Conference
Papers and Abstracts

The Central Challenge for Caribbean Scientists, Engineers, Technologists and Economic Planners

Winston H.E. Suite

Faculty of Engineering, The University of the West Indies, St Augustine, Trinidad and Tobago, West Indies;
Email: winstonsuite@gmail.com; winstonsuite@yahoo.com

Abstract: *As scientists, technologists, engineers and economic planners wrestle with the question of Caribbean development, they seek to focus specifically on the issue of innovation. But underlying this search is the need to explore the link between the scientists, technologists, engineers and the manufacturing sector. They must review the efficacy of the ideas and experimentation in one sector of the society, the academics generally and those involved in the production of goods and services in industry, private sector and public sector. In the first two decades of CAS the focus was on developing the science and technology culture with the focus being mainly but not exclusively on the teaching of sciences and technology in schools, primary, secondary and at university levels. In the last decade the focus was shifted to science and technology policy and the intensification of the focus on research in the tertiary level institutions. In the next decade the central challenge must be about building linkages with existing industry and fostering incubators of industry and building bridges between academia, public sector planners (governments) and the manufacturers. This third stage must be the central focus at this juncture as we meet to discuss the next decade of CAS existence. This paper focuses on developing mechanisms to achieve this objective. It seeks to work towards pushing Caribbean Industry to internalise structures to achieve research and development centres within the manufacturing operations and above all, establish links with international industrial and manufacturing centres of new ideas that the developed world and that leading state of the art in operations. This is the way forward for Caribbean Industry, manufacturing and engineering practice.*

Keywords*: Science, Technology and Innovation*

1. Introduction

"Necessity is the Mother of Invention." Need and the demand of exigency may have explained some development in the past and may continue even today as the source of new scientific advancements and technological and engineering strides but one may be challenged as to whether it is the source of significant driving force or the principal lever in the strides of a twenty-first century in Science, Technology and Engineering. Today, incremental changes in manufacturing and industry may be in response to the immediate demands of the market or attempts to solve problems in the production process. This paper seeks to advance the principal sources of new scientific ideas and inventions that have long gone beyond the work of individual genius working in garages, self-financed or protected and sponsored by individual wealthy benefactors. These mechanisms of development reached their peak towards the end of the first industrial revolution (1750 – 1800) at the end of the nineteenth century.

As we moved into the second industrial revolution (1900 – 1950), two mechanisms moved to the forefront in the development of scientific ideas and technology and engineering devices. The first was the Universities and the other was the Limited Liability Company. These two mechanisms became the principal producers of new scientific ideas and new engineering devices. Let me hasten to add that this did not mean the end of the individual efforts as characterised by the creativity of individuals. The search for new ideas (theories) and inventions was now driven mainly by governments and the competition between companies in the market place. Governments were driven by the desire for dominance not to omit the large scale wars (such as WWI, WWII and the number of undeclared and declared wars). In short, the competition between nations and by extension, their governments and the continuous and often fierce competition, even in peace time. On the other hand, the no less fierce competition between companies drove the scientific community to deliver technological advantage. In short, it was competition between States and Governments on the one hand and competition between companies on the other that began to be the driving forces for new scientific ideas and engineering and technological products, processes and systems.

These two mechanisms produced new and fundamental ideas. But the market place was not equally divided. Governments tended to fund fundamental ideas only, while the companies tended to fund both fundamental research and developmental research. As the competition between States and States on the one hand and between company and company at the other for market dominance grew fiercer we literally saw a blurring of the two sources of research. The new phenomenon in research even developed to where the State contracted out its research to private companies or the private companies conducted the research and developed research products only to sell the end

product to the State. Fundamental research today is carried out in State research agencies, in universities as well as in the private sector. (Industry/Companies) Product and process development research is done mainly in the private sector (Industries) and a very little in Technical universities. It is this complex situation of the development of fundamental research and applied research that the paper seeks to address.

2. The Central Challenge for the Caribbean

By and large, the Caribbean region is more a taker of scientific ideas and research products than a net developer of fundamental research or applicational developmental research. We must admit that at the present moment our industries import these from the developed, industrial countries of the North. It is not reasonable to expect that miraculously, the Caribbean economies and more specifically their industrial sectors, will be metamorphosed into forms now common in the more industrialised countries in the near future. The local industrial sector in many respects have not yet fully embraced the fruits of the second industrial revolution (1900 – 1950) and mastered its principal tool electrical driven mechanism and the gasoline engine in production processes. This is not to say that we have not employed the same fruits of the third industrial revolution (1950 – 2000), electronics and solid state devices and the computer. One can say without fear of contradiction that Caribbean industry has not yet contemplated the next industrial revolution 2000 – and its principal tool, robotics and what some describe as the IT and artificial intelligence. This is where industrial development is in the industrialised countries of the North and some of the South. It is this panorama of the development of scientific ideas, processes and products that are already the competition.

The question we in the Caribbean must face is, where are we? Where is Caribbean Science and Technology? Where is the Caribbean Engineering Theory and practice, where is Caribbean manufacturing and industry? The next section will briefly indicate where the author thinks we are with respect to these issues and how do we compare with the industrial, developed countries and even where we are now as compared with other countries that were considered less industrially developed than we were forty years ago (e.g., Singapore, Malaysia to name a few).

3. Where We Are on the Spectrum of Industrial Development

To properly address this question, we must begin with the teaching of science from Primary through Secondary to University levels. We must admit that at the primary level the early teaching of sciences is far from satisfactory. There is a deficiency in both the quality and quantity of teachers equipped to undertake this most important task. Little wonder that the level of science interest is not where it should be. We are witnessing a poor level of interest in sciences in the high schools (i.e., Secondary Level, age 11 – 18). Generally, there is less than thirty (30) percent of students exiting secondary school with passes in mathematics and one science subject. Our secondary school curriculum is equal to that in the developed countries. While the science and technology culture we had hope for two decades ago (2000) has not materialised. This defect in Primary and Secondary school levels has resulted in a complex situation at University level.

i. Low levels of students entering science programs;
ii. The gender disparity is stark. Approximately seventy percent of students at university level are female (generally).

Against this background, we have noticed that more than sixty percent of teachers at Secondary Level are female including the science teachers in the Boys schools. Besides, the human resource to fill our industries is both seriously numerically below required level, as well as a low interest among graduates eager to go out and transform the industrial culture and to drive the modernisation of the production processes. It is against this background of a numerically deficient primary teaching resource needed to take the industrial sector to the next level.

4. The Path Forward

If the Caribbean industrial base is to become modernised and more towards embracing the fruits of the third industrial revolution, then there are several steps that must be addressed.

i. **Science teachers for the Primary School level -** A more aggressive drive to attract a better quality of science training among young persons from whom we are to select the teachers at the primary level. There is need of a radical change in the curriculum at this level. Our thrust to develop a science and technology culture in the decade of the 1990's was far from successful.
ii. **Higher Level of Science Literacy -** A specific plan to ensure that all students have a chance of becoming science literate and overcome the fear or disinterestedness in science. The aim should be to ensure that all students have a good exposure to a full complement of the basic sciences up to CXC.

iii. **Science Group in Pre-University Level -** A specific plan to increase the number of students including at least two science subjects at CAPE level. (Chemistry, Biology, Geography and Environmental Sciences).

