from an initial average of 5.95 to a final pH of 4.23. The change in pH was significant as was calculated by the paired t-test at 95% confidence interval ($\alpha \leq 0.05$) with the p value being 0.00. The microbes identified during the fermentation process were *Escherichia coli* spoilage microorganism) and *Lactobacillus plantarum* (microbe responsible for the fermentation of maize meal to sour porridge).

Keywords: *traditional foods, mahewu, fermentation*

DEVELOPMENT OF AN INDIGENOUS MICROBIAL STARTER CULTURE FOR BIOREMEDIATION OF CYANIDE CONTAMINATED ENVIRONMENTS

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Cyanide is highly toxic to the living organisms as it inhibits respiration system in the cell mitochondria. Cyanide is commonly used in gold extraction process and poaching of elephants whereas its discharge into the environment not only causes pollution but it also brings harm to the surrounding population. Bioremediation offers an ecofriendly, cheap and safe alternative way to deal with cyanide contamination compared to chemical treatment. Three strains (A, B, & C) were isolated from a local gold mining site using nutrient agar medium. Cyanide degradation test were performed on each strain using M9 minimal medium supplemented with potassium cyanide as carbon and nitrogen source, to access the efficacy of the isolated strains on degrading cyanide. Silver nitrate titration method was used for the quantitative detection of cyanide during the biodegradation tests were potassium iodide acted as the indicator. Both strains were able to tolerate and effectively degrade cyanide up to 300 mg/L. Strains A and B were inhibited at 400mg/L and 500mg/L concentration of cyanide respectively, whereas strain C was capable of tolerating and effectively degrading cyanide up to 500mg/L. Biochemical characterization was performed on each strain. Strains A and C were identified as *Pseudomonas* species and strain B was identified as a *bacillus cereus*. It can be concluded that three varied groups of the isolated microbes, *Pseudomonas* species and *Bacillus cereus* can play a vital role in bioremediation of cyanide contaminated environments. Strain C was chosen for the development of a microbial starter culture due to its ability to tolerate and effectively degrade cyanide up to higher concentrations. Further studies will need to be carried out, on *in situ* and *ex situ* bioremediation strategies for the successful implementation of this project.

Keywords: *starter culture, in situ bioremediation, ex situ bioremediation, cyanide*

DETERMINATION OF THE OPTIMUM STEEPING CONDITIONS NECESSARY TO PRODUCE HIGH SOLUBILITY AND SORGHUM DIASTATIC UNITS (SDU) IN NS5511 SORGHUM MALT

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The optimum steeping conditions of the NS5511 sorghum variety in Zimbabwe are currently not fully understood and much can still be improved in the process. Ambient conditions in the malting of sorghum malt in Zimbabwe are unsustainable in cold conditions. In this study, the effect of the steeping calcium hydroxide concentration and temperature on the malt quality of NS5511 sorghum malt was assessed. Red NS5511 malting sorghum varieties were obtained from the Delta Beverages Aspindale Maltings and was analyzed for malting suitability according to the Delta Beverages Maltings Technical Manual. NS5511 sorghum grains were steeped in 0.021, 0.0245, 0.028, 0.0315, 0.035 and 0.0385M concentrations of calcium hydroxide ($Ca(OH)_2$) and 30, 35, 40, 45°C for 8hrs. Germination conditions of 30°C were applied to all samples for 96hours which were then kilned off at 60°C for 48hours. The germination rate, as measured by the chit count was determined and the temperature treated samples showed reduced germination rates at higher temperatures (40-45°C). A full malt analysis was then carried out. The alkali and treated samples showed a significant increasing

malt quality trend with increasing alkali concentration at the 0.05 level of significance. The temperature treated samples showed an increase in malt quality with increasing temperature and a reduction in free amino nitrogen content. Temperature was shown to be critical in the final bacterial load of the malt. It was concluded that a steeping temperature of 40°C and an alkali concentration of 0.028M $Ca(OH)_2$ be adopted for the steeping of the NS5511 sorghum variety for the highest malt quality.

Key terms: *steeping; malting; germination*

DETERMINATION OF THE PREVALENCE OF NEWCASTLE DISEASE VIRUS IN BACKYARD CHICKENS USING RT-PCR: CASE STUDY HARARE SOUTH REGION

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Newcastle disease is one of the important global cause of morbidity and mortality in wide variety of avian species especially chickens, capable of causing periodic epidemic disease. Newcastle disease kills chickens in large numbers and it is a viral disease. The outbreak of Newcastle disease (frequently fatal), usually occurs when the virulent strains of the virus infect one chicken, then it is easily spread to other uninfected chickens resulting in a great economic loss to the owners. The infected individual chickens are the source of the virus, can be brought by the transportation of the chickens from one place to another and also the fact that most of the backyard chickens are very active so they easily mix each other from one household to the other. This results in the quick spread of Newcastle on large poultry population in a particular area.
Beginning a survey in early November 2015 there were large numbers of infected chickens in Harare south region which showed the symptoms of Newcastle disease and samples were brought for diagnosis .Blood samples and cloacal swabs were collected in 119 chicken samples in Harare south, these samples were transported at the temperature of 4°C and stored below the temperature of -20 °C. RNA was extracted from the samples using processes of centrifugation, vortexing and filtration as indicated in the Zymo-spin protocol. Reverse-transcription PCR (RT-PCR) was used to reverse-transcribe RNA to complementary DNA then amplifying this DNA into many copies and lastly gel elecrophoresis to separate the DNA by applying electrical field. Analysis of the bands viewed after gel eletrophoresis helps to diagnose the presence of the Newcastle Disease Virus (NDV) in the samples. This project was carried out in order to obtain data about Newcastle disease, interpret it and promote health in poultry production therefore correct measures such as vaccination to reduce the disease. This increases awareness to the chicken owners so that they completely eradicate the disease.

Key terms: *Newcastle Disease Virus; Reverse-transcription*

A STUDY OF THE EFFECT OF *TRICHODERMA VIRIDE* AND *BACILLUS SUBTILIS* ON *OIDIUM NEOLYCOPERSICI* WHICH CAUSES POWDERY MILDEW IN TOMATO PLANTS

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Environmental contamination which is mainly caused by excessive use of chemical fungicides increases the interest in integrated pest management, where chemical fungicides are substituted by bio fungicides to control plant pests and plant diseases. The *Trichoderma* species is a potential fungal bio control agent against a range of plant pathogens including *Oidium neolycopersici* which causes powdery mildew in tomatoes. The success of bio control and increase in the yield depends on the nature of antagonistic properties and the mechanisms of action acquired by the organisms used. Both fungi and bacteria are able to synthesise a wide range of metabolites with fungicidal effects. In this study however, *Trichoderma viride*, evaluated under laboratory conditions against *Oidium neolycopersici* (powdery mildew causing fungi), effectively inhibited the growth of the tested pathogens in dual cultures by hyper parasitism and by secretion of volatile metabolites. In the dual culture experiment, the maximum inhibition recorded for *T. viride* against *O. neolycopersici* had an inhibition percentage of approximately 85%. The volatile metabolites of *T. viride* were most effective against *O. neolycopersici.* On the other hand, the maximum average percentage inhibition of *Bacillus subtilis* calculated for all three trials of the experiments was .Thus, it is recommended to use *Trichoderma viride* as a common biocontrol practice in agriculture.

Key terms: *Trichoderma viride, Oidium neolycopersici, biofungicide, powdery mildew*

AN INVESTIGATION ON THE EFFECTIVENESS OF ACTIVATED CARBON AND AMINOBACTER FILTERS ON CLEANING CONTAMINATED WATER FOR HOUSEHOLD USE

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The water shortages in Zimbabwe have resulted in the people in high density areas relying more on wells dug near contaminated streams. This project was done to assess the effectiveness of the Aminobacter and activated charcoal in the treatment of water from contaminated open wells. Samples were taken from an open well near a stream contaminated by sewage. Tests for the contamination levels were done before and after the purification of the samples using coliform tests like MPN, plate count and also COD. Purification was done by the filter which was made of activated charcoal and Aminobacter sp. MSH1. The results for MPN before the purification process was >1100 per g (ml) and for the COD was 349.36mg/L. The activated charcoals help to remove odours and inorganic contaminations and also chlorine from detergents. Aminobacter removes microbial contaminations from the water and replaces the use of chlorine which has harmful side effects. The

results of the tests ran after the purification process showed a significant decrease in the level of contamination. The results of the MPN after were 35 per g (ml) and for the COD it was 66.6 mg/L

Key terms: *Aminobacter, activated charcoal, adsorption*

ISOLATION AND CHARACTERIZATION OF BACTERIAL ENDOPHYTES FROM INDIGENOUS TREE LEGUMES MUSASA (*BRACHYSTEGIA SPICIFORMIS*) AND SCREENING FOR THEIR POTENTIAL TO PRODUCE PLANT GROWTH PROMOTING HORMONES.

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Zimbabwe has an abundant variety of indigenous tree legumes but has no comprehensive local endophytic classification database. This research sought to use morphology and biochemical techniques in the characterization of endophytic bacteria species. The research also sought to determine the potential of these endophytes to produce plant growth promoting compounds. Freshly ground leave samples were used and the modified extraction protocol was used. The method yielded some extract which was then inoculated on Nutrient Agar and incubated at room temperature. Four distinct colonies were observed and sub-cultured, which were then used in the analysis. Morphology and Biochemical tests were performed which include Sugars tests, Antibacterial Sensitivity test, Antibacterial activity test, Salt Tolerance test, Catalase Activity, Citrate Hydrolysis Test, Plant growth hormones analysis, Starch hydrolysis, Ammonia production test and Hydrogen cyanide production test. These tests yielded highly reproducible results which were able to be used for the bacterial identification using the Bergey's Manual of Determinative Bacteriology (see appendix B). Four different strains namely *Bacillus subtilis, Micrococcus varians, Erwinia chrysanthemi* and *Serratia marcescens*, were identified. The plant growth hormones test was done and the results showed all the species produced siderophore, and ammonia whilst the Bacillus specie was the only one which did not produce indole 3- acetic acid. This data is only conclusive with regards to the four isolated bacteria hence there is need for further investigation using different species from different regions of the country so as to have a sound indigenous tree legumes endophytic bacteria database for Zimbabwe.

Key terms: *bacterial endophytes, Brachystegia spiciformis, plant growth hormones*

ISOLATION AND CHARACTERISATION OF POTENTIALLY PROBIOTIC LACTIC ACID BACTERIA FROM TRADITIONALLY FERMENTED MILK FOR INCLUSION IN POULTRY NUTRITION.

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Magumbo dairy farm project is owned by Mr Nyagura, a resettled farmer who took this project from the previous owner, Mr Smith. The dairy farm project is mainly involved in the production of fermented milk using traditional techniques, The milk product is known for its unique test and flavour but the lactic acid bacteria responsible for these unique characteristics have not yet been studied or been identified. The sour taste that this milk product exhibits shows that the lactic acid produced by these bacteria is strong which therefore leads to the potential of these bacteria being probiotic. The industry of cultivation of probiotics has been experiencing growth and has generated a lot of revenue for companies that produce them. The use of probiotics has also increased in agriculture as an alternative to antibiotics used as growth promoters and in select cases in the control of enteropathogenic bacteria. The field of discovery of new probiotics continues to receive attention because the effects of probiotic inclusion in poultry nutrition have been studied. The lactic acid bacteria in this milk product were isolated on MRS agar and identified biochemically to be *Lactobacillus casei, Lactobacillus parabuchneri, Lactobacillus plantarum, Lactobacillus nantensis* and *Lactobacillus ferintonshensis*. The in vitro assessment of antimicrobial activity against enteropathogenic bacteria of isolates was carried out and the isolates proved to be effective. The zones of inhibition of each isolate were measured and two methods were used to study their antimicrobial property which are the disk diffusion assay and the radial diffusion assay. Antibiotic sensitivity tests were carried out on the isolates and all the isolates were resistant to antibiotics. This is a threat to food safety since the antibiotic resistance genes can be transferred to other pathogenic bacteria which then poses the threat of drug resistance to consumers. The survivability of isolates was investigated to check their tolerance and resistance to acidic pH, high osmotic concentration of NaCl and their growth at 15°C and 45°C. Therefore research has to be carried out to identify if there is the presence of transmissible antibiotic resistance genes. The lactic acid bacteria proved to be potentially probiotic and a mixed strain preparation of lactic acid bacteria was produced.

Key terms: *probiotics, Lactic acid bacteria, antibiotic*

AN INVESTIGATION ON THE EFFICACY OF RECYCLED CELL CULTURE MEDIA IN THE SUPPORT OF GROWTH OF *E.COLI* AND *S. AUREUS* LABORATORY ROUTINE ANALYSIS

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Cell culture media is widely used for different purposes but mainly for culturing and identification of microorganisms from samples like water, foods, blood and bio-pharmaceuticals and then discarded after use. Culture media is expensive therefore the use of used cell culture media was investigated basing on the objective that bacteria weighs 2 pico gram and a plate of media contains approximately 1gram of nutrients. Bacteria does not utilize all the nutrients after complete incubation of 24 to 48 hours therefore media was recycled to optimum levels till exhaustion of nutrients, depletion of nutrients and agar quality was assessed. Plate count agar, nutrient agar and violet red bile agar were reused for bacteria cultivation for 4 times until all nutrients were exhausted.

The recycled cell culture was tested for the central features of media in microbiology. Colony morphology and agar integrity was assessed after recycling, results were recorded.

Key terms: *recycled media; Escherichia coli; Staphylococcus aureus*

MICRO PROPAGATION OF *CATHARANTHUS ROSEUS* (MADAGASCAR PERIWINKLE) AND EXTRACTION OF ITS ALKALOIDS WITH POSSIBLE ANTI-INFLAMMATORY PROPERTIES FOR ALLEVIATING PAIN

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The project was carried out to micro propagate *Catharanthus roseus* and to evaluate the plant's alkaloid content. Micro-propagation was aseptically carried out using nodal cuttings and seeds. Effective surface sterilisation of the explants was achieved by treating the explants with detergent and 20% sodium hypochlorite solution for 20 minutes. The explants were cultured on full strength MS media supplemented with 1mg/ml of Gibberellic acid (GA) and incubated at 25°C, with 8 hour daily photoperiods being observed for root and shoot induction. Seventy six percent of the cultured explants regenerated shoots.
Alkaloids in *Catharanthus roseus* roots and aerial parts were extracted using methanol solvent extraction. The extracts were assayed qualitatively for the presence of alkaloids using the Mayers reagent test and both extracts gave positive results. Spectrophotometric analysis detected the alkaloid Vindoline at a wavelength of 212nm.