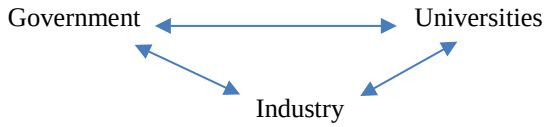
These three would significantly increase our chances of developing the students entering university either to pursue a full science based suit of subjects or including at least one science subject at the university level. The industrial demands of the present industrial revolution (2000 -) would raise serious questions. The question of the educational thrust must come from the initiative of the government. This is where policy lies. The universities must join this initiative, in fact they must strategically seek to lead it. This question of educational policy change must have the blessing of the various Caribbean governments. Otherwise the process will be an utter failure or simply never achieve take off momentum.

The other initiative involves a more difficult task. This is the question of developing a mechanism or mechanisms to develop the necessary initiatives within industry itself. We must note that very few industrial operations have research and development departments with dedicated staff and the necessary budget to undertake not fundamental but developmental research work. It is this mechanism that holds the final key to the technological development of regional industries to a position anywhere near to their counterpart and competition in the industrialised countries of the North and even some within the dynamically moving industries in the countries of the South. Who should lead this initiative?

This must be an idea which industry itself must come to recognise and enthusiastically embrace as not only necessary but inevitable if they are to move beyond simply being the takers i.e. buyers and users, of First World technological innovation. We must be reminded that innovation is more than machinery and equipment, it is ideas and therefore we must build within the industries the intellectual and technical (idea) capacity. It is not acquisition of equipment or structure packages. The development of this industry based research must be the result of the partnership mainly of the traditional research based institutions, our universities of the Caribbean. The partnership must be wielded by the involvement of the State. These are the three partners to the mechanism. It is not a new proposal. It has been developed in Japan (Japan Inc.), in South Korea and the super-giant China. The paper therefore offers two very old mechanisms.

i. The Science and Technology Culture Development.
   [Government ←---------→ Universities]

ii. The Industry Based Research, Development and Innovation Centres within Industry Itself.



The author does not claim to be advancing a fundamentally new idea. He offers a concept and a mechanism that has been employed with great success in a number of countries. The present concern is why the proposal made before has not been implemented or attempted to date. What is required is as is often said, "*This is not rocket science*" even if the process were to result in rocket like scientific initiatives.

Author's Biographical Note:

Winston H.E. Suite *is a Professor Emeritus of The University of the West Indies since 2010 and a Professor and Senior Research Fellow of the University of Trinidad and Tobago. He is a Civil Engineer by training and has a BSc. In Special Physics, a BSc in Civil Engineering (Hons), a PhD in Civil Engineering and an MSc in Civil Engineering (Construction Engineering and Management). He has served as a Contractor for seven (7) years and a Consultant since 1978. He was a founding member of the Caribbean Academy of Sciences and a fellow of several scientific and engineering organisations.*

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On a Stochastic Differential Equation with Gamma-Distributed Jumps

Jasmine Cesars[1], Silvere P. Nuiro[2] and Jean Vaillant[3]

LAMIA, Université des Antilles, Campus de Fouillole, BP250, Pointe-à-Pitre F-97115, Guadeloupe F.W.I., France.

[1]Email: jasmine.cesars@univ-antilles.fr
[2]Email: paul.nuiro@univ-antilles.fr
[3]Email: jean.vaillant@univ-antilles.fr

Abstract: *Many economic, physical and epidemiological phenomena can be described by stochastic modelling. One way to do this is to consider a stochastic differential equation (SDE) and perform analytical or numerical calculations. The trajectories obtained can then be compared with the observed trajectories in order to test whether the SDE-based model corresponds correctly to reality. We studied a situation corresponding to a variable whose fluctuations are caused by fractional Brownian motion and a Poisson process. The distributional properties of the solutions of this SDE are presented. Illustrations are also provided using artificial data generated by this model. An application in epidemiology is proposed.*

Keywords*: Stochastic differential equation, fractional brownian motion, Ito formula, Poisson process*

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Authors' Biographical Note:

Jasmine Cesars *is a PhD student in Mathematics at the Université des Antilles. She obtained a financial support from the French Embassy in Haiti. She is in her third year of PhD studies. She is teaching mathematics at the Université d'Etat d'Haiti.*

Silvere P. Nuiro *is an Assistant Professor in Mathematics at the Université des Antilles. He is supervising Jasmine Cesars' PhD study. His research subjects are "Nonlinear Shroedinger equations", "Nonlinear degenerate PDEs with very irregular date" and "Stochastic differential equations". He also performs mathematics lectures in Master's degrees at the Université d'Etat d'Haiti.*

Jean Vaillant *is a full Professor in Mathematics at the Université des Antilles. He is supervising Jasmine Cesars' PhD project. His research subjects are "Point process statistical inference" and "Stochastic process behaviour".*

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Integrating Global Biomedical Sciences for Health Research in the Caribbean: The University of the West Indies and State University of New York Health Research Task Force

John F. Lindo[1,2,4]; Jeffrey C. Lombardo[2,4]; Terrence Forrester[1], Horace Fletcher[1]; Tomlin Paul[1]; Gina Prescott[2]; Alison Nicholson[1]; Andrew H. Talal[2,4]; Sanjay Sethi[24,]; Brian Tsuji[2,4]; Venu Govindaraju[2]; Karen Phillips[1]; Tyler Mullen[1,2]; Jack DeHovitz;[3,4] and Gene D. Morse[2,4]

[1]Faculty of Medical Sciences, Mona Campus, University of the West Indies, Kingston, Jamaica; E-mails: john.lindo@uwimona.edu.jm; Terrence.Forrester@uwimona.edu.jm; Horace.Fletcher@uwimona.edu.jm; Tomlin.Paul@uwimona.edu.jm; Alison.Nicholson@uwimona.edu.jm; Karen.Phillips@uwimona.edu.jm;

[2]Center for Integrated Global Biomedical Sciences, University at Buffalo;

[3]SUNY Downstate Medical Center;

[4]SUNY Global Health Institute; Email: emorse@buffalo.edu

Abstract: *Enhancing research and scholarly activity to achieve sustainable development goals (SDGs) will require approaches that guide priorities, mentoring and research applications. A joint Health Research Faculty Task Force will identify priority areas and implement a strategic process to utilise information and communication technology to foster collaboration between The University of the West Indies and the State University of New York. A needs assessment to identify health research and education priorities and a timely approach for dual university system collaboration to promote competitive research grants that target SDGs was implemented. SDGs were identified that included a national Infectious Diseases Research Center, a clinical research center infrastructure, antimicrobial resistance/stewardship, diabetes/liver/kidney disease programme, cancer, cannabinoid sciences, natural products and nanomedicine. A 5-year virology research capacity building grant from the Fogarty International Center was received. The Health Research Task Force was able to begin implementation of multiple Caribbean health initiatives. The priority research areas have been identified and scientific, administrative, fiscal and infrastructure planning is the current focus of program development and will drive the timeline and milestones to be achieved. An integrated biomedical sciences approach promotes faculty collaboration and provides a strong translational science foundation toward SDGs.*

Keywords: *Sustainable development goals, integrated biomedical sciences approach, faculty collaboration*

SEM/EDAX Studies on Consolidated Volcanic Soils and Crystalline Rocks Indicating the Strong Presence of Rare Earth and Rare Elements in the Caribbean Island of Grenada