Key terms: *Catharanthus roseus; micropropagation; plant derived alkaloids*

INVESTIGATION OF THE EFFECTIVENESS OF VINEGAR, GARLIC AND PAPAYA ROOT AND LEAF EXTRACT IN THE TREATMENT OF SMELLY FEET

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Antibiotics are chemicals that inhibit microbial growth. Scientists are looking for alternative ways to treat diseases caused by microorganisms such as bacteria because of the problems of resistance to treatment that is developed by theses microbes after a long exposure to the antibiotic requiring higher doses of antibiotic. This study was focusing on an investigation of antimicrobial activities of garlic extract, papaya leaf extract and acetic acid on foot microbes that cause smelly feet to provide an alternative for the expensive foot powders which are not efficient in the long run. Foot swabs were collected from random sample of patients of smelly feet disease and they were inoculated on nutrient agar and incubated for 48hrs.from these samples pure colonies were obtained using the

streaking method and sub-culturing. The isolates were taken through a series of biochemical tests for characterization purposes. They were identified to be *Brevibacteria epidermis, Staphylococcus epidermis* and *Bacillus subtilis.* Fresh leaves of *Carica papaya* were collected from a local pawpaw tree in belvedere and alcoholic leaf extracts were made over 24hours. Fresh garlic was bought from a local supermarket and alcoholic extracts were also made over a 24 hour period. These crude extracts were used to treat the isolates using the disc diffusion method. 99.9% acetic acid was also used as a treatment with the sole purpose of investigating their effectiveness in inhibiting bacterial growth using vancomycin, an antibiotic for gramme positive bacteria as a control. Garlic and carica papaya extracts showed closely similar antimicrobial activity based on their similar diameters for zone of inhibition which was an average of about 10mm for both treatments excluding the diameter of the disc. Acetic acid

Key terms: *bromodosis, garlic extract, papaya leaf extract; and acetic acid*

Food Processing Technology Department

DESIGN OF A MIXER FOR RECONSTITUTION OF MILK POWDER FOR USE BY MICRO, SMALL AND MEDIUM DAIRY COMPANIES IN ZIMBABWE.

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Currently the Zimbabwean dairy sector is in short supply of fresh milk, thus, the milk being produced fail to sustain the demand for milk by dairy companies. This has led to many companies (new and existing) resort to supplementation by reconstitution of milk powders. The cost of mixing equipment used for reconstitution is prohibitive therefore in this project a cheaper design was made. From the concepts formulated one was chosen which could effectively reconstitute milk and lower temperature of the product at an affordable price. The chosen concept was affordable and easy to make for micro, small and medium Zimbabwean Dairy companies. The chosen design parameters were calculated and defined. After making of the prototype the machine was validated and verified for functionality. Mixing efficiency, removal of impurities and temperature control was measured on the prototype. Decrease of impurities by 9% from 10% was obtained due to the sieve that was on the prototype hopper. The number of lumps formed at a temperature of 47°C at 3000 revmin^{-1} was 0, therefore a reconstitution temperature of between 45°C - 50°C was recommended. The average variance of the mixture was 80.5 which is a high value and showed that mixing efficiency was fairly high. Temperature decrease was also calculated and the mean was 84.1 %. A t-tailed test was also

used to support this observation and H_0 which was $\mu_1=\mu_2$ was rejected showing that there was significant difference in temperature of the raw materials and the product. Mixer unit for particular industrial field is not very common, unlike other ordinary mixer solutions, therefore special care was taken to first study the milk powder properties to be mixed before the machine for reconstitution was designed.

PRODUCTION OF AN INSTANT PORRIDGE FROM SWEET POTATO *(IPOMOEA BATATAS L.)*

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In Zimbabwe, sweet potatoes have always been grown and eaten, (roasted or boiled), with no further processing being done to preserve the sweet potato for future utilisation, (Anochili, 2004). One strategy to ensure the availability of sufficient food, especially during the lean seasons and where sweet potato cultivation is limited to only one season in a year, is to process the roots into an instant porridge, which is the idea presented by this research project. The sweet potato tubers were purchased from a local greens supermarket. The variety selected was Northern Star, which is known to be the most abundant in Zimbabwe according to New Farmer, (2004). The sweet potato tubers were cleaned manually using tap water and sliced to 5, 8, and 12mm to increase their drying surface area. Three different techniques of drying were employed; solar, oven and open-air drying. A combination of solar and oven drying was found to be more efficient. The dried slices were ground using a blender to a fine flour of mesh size 250µm. The sweet potato flour was used to develop an instant porridge. Gelatinisation of the starch was done at 80°c and the slurry was dried using an oven until a constant weight was obtained. The thermogram described endothermic enthalpy corresponding to sweet potato starch gelatinization of 9.8 ± 0.2 J/g, with a peak temperature of 78.1˚C ± 5.0˚C, an onset temperature of 69.1˚C ±0.5˚C and a conclusion temperature of 85.1˚C ± 0.2˚C.Results showed that the sweet potato flour could not be fully gelatinised because of the structure of the starch granules found in the tubers. The final product was found to contain several nutrients after a proximate analysis which included ash and carbohydrates. With reference to the regulations and microbial tests which were carried out, the instant porridge was also found to be microbiologically safe. Consumer tests indicated that the product was generally acceptable and had the instant porridge consistency ranked third, using Friedman test, after the Cerevita porridge from Nestle and mealie meal porridge, and Movite porridge form South Africa was ranked fourth. As a recommendation, flour modification can be done, chemically, to obtain a high quality flour and products. Acetylated starches possess unique characteristics.

AN INVESTIGATION OF INTERVENTIONS TO ACCELERATE ALCOHOL DEVELOPMENT DURING OPAQUE BEER PRODUCTION: A CASE STUDY OF CHIBUKU SUPER.

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Consumer demand for lager beer has continued on a downward spiral as imbibers opt for the less expensive sorghum beer in the face of a challenging business and economic environment. The downside to this is the manner in which opaque beer demand is surpassing supply resulting in a 'dry' market. Need has thus arisen within the industry to find ways in which productivity can be increased. The study thus sort to optimise alcohol development in opaque beer and to investigate the brewing potential of barley and sorghum malt in opaque beer brewing. Laboratory scale brews were then put up in triplicate for reproducibility. Differences were in the use of either barley malt or sorghum malt in first and second conversion; straining or not straining the product prior to pasteurisation and the mesh sieve sizes that were used. Product profiling was done on these products to determine alcohol content, viscosity, total acidity, pH, brix and real degree of fermentation. The resultant product was assessed organoleptically. The results showed that brews with an addition of barley malt with ratio 1:1, Composite brew with a ratio 1:2 proved a reduction time in terms of alcohol developed because there was a significance difference in the alcohol content when comparing brews prepared from sorghum mixed with barley (ratios 2:1 and 3:1) versus those prepared from sorghum only. This was attributed to the fact in the composite brews where a fraction of barley malt was added there is greater β-amylase activity implying a greater saccharification power in the beer production process. There was lower alcohol content in double strained brews compared to single strained brews. An analysis of variance was carried out to find out whether there was an effect of mesh sieve size. It was concluded that there was a significance difference in alcohol content with the different mesh sieve size used. It was observed that mesh sieve of 0.80mm attained higher alcohol content than mesh sieve sizes of 1.0mm and 1.20mm. Product profiling results showed that composite brews had lower bite intensity and viscosity as compared to the conventional brew which had higher bite intensity and higher viscosity. From a hedonic scale the sorghum brews and composite brews scored 8.50 and 7.00 out of a possible 10 respectively: single strained brews and double strained brews scored 8.25 and 8.00 out of a possible 10 respectively and mesh sieve sizes of 0.80mm, 1.0mm and 1.20mm scored 6.25, 8.00, and 7.25 respectively out of a possible of 10. Overall comments in the organoleptic assessment for the composite brew were that of a slightly watery product and low bite intensity whilst for the sorghum exclusive brew, slightly low alcohol content was noted. From the study it was concluded that the use of a fraction of barley malt when mashing sorghum can be seen from the results to increase the levels of fermentable sugars in its wort and in turn increase the alcohol content in the opaque beer. Further research is, however, needed in areas of rectifying the low acid development and low viscosity levels which negatively impacts organoleptic property.

DEVELOPMENT OF CARBOXYMETHYL CELLULOSE FROM SUGARCANE BAGASSE (A LOCAL RESOURCE) FOR USE IN THE IN THE DAIRY INDUSTRY

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The objective of the study was to develop a functional stabilizer CMC from sugarcane bagasse which can be used in the dairy industry. The extraction of cellulose was carried out in a 1000ml beaker, equipped with stirrer and temperature controller. A 38% of cellulose was successfully extracted from sugarcane bagasse through 4% nitric acid hydrolyzed process followed by alkali treatment. Cellulose obtained was not purer cellulose. The crude cellulose was then converted to carboxymethyl cellulose (CMC) by treatment with 1 mol sodium hydroxide (NaOH) concentration and successfully etherified with 6g of monochloroacetic acid. Viscosity measurements on 2% CMC concentration showed a decrease in viscosity with increase in temperature. Functionality of the CMC was further tested by preparing a yoghurt against gelatin at different concentrations thus 0.5g/L, 1.0g/L, 1,5g/L. After the viscosity and sensory evaluation measures it was concluded that the CMC at 1.0g/L was best suitable for drinking yoghurt or stirred yoghurt.

DESIGN OF A WASTEWATER TREATMENT SYSTEM: A CASE STUDY OF LUNAR CHICKENS (CHISHAWASHA)

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This project focuses to design a wastewater treatment system for Lunar Chickens which produce an effluent meeting the recommended microbiological and chemical quality and to design a system of anaerobic, facultative and maturation ponds at low cost and which can be easy to maintain wastewater stabilization ponds. Wastewater from Lunar Chickens abattoir was collected for samples which was used to run through a sequential series to determine the characteristics and composition of the wastewater. The wastewater was subjected to Total bacterial Count (TBC); the Biological Oxygen Demand (BOD5) level in 5days was determined, the Chemical Oxygen Demand (COD) was determined and was subjected to enumeration of the *Salmonella.* The results showed that the wastewater from the abattoir was characterized with a number of 7.1 x 10-5ml-1 TBC, 9.8mgL-1 BOD5 level, 288mgO2L-1 COD level and also showed positive results with the Slide Agglutination test

to enumerate *Salmonella* i.e. agglutination was observed to be strong and it was clearly visible within one minute and bubbles were also observed in the brown compound in the petri dishes. The wastewater was subjected to the anaerobic stabilisation pond reactions i.e. the putrefaction and the methanogenesis processes for 5 days. After the anaerobic stabilization pond reactions, the test water samples were again subjected to the Total bacterial Count (TBC), the Biological Oxygen Demand (BOD5) test, the Chemical Oxygen Demand (COD) test and was subjected to enumeration of the *Salmonella*. The results showed that there was reduction in the number of the bacteria i.e. 0.4 x 10-3ml-1 TBC, the BOD5 level reduced to 2.5mgL-1 from 9.8mgL-1, the COD level reduced from 288mgO2L-1 to 64mgO2L-1 and its showed negative results with the Slide Agglutination test i.e. agglutination was not observed and no bubbles were also observed. The results show that the anaerobic pond processes were effective in effluent reduction i.e. the chemical and microbiological quality reduction.

DESIGN OF AN AUTOMATED CABBAGE CUTTER

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The aim of the project was to design an automated cabbage cutting machine that would have very little human interference in the operation while reducing the time and labour in the cabbage cutting process. The Norman design was used in coming up with the machine design, after brain storming the machine design the best design was then selected, it was evaluated the fabricated. Data was collected from the cutting time of humans while analyzing the consistency in the size of the cut and compared with that of the machine. On average an untrained human being takes 25 to 35 minutes to cut a cabbage, a trained caterer takes on average 15 minutes to cut a cabbage. The cabbage cutting machines takes less than 5 minutes to cut the cabbage. There was variation in the sizes of the cut from the samples of the human subjects and there was very little variation in the size of the cuts from the cabbage cutter. The machine significantly reduced time and labour in the cutting process with very little human intervention.

DESIGNING UNSHELLED GROUNDNUTS (*ARACHIS HYPOGAEA*) RESIDUAL SOIL CLEANING MACHINE FROM A FOOD SAFETY PERSPECTIVE

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The objective of this research was to design a machine that can improve the quality of the groundnuts after harvest by removing residual soil from the surfaces of the groundnuts that have been grown on clayey soils. Residual soil carries fungal spores that can lead to the production of aflatoxin in groundnuts. Aflatoxins are mycotoxin that renders food unsafe for human and animal consumption. Soil also carries eggs of pests which when hatched can proliferate the groundnut shell degrading the intactness of groundnut shell thereby making the kernel susceptible to aflatoxin infection. Small scale famers that relocated in different agricultural zones due to the Agrarian land reform of 2000 continue with their faming of traditional crops, groundnuts included. However some of the farmers relocated to regions with clayey soils. From the researchers point of view, these farmers to do not have adequate technologies to remove clinging clay soils from the surfaces of the groundnuts leading to the infection of groundnuts by aflatoxin thus post-harvest losses due to loss of quality by groundnuts

The design project aimed at developing a cleaning mechanism of removing residual soil from the surfaces of the groundnuts without causing significant gain in moisture content and bruising or damaging the groundnut shells. Groundnut samples from Goromonzi, Mutare and Murehwa were used for experiments in the design .The design project aimed at controlling the gain in moisture content of the groundnuts by deducing a residence of the groundnuts in the washing chamber in relation to their hydration capacity, the water pressure required to remove residual soil and abrasive action that can help scour away residual soil. The design also aimed at controlling the bruising or damaging of the groundnuts by controlling the speed of rotation of shaft during cleaning. The design includes a washing chamber, brushes lined on blades mounted on the shaft to. Blades provide agitation while brushes scour away residual soil from the surfaces of groundnuts while the shaft rotates. The shaft is driven by a 2 horsepower electric motor. The design also consists of a drainage facility to drain away used water from the washing chamber and thus no accumulation of water which could lead to possible absorption by the groundnuts. Water is introduced in the design by spraying nozzles at a flow rate of 5.64lms-2.

To ascertain effectiveness of design machine, pre, and post cleaning moisture content was measured. The fungal spores present in the wash water during start of cleaning duration and after where enumerated. The bruised or damaged groundnuts after cleaning where also calculated together with the cleaning efficiency of design.

DEVELOPMENT OF AN ANALYTICAL MODEL FOR BUTTERFAT DETERMINATION, IN BOVINE MILK, BASED ON ELECTRICAL CONDUCTIVITY PRINCIPLE. THE MILKLIPIDOMETRIC MODEL.

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Methods used for butterfat determination are considered expensive and time consuming. Therefore, it was then indispensable to develop an analytical model which is inherently flexible for easiness of use and considerably cheap for accurate and precise determination of butterfat in bovine milk. Hence, the development of analytical model based on conductivity principle – *Milklipidometric* model. The model was developed through sampling and preparation of raw milk sample with varying butterfat concentration (n=39 for modelling; n=12 for validation) in dairy companies around Harare, Zimbabwe. The samples were analysed for compositional profile and total dissolving solids (TDS). Electrical conductivity and viscosity were analysed at constant temperature (25±0.5°C) and varying temperatures (5-60°C). Models were developed using linear regression, by considering established mathematical relationships of milk conductivity and using robust linear regression modelling. The best fit model was obtained using robust linear regression modelling (Bisquare), and the parameters include electrical conductivity (ε), volume fraction of whole milk ($\phi_{vol}(WM)$mL), calibration ratio ($\in$), temperature (θ) and temperature dependent power constant (ω). The predicted butterfat shows no significant difference with observed butterfat at 95% confidence interval, and also shows a correlation of 96.0%. Considering the general model assumption a conclusion was made that there was a relationship between butterfat concentration and conductivity of milk. The model can be used for prediction of whole milk and whole milk-skimmed milk dilution. A calculator was also programmed using visual basic studio for easy calculation of butterfat concentration.