Ramsey Saunders[1], Leon Radix[2], and David Hinds[3]

[1]St. George's University (BEC), True Blue, Grenada, West Indies; Email: rsaunder@sgu.edu

[2] St. Georges University (BEC), True Blue, Grenada, West Indies; Email: lradix@sgu.edu

[3]Department of Physics, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies; Email: David.Hinds@sta.uwi.edu

Abstract: *Grenada is a member of the chain of volcanic islands of the eastern Caribbean. In the formation of these islands, materials from deep within the earth's crust were brought to the surface and via a process of erosion and weathering produced the existing rocks and soils. Such materials may contain valuable mineral resources. In this study we investigated via SEM/EDAX the elements present in the consolidated volcanic soils and some crystalline rocks of Grenada. In many coastal areas the volcanic rock layers are clearly visible and often a thin white layer is found sandwiched between brown layers. Samples from the interface between white and brown layers as well as from crystalline rocks were taken for SEM/EDAX studies to determine whether they contain important minerals. Samples were all about 0.5cm in diameter and were sputter coated with gold (24 nm) prior to SEM/EDAX studies. In addition to elements generally found in soils such as Oxygen, Carbon, Silicon, Iron, Calcium, Aluminum and Magnesium, high total concentrations of rare earth and rare elements (up to 21%) were obtained in both the consolidated volcanic soil samples as well as the crystalline material. These elements included Rubidium, Strontium, Holmium, Lutetium, Praseodymium, Palladium, Samarium, Europium, Selenium, Niobium, Osmium, Technetium, Zirconium, Neodymium, Molybdenum, Dysprosium, Uranium, Gallium, Silver, Cerium and Ytterbium. The combination of Rubidium and Strontium was detected only in the white region of the consolidated soil samples. Rubidium without Strontium was however observed in the crystalline material. Rubidium has two naturally occurring isotopes, Rb(85) that is non-radioactive (72%) and Rb (87) that is radioactive (23%). Rb (87) decays by loss of a β-particle to produce nonradioactive Sr(87). The presence of Strontium clearly indicates the presence of Rb(87) which has a half-life of several billion years. The presence of Rare earth as well as rare elements is attributed to past volcanic activity and the relatively high concentrations of these elements suggest the need for further studies to determine whether these elements may be of economic importance to Grenada.*

Keywords*:* SEM/EDAX, volcanism, rocks, rare earths, economic importance

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Authors' Biographical Notes:

Ramsey Saunders *is a Professor of Physics at SGU, Grenada and Visiting Professor to the Medical University of Berlin. He obtained his PhD at the Imperial College, London 1971 and subsequently did post-doctoral work as an Alexander von Humboldt Fellow and worked later as Scientist of the German Science Foundation at the Free University, Berlin. He returned to UWI Trinidad in 1978 and has been Head of Physics for 30 years. He has numerous quality papers to his credit and currently researches Alzheimer's disease in Berlin and Uppsala and rare earth elements in Grenada.*

Leon Radix *is a Lecturer in the Department of Biology, Ecology and Conservation at St. George's University. Grenada. He holds a Master's in Environmental Policy and Management and a Bachelor's in Life Sciences. He has worked in the education sector for twenty years. He is currently pursuing a PhD in Biological Sciences.*

David Hinds *is a Developmental Engineer in the Department of Physics at The University of the West Indies, St Augustine Trinidad. He has worked extensively in the Electron Microscopy field for the past 28 years. First in the service of Electron Microscopes in the USA for 10 years and then in service and applications for the past 18 years. He has co-authored journals and publications in the applications of the Electron microscopes.*

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A Story of the Accidental Formation of Novel Titanium(IV) Schiff Base Salen Complexes

Alvin A. Holder[1], Raj K. Gurung[2], William L. Jarrett[3], and Colin McMillen[4]

[1,2]Department of Chemistry and Biochemistry, Old Dominion University, Norfolk, VA 23529, U.S.A.;
[1] E-mail: aholder@odu.edu;
[2] E-mailrgurung@odu.edu;

[3]School of Polymers and High-Performance Materials, The University of Southern Mississippi, 118 College Drive, #5050, Hattiesburg, MS 39406, U.S.A; E-mail: william.jarrett@usm.edu;

[4]Department of Chemistry, Clemson University, 219 Hunter Laboratories, Clemson, SC 29634, U.S.A.; E-mail: cmcmill@g.clemson.edu

Abstract: *Many titanium-containing complexes have been reported in the literature. They are very important for their catalytic properties and material applications. Such complexes are coordinated by the tetradentate Schiff base ligand, the N,N'-ethylene bis(salicylideneiminate) dianion (salen). The salen ligand has been reported to be rigid and planar when coordinated to metal centers. Numerous chiral titanium-containing salen complexes have been extensively studied for their catalytic properties which have been useful in organic synthesis such as polymerisation, oxygenation of an alkene, and epoxidation. However, studies reporting the characterisation of achiral titanium(IV) salen complexes are scarce due to their intricate nature. In this report, the hypotheses are as follows: (1) the rigid tetradentate salen ligand will be able to control the coordination properties of titanium(IV) salen complexes creating a uniform environment around the titanium(IV) metal center and (2) the ligands in the axial position will be able to stabilise a mononuclear complex.*

Such complexes would be comparatively less expensive and easier to prepare synthetically, and thus could represent an excellent alternative to the more expensive chiral titanium(IV) complexes. Recently, our research group accidentally synthesised a series of octahedral titanium(IV) Schiff base complexes along with various substituted phenols as ligands. The complexes were characterised by elemental analysis, electrochemistry, UV-visible, ^{1}H, ^{13}C, ^{19}F, and ^{49}Ti NMR and FTIR spectroscopies. From the elemental analysis data, the complexes were proposed to have the general structural formula, $[Ti(salen)(OPh\text{-}X)_2]$ (where X = F, NO_2, and CH_3). Based on the results from our study, we concluded that achiral titanium (IV) Schiff base salen complexes can be accidentally synthesised, but more efficiently, and at a cheaper cost when compared to chiral titanium(IV) salen complexes.

Keywords*: Titanium(IV); ^{49}Ti NMR spectroscopy; X-ray crystallography; Schiff bases*

Authors' Biographical Notes:

Alvin A. Holder *is an Associate Professor in Chemistry at Old Dominion University. Previously he was an Assistant Professor in Chemistry at The University of Southern Mississippi (USM) from August 21, 2006 until August 12, 2013. He was also faculty member at Cave Hill Campus from 1994-2003. His area of research revolves around biological and inorganic chemistry, bioinorganic and inorganic reaction mechanisms. He has published more than 70 articles, two textbooks, and five book chapters; directed three postdoctoral fellows, and directed six graduate students at USM and the University of the West Indies, Cave Hill Campus, Barbados.*

Raj K. Gurung *is a graduate student in Dr. Alvin A. Holder's laboratory at Old Dominion University. His research is based on coordination and metallomesogen chemistry.*

William L. Jarrett *is an associate research professor, Polymer Science & Engineering, University of Southern Mississippi. He is the NMR Facilities Coordinator.*

Colin McMillen *has served as the crystallographer and Director of the Molecular Structure Center in the Department of Chemistry, Clemson University since 2012. He received a B.Sc. degree in Chemistry from Clemson University in 2002 and subsequently earned his Ph.D. degree in Chemistry from Clemson University in 2007 while studying inorganic chemistry with Professor Joe Kolis. He was the recipient of the 2013 Young Scientist Award*

presented by the American Association for Crystal Growth for accomplishments in hydrothermal crystal growth. Colin's research interests in crystallography, crystal growth, and descriptive crystal chemistry span a variety of chemical disciplines.