AN INVESTIGATION ON THE POTENTIAL OF MICROFILTRATION ON MILK MEANT FOR CHEESE PRODUCTION

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This research investigates on the potential of microfiltration on milk meant for cheese production. I examined the relationship between a high SCC and the quality of milk and its product yield thereof, and investigated on the effectiveness of microfiltration in reducing the number of SCC in milk meant for cheese. This research offers two hypotheses: `1) there is a significant difference in SCC of milk before microfiltration and milk after microfiltration; and 2) there is not a significant difference in SCC of milk before microfiltration and milk after microfiltration. It was hypothesized that with the application of microfiltration to milk, there is a significant decrease in SCC than when the milk had not been filtered. This research has three aims; 1) to investigate on the potential of using microfiltration on milk meant for cheese, 2) to elucidate on the effectiveness of microfiltration

against SCC; and 3) to try and formulate a cheese from micro-filtered milk and compare properties of this cheese to the commercial cheese on the market. Previous research has shown that traditionally, cheese milk pre-treatment alternatives have been ultra-filtration and high temperature heat treatment. In all cases a large amount of whey is released, the quality of which depends on the cheese process.

By using microfiltration as a cheese milk treatment method, it is possible to reduce SCC and to standardize cheese milk protein, lactose and ash composition, (Lortal 1999). Literature on somatic cell count in milk has focused almost exclusively on how a high SCC in milk is the main indicator of mammary gland infection and how world-wide, dairy product manufacturers have become very concerned about the impact of raw milk quality on finished dairy product quality such as cheese. This study advances our understanding of SCC and its effects on milk quality and cheese production. To date no systematic investigation in Zimbabwe has considered the potential of microfiltration on milk against SCC. Laboratory experiments and field studies have been conducted to test the hypotheses. Multiple methods such as use of different filter membranes and varying pore sizes of the filters were implemented. Another method used was; directly filtering the milk and centrifuging before micro-filtrating the milk. Use was made of three samples from three different farms and data from these sources collected. I tested the hypotheses using the paired samples t-test method. The findings from the research showed that the impact of microfiltration against SCC is more effective; however the formulation of the cheese was more complex than previously assumed. The findings showed an overall reduction in SCC which provides support for the key arguments. Also offered insights into how milk returns can be avoided as a result benefiting both the farmers and the dairy producers. It can be concluded that microfiltration is an effective method against SCC in milk, however recommended is the use of high pressures and filters in steps to achieve maximum standardization of milk meant for cheese.

THE PRODUCTION OF FOOD GRADE ALGINATES FROM LOCAL EDIBLE ALGAE SPECIES.

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Laminaria digitata was found in Kariba dam, Chinhoyi river and Mazowe dam while *Laminaria hyperboria* was found in Mazowe dam only. These two species were cultivated for 53 days and 48 days (Laminaria *hyperboria* and *Laminaria digitata* respectively) and they were harvested. *Laminaria*

hyperboria yielded a biomass of 1.653 grams while *Laminaria digitata* yielded 0.976 kilograms. *Laminaria hyperboria* was harvested by filtering on filter paper and oven drying at 50° C. *Laminaria digitata* was dried using two methods which were compared and these were oven drying and air drying. The air drying method gave a better quality dry algae but it took 8 to 9 days compared to the oven drying method which took 5 to 6 hours. The *Laminaria digitata* was used for the extraction process as it had a higher biomass and the extraction was done using two methods denoted method A which was as per patent number US3396158 (US Patent office, 1959) and method B as described by Columpong *et al*, (1999). The alginates obtained were analyzed physically and chemical to ascertain if fulfilled their functional properties. The results obtained showed the following quality attributes; yield of 6.908% and 15.8958% for method A and method B respectively, purity of 69.83% and 96.2% for method A and method B respectively as well as color which was 75.236% and 72.6785% respectively. The alginates were analyzed microbiologically and the results were as follows; *E. coli* 3CFU/g, *Micrococcus leutus* 2 CFU/g, fungi 1 CFU/g and yeast 13CFU/g and these were within the recommended specification range. The alginates were used to stabilize yoghurt and this was done by measuring its viscosity over 21 days and synerisis was observed on the on the 14th day while for the control it was observed on the 9th day. The gelling properties were investigated by production of a gelly powder which was then made into a gel whose viscosity was measured and was 7.42 centipoise at 1.5 °C compared to that of the control which was 1.54 centipoise at 4.9°C. It was concluded that *Laminaria digitata* can be used at industrial level to produce food grade alginates based on its yields and the fact that it met international specifications.

Pharmaceutical Technology Department

PREPARATION OF METRONIDAZOLE MICROCAPSULES TO ENHANCE PALATABILITY IN PEDIATRIC PATIENTS

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Pediatricians prescribe antibiotics frequently than any other pharmacotherapy for their patients. The unpleasant taste of medication is a major hindrance to compliance and with antibiotic therapy; this can result in therapeutic failure and the emergence of resistance. Metronidazole, a nitro-imidazole antibiotic, contains three nitrogen atoms in its structure and it is thus associated with a bitter taste. Taste masking by microencapsulation has found commercial success as exemplified by ciprofloxacillin oral suspension.

Microencapsulation of metronidazole by solvent evaporation was undertaken in this project with ethyl cellulose, a water insoluble resin as the encapsulating polymer of choice. Investigations on the effect of polymer concentration, agitation with a magnetic stirrer during the solvent evaporation stage and the homogenizer type where carried out in order to optimize formulation parameters. 1% ethylcellulose solution was used on the basis of experimental results, as was an Ultta-Turrax IKA T10 Basic Homogenizer and a magnetic stirrer. Light microscopy with a methylene blue stain indicated the existence of an ethylcellulose coat as the dark blue stain was retained.
Sieve analysis indicated a particle size distribution of 91 to 249µm. The percentage yield was found to be 76.9%. Micrometric properties were investigated and determined to be as follows: bulk density, 0.036g/ml; tapped density, 0.0375g/ml and Hausner's ratio was 1.03. Quantification of metronidazole was done using UV-Vis spectrophotometry and a calibration equation obtained using absorbance data from a series of metronidazole standard solutions. The method was validated using a precision and robustness study. The encapsulation efficiency was 13.8%. Dissolution tests under simulated salivary pH conditions followed by spectrophotometry and statistical analysis indicated significant taste masking relative to commercial crushed tablet preparation. An in vitro soft food study using dissolution tests was conducted and it was established that mixing the microcapsules with food prior to administration did not affect the drug release properties. The formulated microcapsules were packed in capsule.

Key words: *metronidazole, microencapsulation, palatability, paediatric*

NUTRACEUTICAL FORMULATION OF A THERAPEUTIC CEREAL USING BIDENS PILOSA, MORINGA OLEIFERA LEAVES, AND BOVINE COLOSTRUM TO TREAT SEVERE MALNUTRITION.

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Moringa oleifera, Bidens pilosa and Bovine colostrum were collected .In this study they were being screened for phytochemical properties and their capability to nourish the body and modulate immune system.
Moringa oleifera and Bidens pilosa leaves were milled to pharmaceutical grade, and Bovine colostrum was fan dried in a microwave and room temperature. The extracts were then used to formulate an immune-boosting nutracuetical supplement. Moringa oleifera leaves tested positive for carbohydrates, fats and proteins and various phytochemicals such as phenolics and alkaloids. Bidens pilosa tested positive for carbohydrates, protein, fats, phenols and steroids among others. The present study clearly indicated a significant presence of effective constituents in the extracts. This led to the formulation of a paste incorporating these extracts because of their nutritional and antioxidant effects attributed to phytochemicals they contain.

Key words: *Bovine, nourish, pharmaceutical, nutracuetical, antioxidant*

FORMULATION DEVELOPMENT OF A TOPICAL RUB TO ALLEVIATE GOUT RELATED SYMPTOMS USING PLANT EXTRACTS FROM HARPAGOPHYTUM PROCUMBENS AND ZINGIBER OFFICINALE.