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Can Caribbean Countries Ignore Scientific and Technological Knowledge and Still Prosper?

Arnoldo K. Ventura[1] and Sandra M.E. Wint[2]

Caribbean Academy of Sciences, Jamaica (CASJ), Plymouth Crescent, The University of the West Indies, Mona, Kingston 7, Jamaica, West Indies

[1]Email: akhaleelventura@gmail.com;
[2] Email: smewint@gmail.com

Abstract: *This question will be answered by reviewing the socio-economic fortunes of Jamaica and other Caribbean islands against the background of dramatic advancements in global scientific and technological knowledge. The recent surge in knowledge in artificial intelligence, machine learning, genomics, bioengineering, robotics and the use of mass data to make complex decisions are disrupting traditional production systems, jobs and trade. Countries that have invested in the generation and application of scientific and technological results are largely successful, while those that disregard these advancements are struggling to meet the needs of their citizens. Islands that have ignored investments in scientific research and technological development and participate only marginally in the industrial era as providers of raw materials and purchasers of finished products and technologies, have increasingly been unable to improve their economies, protect their fragile ecosystems and quell mounting social tensions. The prosperity gap between Caribbean countries and their scientifically led trading partners are destined to get even wider with the rapid rise of scientific inventions and innovations. Prosperity is now dependent on scientific knowledge, technological investment, invention and innovation, putting the region at even greater disadvantage. The influence of the scientific and technological factors that contributed to the rise of industrialised countries, such as human and intellectual capital, and the heavy tailed distribution of scientific discoveries, will be explored in the context of small island states. The specific consequences of climate change, on the Caribbean, further compound the decisions of selecting priorities for investment and development by governments. Can Caribbean countries survive and prosper without joining the scientific and technological knowledge revolution? The answer seems to be no, based on the scientific experiences of countries whether, big or small, resource poor or rich, and autocratically or democratically governed.*

Keywords*: Caribbean, scientific and technological knowledge, CARICOM Science Technology and Innovation Committee (CSTIC), socio-economic development*

1. Introduction

Chronic economic stagnation and human development declines in the Caribbean have raised questions of the socio-economic models being deployed to satisfy the needs of small island nations in a scientifically propelled world (World Bank, 2018). Jobless growth and growthless jobs, excessive and burgeoning food import bills in the order of US$ 4 billion per annum for Caribbean Community (CARICOM) member countries coupled with disillusionment, crime and violence, with no visible workable solutions, have spread across the region (FAO, 2013). Efforts to address issues of low productivity, quality and inconsistent supply in regional agriculture, for example, have been spearheaded by the Caribbean Development Bank (CDB) to bolster competitiveness (CDB, 2013). Table 1: Chronic Predicaments in the Caribbean, summarises the extent of the common issues that thwart development efforts.

Table 1: Chronic Predicaments in the Caribbean

- Extended weak economic growth
- Jobless growth and growthless jobs
- Growing fiscal and trade deficits
- Food import bill crisis
- Poverty and hopelessness
- Land and air pollution, coastal erosion and loss of coral reefs
- Urban expansion and loss of arable lands
- Climate change – natural disasters and economic losses
- Materialism, coarse behaviour, self-centredness and crime and violence

Many Caribbean leaders, in efforts to assert political relevance, have proclaimed that they intend to achieve developed country status during their short incumbencies, while ignoring the crucial roles of science and technology in development. Is this ongoing denial, given the low economic performance and environmental pressures being faced by most of the region, tenable?

2. Salient Factors of Socio-economic Development

2.1 A Short History of Technological Progress

To answer this question, it is reasonable to firstly, ascertain the major factors that have led to developed socio-economic ranking among a few countries, and secondly, compare these with what prevails in developing and underdeveloped societies (Sagasti, 2004). While developed countries have moved ahead in many areas, developing and underdeveloped countries, have remained structurally constrained by the factors in Table 1: Consequences of these characteristics are low productivity, slow technological uptake, widening fiscal and trade imbalances and declining living standards. In the 2017 Caribbean Economic Review (CDB, 2018) growth rates of Caribbean Development Bank (CDB) member countries were consistently lower – below two per cent between 2010 and 2017 - than all country groups such as emerging market and developing economies, which hovered around six per cent, other small developing states, which fluctuated between three and eight per cent and also fell below the world average of four to five per cent.

Before the Industrial Revolution, when manual labour was being replaced by steam energy in the mills in England and the sugar cane plantations in the Caribbean, all countries were basically economically equivalent. Since then, the deployment of scientific approaches to better understand the trial and error and artisan derived technologies has engendered an explosion of exponential economic growth. Today, it can be confidently concluded that over the last 130 years, some 85 per cent of this exponential growth was due to technological progress (Press, 2013). This led to the notion that scientific and technological knowledge is power, but this is not entirely true, rather it is the proper use of knowledge that is the real power. Another fallacy is that education will transform laggard countries into prosperous ones. There is some truth in this adage, but it is not education, nor, for that matter, investments in health or security, that make the real difference (Salam, 1989). It is the application of relevant information and knowledge that accompanies research and experimental development, that makes a country rich or poor. It is the levels of scientific information that a country applies to education, decision making, production and environmental protection, which makes the difference.

The vital role of scientific and technological (S&T) knowledge in human development is evident in the scrutiny of civilisations, which flourished when they embraced technological creativity and explored science, and their decline when they abandoned these cultural norms. Examples of these are seen in Islam in the ninth to twelfth centuries, when for religious reasons, they retreated from science. The same fate befell the Chinese when they decided to isolate themselves from the rest of the world during their communist revolution. However, when they rebuilt their S&T capabilities some 50 years ago, they quickly became the fastest growing nation in the world. Similarly, after the Vietnam war the United States government chastised the major research universities for their anti-war stance by reducing research funds and the country was promptly overtaken in competitive trade by the Japanese who had been given access to new technologies to rebuild after the second World War.

Another observation which confirms the centrality of S&T to growth and development is the case of oil rich states. They became wealthy from selling fossil fuels from their monopolistic positions. Those that used their riches to invest in S&T were able to withstand the drastic fall in commodity prices, while others had a dramatic decline in economic fortunes. The government of Norway, with a large oil fund provided between 46.4 to 44.7 per cent of research and development (R&D) annual expenditure during 2009 to 2015. It is important to note that in tandem with the high level of priority placed on publicly funded R&D the private sector provided approximately 42 per cent to the national spend. (Research Council of Norway, 2017). Saudi Arabia, under the auspices of the King Abdulaziz City for Science and Technology (KACST), established in 1977, plays the major role in science, technology and innovation development by coordinating policy and research activities. The priority areas of research point to the development of other sectors to oil (KACST, 2016). These two examples clearly show that complacent thinking that dependence on natural resources will maintain levels of economic progress is being replaced by comprehensive efforts to embrace transformative new and emerging realities that investment in S&T provides. There is no doubt that a country, or region, that remains in scientific backwardness, will be unable to satisfy their socio-economic needs in a scientifically led and competitive world.

The factors that enable the emergence of advanced economies are briefly summarised in Table 2: Factors leading to Advanced Economies. Important to the activation and integration of these factors are the underpinning confidence and commitment to make consistent investments in developing and using scientific and technological

capacity to solve domestic problems, enhance decision-making and integrate into the global community. In the two centuries following the rise and use of science as the principal means of boosting production, a new era was considered to have arrived - the scientific revolution. A prominent feature of this revolution was the observation that speculative thought and scientific reasoning dominated the economic scene of advanced economies. Governments of these countries made generous investments in their science and technology infrastructures in research and in education and training. As the pivotal role of S&T became manifest, the private sector took over the position of chief investor in research and related activities. As the market became more sophisticated, the private sector saw fit to produce their own transforming scientific and technological information for innovative and commercial purposes. These developments intensified the concept of a knowledge economy, characterised by the features outlined in Table 3: Main Features of a Knowledge Economy (Lee and Lim, 2001).

Table 2: Factors leading to Advanced Economies

- The rise of scientific technologies
- Consistent investments in science and technology
- Education of skilled workers
- Creation of implementing infrastructures
- Private sector involvement in innovation and commercialisation
- Policy, Planning and Implementation
- Monitoring, Evaluation and Adjustment
- Supportive services, standards, legal and industrial property
- Research and application of new technologies

Table 3: Main Features of a Knowledge Economy

- Incentives for creation, dissemination and use of information
- A population able to create and use domestic knowledge – new technologies and innovations
- Capability to use global knowledge to create products and services
- Infrastructures to facilitate effective communication, the spread, processing and use of information
- Capacity to formulate vision of trust, self-confidence and values of S&T for development
- Networking, sharing and learning

It was reasoned that countries should have a modicum of S&T capacity to satisfy as much of their needs as possible, while enabling them to benefit from the collective goods of global S&T knowledge systems. The old notion that land, labour, financial capital and education were the major factors of production were considered dated, in the face of the reality that technological progress was contributing the bulk of modern economic and human development. With this shift, came the notion that each nation should play a role in the emerging knowledge economy to catch up and prosper. The technology movement is intimately related to human and intellectual capital, capable of positive feedbacks and enabling virtuous cycles of exponential growth. Technological progress is not linear but is most impressive when it starts with basic research, which though debatable, has returns on investment of about 20 to 60 per cent (Press, 2013). Basic research is not appropriable, in that its returns are not exclusive to its creator, nevertheless it possesses heavy-tailed distribution characteristics which can bestow extraordinary gains to anyone capable of exploiting its economic potential making its impact difficult to quantify. Economists struggle to confidently measure the costs and benefits of research (Macilwain, 2010). Nonetheless, stable investment in S&T, over time, is clearly a strong predictor of success in the extant economic arena. How economically struggling S&T insensitive countries can cope with these realities is what is being explored in this paper.

2.2 Elements of Functioning Scientific and Technological Knowledge Infrastructures

Scientific approaches to technological development and use in the 18th century quickly transformed the efficiency and efficacy of technologies that emerged during the pre-scientific era. These techniques became better understood, were made more flexible, easier to manipulate and energy and cost advantageous. This led to universities placing emphasis on the development of science, technology and engineering in sectors of immediate importance, such as agriculture and manufacturing. In tandem with this, were education and training, to provide qualified workers and

relevant information needed to expand production and increase productivity. The times between scientific discoveries and the products they spawned, were also steadily decreasing.

Alongside these advancements, efficient and vibrant business environments grew, equipped with commercial, legal and financial institutions to exploit and support them (Lee and Lim, 2001). The benefits of basic and applied research were justified with discoveries, such as penicillin and other antibiotics saving thousands of lives. Similarly, the fundamental discoveries of atomic structures and quantum mechanics led to modern electronics, the computer and the internet. The ensuing spread of digital techniques and telecommunication systems, caused the time lapse between basic scientific discoveries and commercialisation, to be further and progressively reduced, and sites of action to be multiplied taking on a more global spread, as were the lessening of the amounts of materials and energy involved in manufacturing and services in many fields and industrial sectors (UNCTAD, 2018).

Today we are witnessing the incorporation of robotics, artificial intelligence, machine learning, the Internet of Things (IoT) and 3D printing into a range of research, commercial and social activities. With these and sometimes because of them, other scientific technologies such as genetic, material, nanotechnologies and alternate energy methods, have emerged with novel and profound effects. Hybrids of these technologies became possible, making operations more efficient, less wasteful, faster, cheaper and safer (UNCTAD, 2018). These advancements are commonly accepted to have ushered in a new era - the fourth industrial revolution, which is anticipated to be decisively more disruptive in commerce, jobs and occupations, and significantly alter the relationship between humans and machines.

Those who are ignorant of, or have decided to ignore, these disruptive activities and have not revamped their production and social systems to accommodate them, are left with anachronistic capabilities and will find it very difficult to compete and consequently are losing mainstay businesses, industries and exports. Their economies have steadily contracted, jobs are being lost, and there are dwindling hopes for students graduating each year to be gainfully employed. The situation is destined to get worse, as technologies such as artificial intelligence, machine learning and robotics, are now capable of doing many of the physical things and labour intensive jobs that were otherwise the purview of experts and professionals in the mass data, medical, engineering and manufacturing fields.
As direct consequences of these scientifically propelled technologies and executing infrastructures, features of which are summarised in Table 4: Physical and Institutional Infrastructures in Advanced Economies, the competitive positions of the developed countries continue to strengthen and the gap between them and the developing countries continue to widen. The contrast is especially stark against those that have not attempted to integrate into the rapidly expanding and diverse global technological arrangements.

Table 4: Physical and Institutional Infrastructures in Advanced Economies

- Technology support institutions
- R&D, scale-up, pilot plants and testing institutions
- Technology and market information
- Metrology, Standards and Quality Control
- Transport and telecommunications
- Financial services and venture capital
- Legal and patent systems
- Export and security

Some of the developing countries that have embraced these scientific and technological developments have improved their economies over the last five decades and are now known as rapid growth developing countries; well-known examples are South Korea and Singapore. Singapore is of special importance as it is an island of small population size (5.7 million) and mixed ethnicities, similar to Caribbean countries, and was as underdeveloped as the Caribbean was in the 1960s. By steadfastly investing up to two per cent of its Gross National Product (GNP) in research and development, Singapore has spawned a national budget 130 times that of Jamaica's and has been able to occasion a national R&D budget comparable to that of Jamaica's total national budget (Yap, 2016). Imaginative and relevant research, innovations, constant upgrading of goods and services, growing exports and collaboration with the best in research and experimental development, have become hallmarks of Singapore's economy.

Countries that are today considered prosperous have, on average, invested one to three per cent of their (GNP) in R&D and over six per cent in S&T and education (Yap, 2016). Whilst the management and execution of national S&T projects are guided by policies and plans directed by the highest political office, their S&T strength and impacts are regularly monitored and adjusted to ensure they maintain their competitiveness. This is in sharp

contrast to what obtains in some emerging and underdeveloped societies such as those of the Caribbean (Ventura, 2015). To elevate their status and maintain societies built on sustainable principles, Caribbean countries will have to, at least, promote and incorporate the key strategic building blocks set out in Table 5: Acquiring a Knowledge Base in Developing Countries for Success, into their national development plans.