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The purpose of the study was to formulate and evaluate product stability of a topical rub with Zingiber Officinale and Harpagophytum procumbens extracts for the potential use in gout focusing mainly on pain and inflammation. Traditionally in areas where zingiber officinale grows it has been used to cure many ailments including skin problems and cancer, gynecological problems, wound healing, and others. Bioassays have shown that Zingiber officinale contains alkaloids and phenolic compounds which have displayed potent analgesic, antibacterial and anti- inflammatory activities. Harpagophytum procumbens (Devil's claw) has been used most commonly in Africa for rheumatism, arthritis, gout, muscle pain, and other degenerative disorders of the musculoskeletal system. Devil's claw has also been used orally for liver and gallbladder complaints, stomach complaints, loss of appetite, and pain relief and topically as an ointment for skin injuries and disorders. This however brings the idea of formulating a rub with potential use in acute attacks of gout. The product formulation was done and several stability studies were done to evaluate product stability and product aesthetics. Accelerated stability tests which were done include freeze thaw analysis, window ledge analysis, spreadability and skin sensitivity tests. The product showed good aesthetic properties and stability in all the tests which were conducted.

Key words: *Zingiber Officinale, harpagophytum procumbens, gout*,

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MICROENCAPSULATION OF ACYCLOVIR USING *DICEROCARYUM ZANGUEBARIUM* TO ENHANCE IN VITRO DRUG RELEASE

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The low bioavailability of acyclovir is a cause for concern with patients having to take the important drug up to five times daily for herpes zoster and Varicella Zoster virus. This study was aimed at increasing the bioavailability of acyclovir by using a natural polymer *dicerocaryum zanguebarium* in producing microcapsules. Polymer was extracted using 96% alcohol and this was used in the solvent evaporation technique of producing microcapsules. Various blank formulations were made to determine the formulation parameter like polymer concentration, surfactant to use among others.
First, an emulsion was formed using a homogenizer then solvent was removed using magnetic stirrer before filtering and drying of resultant microcapsules. The microcapsules were then tested for drug release using the USP dissolution apparatus with samples being drawn at 5, 15, 30, 60, and 240 minutes and an equal amount been replaced in the medium to maintain sink conditions. The samples were then analyzed using Shimadzu double beam UV Vis apparatus at wavelength of 275nm. The microcapsules were also stained using methylene blue before being viewed using light microscope. The microcapsules were subjected to accelerated stability test in oven set at 45 degree. Tests were also done to determine appropriate pH for drug dissolution which was found to be 7.4. Absorbance reading were obtained for different formulations that included acyclovir microcapsules made by a combination of *dicerocaryum zanguebarium* and ethyl cellulose and this was compared to acyclovir microcapsules made using ethyl cellulose alone as polymer and pure acyclovir powder. Statistical analysis shows there is no significant difference between the release profiles of the three formulations thus showing *dicerocaryum zanguebarium* is an effective polymer as it has a comparable profile to powdered form of the drug thus better than tablet formulation. They also show increased concentration after four hours compared to both the powder and microcapsules with ethyl cellulose. Further areas of study include using

the natural polymer alone in formulation and finding suitable solvents and method of microencapsulation. In line with present study, further area include zeta potential, morphology using scanning electron microscope and total drug content studies.

Key words: *Microencapsulation, acyclovir, dicerocaryum zanguebarium*

EVALUATION OF ANTIMICROBIAL EFFECTS OF LYCOPERSICON ESCULENTUM AND MELALEUCA LEAF EXTRACTS IN THE FORMULATION OF AN EAR DROP FOR THE ALLEVIATION OF OTITIS EXTERNA SYMPTOMS

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Increasing knowledge on traditional herbal medicines has led to the rise in development of complementary medicines in Zimbabwe. In this experiment, antimicrobial susceptibility tests were carried out on Melaleuca alternifolia essential oil and Lycopersicon esculentum crude extract. The inhibition zones of these two extracts on Staphylococcus aureus, Pseudomonas aeruginosa, Aspergillus fumigates and Cryptococcus neoformans were observed. The zones of inhibition of Esculentum were compared to those obtained with M. alternifolia. The higher degree of antimicrobial susceptibility shown by M. alternifolia led to the development of an ear drop for the alleviation of otitis externa symptoms. Pharmaceutical evaluation tests were done on the ear drop in order to produce a standard pharmaceutical product for otitis externa.

Key words: *lycopersicon esculentum and melaleuca leaf otitis externa*

FABRICATION OF GLIBENCLAMIDE NANOPASTE FOR THE DEVELOPMENT OF TRANSDERMAL DRUG DELIVERY SYSTEM FOR TYPE 2 DIABETES MELLITUS

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The present study aims to formulate nanoparticles, nanopaste and single layer-drug in adhesive type transdermal patches containing glibenclamide nanoparticles (a sulfonylurea used in the treatment of non-insulin dependent diabetes mellitus). The nano-glibenclamide transdermal patch is to have reduced side effects, especially the hypoglycaemic effects encountered with the oral glibenclamide therapy. The reduction in particle size and hence a reduction in the dose administered will help reduce side effects. The Bottom up Precipitation method was used in the preparation of the nanoparticles with methanol being the solvent and hexane as the anti-solvent. The nanoparticles were then used to formulate a nanopaste and Di-methyl sulphoxide (DMSO) was used as penetration enhancer. The nanopaste was then incorporated into a transdermal patch. The transdermal patch had to be improvised so the components used during preparation were not the real material for a transdermal patch. The prepared transdermal patches possessed satisfactory physicochemical characteristics. In-vitro transdermal patch release studies were performed using the USP Dissolution apparatus and a Double beam UV-vis. The absorbance collected from the UV-vis were then used to calculate the percentages of drug released within the specified times. The in-vitro transdermal patch permeation studies were performed using the Skin Stripping method with Transpore adhesive tape across a shaved rabbit skin (epidermis). The drug adsorbed on the adhesive strips was the quantified using the USP apparatus and the UV-vis. The results obtained were then

compared to the release and penetration properties of transdermal patches. The results showed that nano-particles were releasing more than desired of the active pharmaceutical ingredient.

Key words: *glibenclamide nanopaste, transdermal drug delivery*

DEVELOPMENT OF KETOGENIC NUTRACEUTICALS USING UNDERUTILISED PLANT SPECIES FOR ALLEVIATING MALNUTRITION IN CANCER

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The aim of the study was to develop ketogenic nutraceuticals which are high fat, moderate protein and low carbohydrate products. It has been shown in accordance with various research done that it helps to improve body weight, protect the muscle tissue and reduce tumour growth in people with cancer. Ketogenic diets are based on the Warburg effect which states that cancer being a metabolic disease the cells are hyper metabolic relying on glycolysis and have defective metabolic mechanisms thus cannot manipulate other metabolic pathways and using of fat for energy production they starve and die. Good nutrition is vital to a person's health and currently Therapy Based Foods (TBFs) and Ready to Use Foods (RTUFs) have begun making a great impact. The idea to formulate supplements using locally available underutilized plant species with potential to serve communities and the country economically was borne. Improvements of nutritional content from formulation 1 which incorporated Nyimo beans, Citrullus lanatus, Mopane worms and Coconut oil and milk. A drink and a powdered meal with the following nutritional information were produced: The powdered meal had caloric value of 334kcal/100g, Protein content 23.4% and mineral content was Ca is 150mg/kg, Mg as 452mg/kg, K is 2792mg/kg and Zn 81.9mg/kg. Formulation was made applying various methods. Microencapsulation of oil was done with the polymers gelatin and gum Arabic but encapsulation efficiency of 11.34 was low thus reverted back to traditional formulation process. Enzymatic reactions used Attenuzyme and fungal amylase BG4000 failed thus leading to a reduced amount of Nyimo beans seed powder (high carbohydrate content at 53.4), increase in Mopane worms powder (high in protein at 60) and coconut oil. To achieve consistency and aid nutritional content baobab seed and the fruit pulp powders were incorporated. Baobab oil which yielded 33.5% by solvent extraction was incorporated and has antimicrobial activity to aid preservation. Estimated shelf life of powdered meal was determined by accelerated studies i.e. oven tests 50°C, fridge tests 2-8oC and room control tests 25°C to be 8months. Moisture content; peroxide and acid value as measures of lipid deterioration were used to determine shelf life. Step drying determined 130°C to be used in moisture analysis by A&D MD70 machine. Titration determined peroxide and acid values. Actual shelf life of the powdered meal was determined by real time studies and the determined storage conditions for the powdered meal were to keep the product at room temperature and the drink to be refrigerated but to avoid freezing

Key words: *ketogenic nutraceuticals, underutilised plant, malnutrition, cancer*

DEVELOPMENT OF A PHONE APPLICATION TO IMPROVE ADHERENCE TOM ANTIRETROVIRAL MEDICINES IN RESOURCE LIMITED SETTING

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Sustained adherence requires a consistent supply of medications along with education and support. Government of Zimbabwe has tried to remove the structural barriers for accessing ART by its free ART roll-out programme. Optimizing adherence and minimizing loss to follow up are two major challenges for the ART roll-out programme in resource limited Zimbabwe. Taking lessons the current situation in the country, a qualitative study was conducted to understand barriers to adherence to ART, designing an adherence oriented mobile phone application and follow up visits among twenty-five participants. Statistical analysis using tile Wilcoxon test was performed to analyse the effectiveness of the adherence oriented application in optimizing adherence. Physical analysis of questionnaire provided features the subjects want the developer to include in latter versions of the application

Key words: *mobile application, adherence, antiretroviral treatment*

FORMULATION AND TESTING OF ZINGIBER OFFICINALE (GINGER) SUPPOSITORIES FOR THE CONTROL OF NAUSEA AND VOMITING.

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Background: Since primitive times, man has gone in different ways to search for cures and relief from various forms of nausea and vomiting by using several plants, plant products and plant-derived products. Recently, there is a scientific curiosity and certain popularity with regard to screening essential oils and extracts from Ginger (Zingiber officina/e) used medicinally to treat nausea and vomiting all over the world. An unexplored path however, is the use of ginger suppositories for the effective relief of nausea and vomiting for those patients who are unable to take oral medication. This research study was targeting two special populations namely cancer chemotherapy patients and nausea & vomiting in pregnancy sufferers.
Aims & Objectives: To Formulate and evaluate Zingiber officinale suppositories for the alleviation of nausea and vomiting, targeting morning sickness in pregnancy and chemotherapy induced nausea and vomiting. To collect, extract and purify Ginger (Zingiber officinale). To formulate Zingiber officinale suppositories using different suppository bases, to carry out evaluation tests (Quality Control) on the suppositories as well as to carry out efficacy tests
The extraction of Ginger was done using a 70 ethanol solvent to be incorporated into the suppository bases. The bases used were PEG 4000, Beeswax and Gelatine to evaluate the best base with the best compatibility with ginger and would dissolve at normal body temperatures. Quality control tests were done on the formulated suppositories in vitro to test for their nature and quality, these tests included: Test of appearance, Test of physical strength, Test of melting range, Test of softening time and Test for uniformity of drug content. Conclusion: The results of this study revealed that ginger possesses good compatibility properties with the Gelatine base, which was chosen and underwent all the quality control studies. There is good potential use of the Suppositories as a relief for nausea and vomiting. Beeswax had good compatibility properties with the ginger extract, but has a melting point of 55-60 degrees Celsius. PEG 4000 base was not compatible with ginger, and crumbled upon incorporation. Gelatine is therefore a good base for ginger, and can be used for formulation of suppositories using the master formula developed in this study. Further in vivo tests are to be done to establish their efficacy

Key words: *Zingiber officinale (Ginger), nausea , vomiting, suppositories*

FORMULATION OF AN ORAL GEL FOR THE TREATMENT OF PEPTIC ULCER DISEASE USING EXTRACTS FROM ZINGIBER OFFICINALE, ALLIUM SATIVUM AND ALEO EXCELSA

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Peptic ulcer disease refers to a defect in the gastric or duodenal mucosal wall that extends through the muscularis mucosa into the deeper layers of the submucosa. It is significant cause of morbidity and is associated with substantial healthcare costs. Ulcer formation is the net result of a lack of homeostasis between factors within the gastro-intestinal tract responsible for the breakdown of food. For example, gastric acid and pepsin and factors that promote mucosal defense and repair like bicarbonate and mucus secretion. The most common causes of peptic ulcers include H. pylori infection, use of non-steroidal anti-inflammatory drugs (NSAID) and stress-related mucosal damage (SRMD). H. pylori infection more commonly affect the duodenum whereas ulcers related to NSAIDs more frequently affect the stomach. Infection normally resides in the stomach and is transmitted via the fecal-oral route or through ingestion of fecal-contaminated water or food. Gastric ulcers (GUs) may occur anywhere in the stomach; duodenal ulcers (DUs) tend to occur most often in the duodenal bulb. The epigastric pain associated with a DU typically occurs during the fasting state or at night and is often relieved by food, whereas pain from a GU is usually aggravated by food intake. Prevalence increases with older age and with lower socioeconomic status during childhood. The desired treatment outcomes are to resolve symptoms, reduce acid secretion, promote epithelial healing, prevent ulcer related complications, and prevent ulcer recurrence. Treatment of PUD includes antibiotic medications to kill H. pylori, proton pump inhibitors which reduce stomach acid by blocking the action of the parts of cells that produce acid and promote healing, histamine H-2 blockers which reduce the amount of stomach acid released into the digestive tract thereby relieving ulcer pain and encouraging healing, antacids that neutralize stomach acid and cytoprotective agents that help protect the tissues that line the stomach and small intestine. Herbal medicines are preparations of herbs used for healing containing different mixtures of organic chemicals that work together to produce therapeutic effect on the body. There is an increased interest and use of the natural product remedies and it is expected to continue growing fuelled by the growth of sales of herbal supplements and remedies. It is estimated that about 80 of the population in developing countries still rely on traditional medicines based on species of plant and animals for their primary health care. Herbal medicines are currently in demand and their popularity is increasing day by day. The screening and study of herbal medicines

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DESIGN, DEVELOPMENT AND TESTING OF A SOFTWARE FOR THE ASSESSMENT OF DRUG-DRUG AND FOOD-DRUG INTERACTIONS FOR USE BY HEALTH CARE PROVIDES.

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The increase in the number of drugs on the market and concomitant treatment of co-infections has increased the potential for drug interactions making it difficult for healthcare professionals to minimize the potential adverse effects of every drug. Fortunately, drug interaction software have been evolving to match this increase in complexity in medical delivery. Drug interaction software has become particularly relevant in addressing some of the undesirable effects associated with the increased practice of polypharmacy. Therefore, the major aim of this study was to develop a rug-

drug interactions and food-drug interaction software for use by clinicians and pharmacists in the prediction of drug-drug interactions. Software was made using java as the programming language. Literature sources were assembled, both as databases, journals and books to extract drug-drug interactions and food drug interactions. A pilot study of the tool showed that it was used to add more drugs into the database adding also drug-herb interactions. Need to also add another interface that could be used as a teaching tool. The software developed during this work is likely to be well received by the medical community starting as a teaching tool. More drugs used routinely need to be added, and a high sample size evaluation of relevance and acceptability conducted. More drugs used routinely need to be added, and a high sample size evaluation of relevance and acceptability conducted.

Key words: *drug-drug interactions, food-drug interactions, software*

HEAVY METAL AND MICROBIAL CONTAMINATION OF HERBAL MEDICINES COMMONLY USED BY HIV –INFECTED PATIENTS.