They must forge economies that provide incentives for the efficient creation, dissemination and use of scientific and technological knowledge to promote growth and increase social welfare. Countries that have focused solely on the economic indicators of development have increasingly come to the realisation that social and environmental factors need to be explicitly identified and included as integral measures of economic success. Effective use of scientific information will crucially depend on putting in place and actively deploying implementing mechanisms, elements of which are outlined in Table 6: Elements of Implementation.

Table 5: Acquiring a Knowledge Base in Developing Countries for Success

• Shifts from commodities and simple manufacturing to knowledge intensive goods
• Work with leaders in innovation, investors and S&T specialists
• Obtain proprietary technological information – licenses and technological transfers
• Attract and keep talented workers
• Promote R&D to respond to markets and social needs
• Open to trade in high technology goods and services
• Pursue technical information from buyers and suppliers
• Protect intellectual property

Table 6: Elements of Implementation

• Specialised manpower – researchers and implementers
• Identified responsibilities and timing – officer or group
• Sufficient funding
• Active network and clearing house of knowledge (information)
• Mining of relevant S&T data
• Monitoring and evaluation – ways and milestones
• Private sector – early involvement
• Standards and services
• Networking – S&T bodies and academies
• Social inclusion

Most of these elements are lacking in the Caribbean and talk is not backed up by actions. The distinction between researchers and implementers have to be made as they ideally possess different mindsets, timelines and expectations. Research should be less directly associated with experimental development, contrary to what obtains in the Caribbean (Ventura, 2014).

3. Specific Situations in the Caribbean

3.1 Historical and Current Conditions

As colonies of Europe, Caribbean islands developed an unworkable S&T situation based on their dependency for socio-economic development, and to this day they have lagged behind their former masters in the development and deployment of technologies that are of specific importance to their wellbeing. Methods for technological advancement that were transferred were specifically designed for the reaping and exploitation of raw materials for export to the colonial rulers. After colonialism, the ex-colonies were afforded tertiary institutions with science faculties, largely to provide the basic requirements for the education of health and other social service professionals. Subsequently, technological upgrading was achieved by adopting the techniques and thinking of the developed world without introspection and reference to the unique circumstances of the region. Essentially, Caribbean leaders seem quite comfortable in continuing to target low level jobs for socio-economic growth.

Historically science and its technologies were not seen as tools specifically for domestic production or social enhancement. Some of these imperatives are now being addressed, but without adequate S&T infrastructure to ensure implementation of scientific findings and transfer of technologies. Issues of urgency are often directed to foreign consultants without the results being assigned to institutional memory; often to be raised and tackled in the

same fashion years later. Many leaders, managers and technicians are graduates of the region's universities, but few have a clear understanding of, or commitment to, the vital role they should play in research and the knowledge required for sustainable development in their communities. This is graphically displayed when some of them take up roles in political leadership; there is much optimistic rhetoric but few meaningful actions. As outlined in Table 7: Critical Science and Technology Shortfalls in the Caribbean, the weaknesses and gaps in the S&T arena are wide ranging but are unevenly evidenced among the islands. The larger islands, Cuba and Jamaica in particular, have some science and technology infrastructure with Cuba having placed major emphasis on the development of a national scientific capability, starting in 1959, built around an emphasis on science and education and in the early 1980s embarking on developing biotechnology and genetic engineering programmes (Ellis, 1995).

Table 7: Critical Science and Technology Shortfalls in the Caribbean

Weakness or insufficiency in:
o Embracing S&T for socio-economic development
o Investments in S&T by public and private sectors
o Small in absolute and per capita numbers of workers
o Relevant research results and information
o Implementing strategies and bodies
o Policy, planning and implementation
o Coordination and integration of relevant units at national and regional levels
o Networking and sharing
o Monitoring, evaluation and adjustments

There is no comprehensive overall policy or plan for S&T and no sector plans to use these instruments to increase the quality or quantity of raw materials, semi and finished goods and services. Capital goods facilities are limited, and pilot plants are few, or totally absent in many sectors. Funds from commercial and development banks for technologically led or innovative projects are often unavailable, as they are instinctively risk averse. The tendency is to rely on outside financing for projects that are deemed essential for local development or presumed necessary for survival. The result is an underutilisation of talent and a constant drain of S&T graduates in the region (Ventura and Wint, 2016). There is evidence of some science being practiced, but little use is being made of local or foreign scientific results. A critical gap that constrains the use of new discoveries is the absence of coordinated communication channels that make the information visible and accessible to the public.

A restricting factor is the lack of information about shared problems, range and shortage of skills and capabilities of institutions in neighbouring islands, which acts as a break on integration, cooperation and divisions of labour. Essentially, Caribbean islands possess all of the problems seen in other developing countries as well as those that are peculiar to them as small island states, the most problematic of which is the inability to properly design and implement regional S&T led policies and projects.

3.2 Current Hindrances and Required Responses

Jamaica will be used as a proxy for the best case scenario in the English speaking Caribbean. It is the largest of the fourteen English speaking islands and shares many of the social and political features that are found across the region. Cuba and Hispaniola, although similar in particular ways, will not be emphasised in this discourse. Small size in the Anglophone islands is a significant constraint to building adequate domestic capabilities and capacities to follow and harness emerging global scientific insights. Jamaica has just under three million inhabitants and a land space of approximately 11,000 square kilometres. While the numbers of scientific workers are measured in the hundreds in the Caribbean region, many of the top pharmaceutical companies alone estimate their S&T staff to be in the thousands. The question therefore is, can the Caribbean really mount a functional and effective S&T capability? From what has been reviewed realistically the answer is - it must.

Currently, there are few ways to earn desperately needed foreign currency to satisfy domestic demands. The main options exercised rely on natural beauty to attract visitors, declining agricultural exports and remittances from nationals working overseas. However, these are insufficient to fill the growing ambitions of Caribbean citizens. The consequence is, a small privileged class living above its means, precipitating large national debts and a region with one of the largest income inequalities and declining quality of life in the world (Hoffman and Centeno, 2003). This is in contrast to Singapore, with a small population like Jamaica, being able to build a competitive knowledge economy and become prosperous, despite its small size. What is different in the two cases is the political will,

astuteness and fortitude of leadership to craft creative ways to use S&T. What is true of Singapore is also mirrored in Scandinavia and New Zealand, among others. Small size is clearly not an insurmountable deterrent to acquiring notable technological prowess leading to economic success and social wellbeing.

To make the transition to S&T proficiency, these countries started an uncompromising drive by their political leaders to establish infrastructures and skills to capture and deploy global scientific and technological knowledge for local purposes. In the case of the Caribbean, the political establishment is stocked with lawyers and businessmen, with little understanding and responsiveness to the power of sciences and its technologies. As a consequence, there is a palpable lack of urgency and confidence to make the required long-term investments in scientific knowledge. Because of this reality, the pressing job of creating a culture of science, investigation, creative thinking and innovation falls squarely on the scientific communities. They have to unequivocally demonstrate to the current leaders and civil society that science works and that investments in its technologies are critical and mandatory. To discount the value of S&T to Caribbean survival, is reckless and short sighted. It is clear that political immodesty and glib rhetoric are no substitutes for S&T proficiency and application of knowledge to addressing the challenges constraining regional well-being.

Eventualities such as changing climatic conditions, falling productivity and stagnant economic growth and deteriorating social stability, compel some measure of domestic research to sufficiently understand these phenomena and proffer solutions to prevent or curtail them. It is clear that individual islands can do much better to help themselves with considered regional S&T integration through divisions of labour. With respect to small land size, is the relatively large marine jurisdictions of the islands. The possibilities inherent in this reality are not yet fully explored, but global attention is turning to developing another companion to the fourth industrial revolution – the Blue Economy. To participate fully in this new horizon, once again, requires concerted research and development efforts. Working closely with the larger islands of Cuba and Hispaniola will expand options and trade. The special case of Haiti presents opportunities for S&T collaboration to address extreme poverty, hunger and environmental degradation.

There is a fetish to interpret technology to mean Information and Communication Technologies (ICTs) only, to the almost total exclusion of other technologies and that innovation and knowledge can only come from investment in these technologies. It has to be accepted that computers and their paraphernalia are enabling components of an S&T infrastructure in the Caribbean and are not the end result. The universities are in some ways complicit with this terminological inexactitude. To increase student numbers, much is made of ICTs, while downplaying the less physically tangible and lesser known technologies such as biotechnologies, genomics and agricultural processing technologies. It is the development of capabilities in some of these arenas that will provide the catalyst to future development.

In the Caribbean context, ICTs are largely enablers, and not foundational production instruments; there is often little to enable. Biotechnologies, for example, which are at the pivot of more efficient agricultural practices, are not given pride of place in domestic development, management or teaching and training, because they are not fashionable and less attractive to students. The benefits that ICTs can bring, inter alia, to food security, nutrition, forest cover, water management and health, are not been fully realised. A manifestation of this is that subsistence farming is still widespread, and there is still inordinate reliance on rain fed agriculture. While the tendency to exaggerate the role of ICTs is quite prevalent, these technologies still are viewed at a pedestrian level such as office management and Business Processing Outsourcing (BPO) services. For example, ICT advances, such as big data and machine learning to head off the impending gridlock and pollution on domestic roads, develop personalised medicine and enhance efficiencies in production systems, are still only abstract concepts to many. Although computers offer many benefits, they cannot provide products and services such as food and medical supplies, which are major components of the region's import bills. The technologies and accompanying skills that enhance local productivity in various fields and, which are dependent on the presence and utilisation of ICTs to be improved, deserve and require prominence in the discussions about creating knowledge and knowledge acquisition systems.

4. The Answer

From what has been reviewed, it can confidently be said that developed countries gained this status through long term investments in scientific and technological progress, which pursued both basic and applied research and engineering within a national framework that promoted science education, investment in inventions and innovation and built collaborative networks. Underdeveloped countries that substantially improved their economies and quality of life, did so by building capabilities and capacities to develop their S&T systems to harness, for their particular development, relevant global knowledge. This, they did in a matter of a few decades, whether they were big or small, resource endowed or not, or democratically or autocratically led. Countries that have unwittingly neglected,

or chose to ignore, S&T for development, are the ones that are struggling to grow and prosper with mounting social and environmental pressures. The speaking of English, the so called scientific language and the world's *lingua franca*, along with relatively modern electronic infrastructure in the Caribbean, makes it easier than most laggard countries to tap into the global knowledge system.

The answer to the question, whether the Caribbean can prosper without making purposeful investments in the knowledge industry, is they cannot. The more relevant question therefore is, can they make the necessary commitments and investments? The answer is they must, but this will rely on a drastic change in political vision and leadership, aided by the informed support and inputs of businesses and civil society. Building a functional S&T infrastructure initially will depend on targeted government investments in science, education, training and research, along with establishing the necessary policy and legislative framework. The active use of scientific insights, and results in economic endeavours will eventually have to become the prerogative of the private sector at all levels, both in the formal and informal sectors. A key part of this endeavour is to encourage all sectors of society to embrace and participate in the development of national S&T frameworks.

Realistically, the Caribbean cannot cover all aspects of the vast domain of S&T and should, as a priority, concentrate on key areas of immediate relevance; agriculture, marine and coastal resources exploration, health, and environmental protection and hazard mitigation and prevention. Whatever is decided, to be effective, the programme must be done on a regional basis to enable the smallest countries to enjoy some of the benefits that they cannot generate individually. This is not an insurmountable feat, if the will is exercised through a collective effort. There are a number of universities and institutions and successful instances of regional integration, to lead the way. CARICOM has to become more involved in strengthening regional and domestic S&T systems for this to happen.

CARICOM must become more active in the S&T imperative and take the lead in supporting the present Science, Technology and Innovation Committee (CSTIC) set up to expedite integrating strategies. It is obvious that CARICOM, as a forum of Governments, cannot move much beyond the lack of insight and savvy of each country that makes up the Community. Astute Caribbean leadership at the administrative level is therefore urgently required. With commitment to S&T development and building relevant R&D capacity, the Caribbean can become a locus of expertise for the sustainable care and commercial exploitation of tropical seas as well as a region committed to poverty reduction. The seeds of these are already present in the local universities and research centres. Commitment from Caribbean leaders to support and implement a regional S&T development strategy to benefit all members will not only be timely; it is absolutely necessary.

Finally, the inevitable dislocating effects of the technologies of the fourth industrial revolution on the Caribbean must be examined and the region's institutions need to grasp the potential adverse impacts on economic growth and wellbeing. Plans of action to craft effective responses to manage the disruptive effects and modify, replace or add to the repertoire of technologies needed to improve economies, social well-being and the environment, are critical to the development of the region.

5. Conclusion

The fact that no country in the modern era has been able to satisfactorily meet the socio economic needs of its population without adequate investments in science and its technologies, makes it quite unlikely that the Caribbean can accomplish such a task. If this is so, can the small Caribbean islands actually build successful S&T skills and infrastructures as outlined in this paper to respond to the imperatives of the market and their populations. Although the individual islands cannot acquire many of the features of a functioning S&T system, together they can, with political commitment, astute management, thoughtful policies and implementation plans and collaborative programmes and projects. These will definitely be made more probable by bringing Cuba, the Dominican Republic and the other territories that are up to now not included in many of the region's integrative initiatives. To have inclusive growth, the Caribbean has to chart its own course in building more balanced and ethical economies. This means more domestic research and innovation as well as more assertive use of the global knowledge economy. From what has been described it is clear that socio-economic prosperity will depend on regional decision making, management and anticipation, to inspire and enable domestic knowledge workers to solve day to day site specific problems at all levels of society.