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Herbal medicine-defined by the World Health Organization (WHO) as "herbs, herbal materials, herbal preparations and finished herbal products, that contain as active ingredients parts of plants, or plant materials, or combinations thereof'-are used to treat a multitude of ailments throughout the world". Despite the physical availability and subsidized costs of several pharmaceutical drugs, the majority of Africans lack the financial means to afford conventional treatments on a consistent and/or sustainable basis". Africans living with HIV/AIDS are no exception, and access to essential drugs, including antiretroviral (ARV) drugs, is often well beyond their means". The specific pharmacokinetic and pharmacodynamic interactions between various combinations of herbal medicine and pharmaceutical drugs have rarely been investigated, leaving the overall consequences of medical pluralism largely unknown. This is particularly true of the potential interactions between African herbal medicines and ARV drugs despite concern being raised about such interactions: African potato (Hypoxis hemerocal/idea) and Sutherlandia can potentially inhibit ARV drug metabolism and transport. The use of herbal or medicinal plants in various forms has been popular for thousands of years and despite significant developments in modern medicine, investigations of new drugs from natural sources are of great importance. Single herbs, polyherbal formulations, and standardized extracts are commonly used for various medicinal properties? Unlike prescription drugs, herbal medicine products can be sold as dietary supplements, which are not required to undergo rigorous testing before entering the marketplace. In general, herbal remedies and dietary supplements are not covered by the strict regulations that govern pharmaceutical druqs'', Quality is inconsistent even among popular commercial formulations; tests have shown that the concentrations of active ingredients can vary greatly from the amounts listed on the packaging. With the ever increasing use of herbal medicines and the global expansion of the herbal medicines market, safety has become a concern for both health authorities and the public in many countries. This is because many contaminants and residues that may cause harm to the consumers have been reported. Many are natural such as naturally occurring radioxides, toxic metals, bacteria and fungi. Some arise from the past and present use of agents or material that pollute the environment and subsequently medicinal plants, such as emissions from factories of the residues of certain pesticides. Microbial contamination of herbal medicines can be influenced by environmental factors such as temperature, humidity and extent of rainfall during pre-harvesting and post-harvesting periods, handling practices and storage conditions of crude and processed medicinal plant materials. For

these reasons, there is currently a global danger to the health and well-being of the people. The risks can be reduced by ensuring that there is enough surveillance of herbal medicines.

Key words: *Heavy metal, microbial contamination, herbal medicines, HIV*

AN INVESTIGATION OF VARIOUS TRADITIONALLY USED PLANTS FOR THEIR INHIBITORY EFFECTS AGAINST NEISSERIA GONORRHOEA FOR POSSIBLE TREATMENT OF GONORRHOEA

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Increases in cases of drug resistant Neisseria gonorrhoea that is currently spreading in the world explain the need to expand the antimicrobial treatment options for this disease. In this study, plants were collected from a herbal garden and screened for activity against Neisseria gonorrhoea. Extraction methods used included the traditional decoction method followed by ethanolic and hexane extraction. In this research comparison of extraction methods in the lab and in the traditional practices was done and the research proved that the traditional practices of extraction can be modified by the use of a suitable extraction solvent for every particular plant in order to obtain a higher yield of antibacterial plant components. Hexane extraction was used to obtain lipid soluble plant components with antibacterial properties and C. Papaya, J. curcas and O phicus are the plants that had biological active components that were mostly soluble in hexane. Ethanolic extraction was for the extraction of water soluble plant components and the ethanolic extracts of Catharanthus roseus, Euphorbia tirucali, Acacia karoo, Cassia abbreviata and Pterocapus angolensis were more inhibitory on N. gonorrhoea because their biological components are mainly more soluble in ethanol. Through this in vitro study, the research obtained that all nine plant extracts inhibited the growth of N. gonorrhoea but their effectiveness varied shown by the different zones of inhibition obtained from the sensitivity tests done. All the plant extracts N. gonorrhoea showed great sensitivity to the C. papaya hexane root extract with a diameter of inhibitory zone of 33mm, followed by the A. karoo and C. abbreviata ethanolic extracts which had a DIZ of 30mm and 30mm respectively. The ethanolic extracts of Tirucali , P angolensis, and C. papaya come in third position of inhibitory potency with DIZs of 28mm, 28mm,and 28mm respectively and the hexane extract of O. phicus with a DIZ of 28mm.In the fourth position there is the ethanolic extracts of 0 phicus and C. roseus ,then the aqueous extracts of A. karoo, P. angolensis and C. papaya and hexane extracts of C abbreviata which all had DIZs of 20mm. The inhibitory effect of these nine plants against N. gonorrhoea might be attributed to the presence of some active constituents in the plant as in other herbal plants. The phytochemical analysis of the study revealed that the extracts of the plants contained bioactive compounds (Flavonoids, Alkaloids, Saponins, tannins, carbohydrates, lycosides & oils). The minimum inhibitory concentration for C. papaya, O. phicus, E. tirucali, J curcas, C abbreviata, A. karoo and P. angolensis was 2% and for C. roseus and Perlagonium was 5%.

Key words: *Neisseria gonorrhoea, herbal plants*

EVALUATION OF THE WOUND HEALING PROPERTIES, IRRITABILITY AND LONG TERM STABILITY OF POLYHERBAL GEL AND FOOT-SOAK FORMULATION FOR DIABETIC FOOT

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The diabetic foot is a poorly managed, detrimental condition imposing discomfort, pain and loss of limbs to the patients. Patients with the diabetic foot wrestle with infection which are not being fully eradicated by the conventional medicines. The flora of plant life within Zimbabwe contains medicinal plants with strong antimicrobial, analgesic, antioxidant, anti-inflammatory and wound healing effects and such plants include Ziziphus mucronata, Kigelia africana, Cucumis anguria and Dalbergia nitidula. The aim of this project was to formulate and evaluate the efficacy, irritability and long term stability of formulated polyherbal gel and foot-soak. In this project, the active phytochemicals responsible for the above effects were extracted and incorporated into gel and foot-soak formulations for combating the Diabetic foot. The stability of the formulations was tested utilizing the real-time and the accelerated stability tests. The formulations were tested for their irritability acute toxicity following the Draize's protocol and they proved to be safe. The formulation efficacy was assessed using a porcine skin model and comparisons were made on the use of the experimental therapy, the conventional therapy and the natural wound healing process. The results of the experiments carried out were analyzed using the SPSS statistical package and deductions were made. The experiments employed showed that the experimental therapies are more or less the same in terms of wound closure when compared to the conventional therapy but exhibit other properties that the conventional therapy does not have such as anti-inflammatory and analgesic properties.

Key words: *Ziziphus mucronata, Kigelia africana, Cucumis anguria and Dalbergia nitidula , stability, wound healing, diabetic foot*

FORMULATION DEVELOPMENT OF A SHAMPOO AND HAIR SPRAY FOR ALLEVIATING SYMPTOMS OF ANDROGENIC ALOPECIA INCORPORATING THE EXTRACTS OF *GUAZUMA ULMIFOLIA, DICEROCARYUM ZANGUEBARIUM AND ZINGIBER OFFICINALE*.

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Androgenic alopecia is the most common type of progressive hair loss which affects both men and women. Although androgenic alopecia does not cause mortality it can affect an individual's confidence and self-esteem which may lead to depression. Due to the limited medication range on the market which also have serious adverse effects and reduced efficacy, patients seem to be drawn to alternative treatments with fewer side effects. This has led to many people using unproven treatments and dietary supplements that are not typically recommended. The flora of plant life within Zimbabwe contains medicinal plants with different phytochemicals that can be used to stimulate and improve hair growth. Dicerocaryum zanguebarium, Guazuma ulmifolia and Zingiber Officinale were used in this project to observe their synergistic effects on hair growth. The plants were collected, plant metabolites were extracted and phytochemical screening was done on the extracts by performing chemical tests. The plant extracts were incorporated in the formulations which were used in animals for efficacy testing. The plant extract formulations showed an increase in hair growth on the tested sites of the animals. The findings of this study showed that the made formulations have a greater potential in the management of androgenic alopecia as we can try to utilize our natural flora of Zimbabwe

Keywords: *Guazuma Ulmifolia, Dicerocaryum Zanguebarium and Zingiber Officinale. Shampoo, hair spray, androgenic alopecia*