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Authors' Biographical Notes:

Arnoldo K. Ventura *is a Board member of CASJ and the CARICOM Science Technology and Innovation Committee (CSTIC). He is a virologist and was former Science and Technology Advisor to Prime Ministers of Jamaica. He is a student of the effects of science and technology on socio-economic development.,*

Sandra M.E. Wint *is a science and technology specialist interested in building capacity for sustainable development with emphasis on SIDS. She is an aquaculturist and was the first executive director of the National Commission on Science and Technology of Jamaica.*

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Lightsources for Africa, the Americas, Asia and Middle East Project (LAAAMP): An IUPAP and IUCr ICSU-Funded Project

Sekazi K. Mtingwa

138 W. Hatterleigh Avenue, Hillsborough, NC 27278, USA; Email: sekazi.mtingwa@gmail.com

Abstract: *We describe a new initiative funded by a 3-year, 300K-Euro grant from the International Council for Science (ICSU) to the International Union of Pure and Applied Physics (IUPAP) and International Union of Crystallography (IUCr) in collaboration with over thirty partner organisations that include sixteen advanced light sources to enhance the utilisation of advanced light sources and crystallography in five targeted regions of the world, namely Africa, the Caribbean, Mexico, Southeast Asia, and Middle East. LAAAMP's programmes include the development of a Strategic Plan for each region; a Colloquium program that sends experienced light source and crystallography users to those regions; establishment of new IUCr-UNESCO Crystallography OpenLabs; design and distribution of a Brochure that describes advanced light sources and crystallography for government officials and the public; 2-month Faculty-Student (FAST) Team training visits to advanced light sources, with approximately forty new users participating in 2018; and culminating in a December 2019 meeting to chart a path forward beyond the ICSU grant.*

Keywords*: Synchrotron; light source; free-electron laser; crystallography; protein structure; palaeontology*

1. Introduction

Many countries are racing to build ever brighter sources of X-rays for a myriad of applications, especially large devices called advanced light sources (AdLSs), based upon either electron synchrotrons or free-electron lasers (FEL). In particular, in the Middle East, researchers commissioned a new AdLS in 2017 called Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME), which is located in Allan, Jordan, 30 km northwest of Amman. There is only one AdLS in Latin America, and it is located at the Brazilian Synchrotron Light Laboratory, where the new fourth generation synchrotron AdLS called Sirius is replacing the older second generation synchrotron light source, UVX.

Africa is the only habitable continent in the world that does not have an AdLS. Hence, there is an initiative underway called the African Light Source (AfLS), which has the mission to bring an AdLS to the African continent in the not-too-distant future. To start this effort, an international conference convened at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France during November 2015 that brought together African researchers and students, representatives from international AdLSs, government policymakers, industrial representatives, and others who support the vision of an African Light Source. Participants adopted a set of resolutions called the *Grenoble Resolutions* that provide the *Why?* for the construction of an AfLS. They are as follows:

1. *Advanced light sources are the most transformative scientific instruments similar to the invention of conventional lasers and computers.*
2. *Advanced light sources are revolutionising a myriad of fundamental and applied sciences, including agriculture, biology, biomedicine, chemistry, climate and environmental eco-systems science, cultural heritage studies, energy, engineering, geology, materials science, nanotechnology, palaeontology, pharmaceutical discoveries, and physics, with an accompanying impact on sustainable industry.*
3. *The community of researchers around the world are striving collaboratively to construct ever more intense sources of electromagnetic radiation, specifically derived from synchrotron light sources and X-ray free-electron lasers (XFELs), to address the most challenging questions in living and condensed matter sciences.*
4. *The African Light Source is expected to contribute significantly to the African Science Renaissance, the return of the African Science Diaspora, the enhancement of University Education, the training of a new generation of young researchers, the growth of competitive African industries, and the advancement of research that addresses issues, challenges and concerns relevant to Africa.*
5. *For African countries to take control of their destinies and become major players in the international community, it is inevitable that a light source must begin construction somewhere on the African continent in the near future, which will promote peace and collaborations among African nations and the wider global community.*

In addition to adopting the Grenoble Resolutions, participants and other colleagues also elected an African

Light Source Steering Committee, chaired by Simon Connell of the University of Johannesburg in South Africa, and a Roadmap to provide guidance in the short-, medium- and long-term future, culminating in the construction of an AfLS.

Subsequently, the International Union of Pure and Applied Physics (IUPAP) and the International Union of Crystallography (IUCr) partnered with 32 other scientific organisations, including 16 AdLSs, and applied for a 300,000 Euro grant from the International Council for Science (ICSU) as part of ICSU's *2016-2019 Grants Programme*. Fortunately, the proposal was successful and a new initiative was born called *Lightsources for Africa, the Americas and Middle East Project (LAAMP)*. The goal of *LAAMP* is to enhance AdLS science and crystallography in Africa, the Caribbean, Mexico, and Middle East. After operating for a year, *LAAMP* expanded its targeted regions to include Southeast Asia, and therefore changed its name to *Lightsources for Africa, the Americas, Asia and Middle East Project (LAAAMP)*. The list of *LAAAMP* collaborative organisations and AdLS partners is found in Appendices I and II, respectively.

2. LAAAMP Objectives

The objectives of *LAAAMP* are the following:

1. Develop a ***Strategic Plan*** for each region to grow and enhance its AdLS and crystallography user communities.
2. Establish a ***Colloquium Programme*** for each region to recruit new AdLS and crystallography users and to advertise *LAAAMP* projects via invited talks at targeted venues. Also, launch a series of new ***IUCr-UNESCO OpenLabs***, which is a network of operational crystallography laboratories in developing countries aimed at increasing the access to, and utilisation of, crystallography in all regions of the world.
3. Publish an ***Informational Brochure*** that describes AdLSs, crystallography, and the many fields that they impact.
4. Facilitate **Researchers' Training Visits** to AdLS and crystallography facilities.
5. Convene a **Meeting at UNESCO** to present the regions' *Strategic Plans* and define the charge for more detailed *Business Plans* that include feasibility studies of constructing AdLSs in regions where they do not yet exist.

To achieve these objectives, *LAAAMP* is partnering with sixteen international organisations and sixteen international AdLSs, which are listed in Appendices I and II, respectively.

3. Project Administration

The Executive Committee leads the management of *LAAAMP* and consists of Sekazi Mtingwa (Chair); Sandro Scandolo, Head of Scientific Programmes & Outreach at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy; and Michele Zema, Executive Outreach Officer for the IUCr. Maitri Bobba, who is the IUPAP Secretary in its Headquarters at the Nanyang Technological University in Singapore, manages the budget. Each region has an AdLS Usage and Strategic Plan Committee shown in Appendix III and whose responsible is to carry out local tasks and develop a Strategic Plan to enhance AdLS and crystallography utlisation in the region. Finally, there is a Steering Committee contained in Appendix IV that provides important input as to overall operation of the project.

4. Current Status

Objective 1:
Lawrence Norris in the USA has developed a survey of AdLS usage and local instrumentation availability and usage, and Michele Zema has implemented it on the *LAAAMP* Website. Researchers throughout the regions are encouraged to respond to the survey so that each regional Usage & Strategic Plan Committee can develop a database leading to a Strategic Plan to guide regional activities forward.

Objective 2:
An example of this objective is the recent visit by Thierry d'Almeida, who is Senior Research Engineer at Commissariat à l'Energie Atomique (CEA) in France, to his home country of Benin during May 2018 to give university lectures on synchrotron radiation and crystallography and their many applications in biochemistry, agriculture, and materials science. That visit led to a subsequent two-week visit back to Benin, where he was able to meet with President Patrice Talon, his Cabinet Ministers and numerous other dignitaries to discuss both *LAAAMP* and the newly proposed crystallography lab and training program called X-Ray Techniques for Sustainable Development (XTech-SD), which will offer crystallography training to approximately 100 students per year, with many coming from neighboring countries, such as Nigeria, Togo, Burkina Faso, and Niger. President Talon has

pledged to provide substantial support to this initiative, which will involve the purchase of a series of state-of-the-art single crystal and powder diffractometers. To strengthen his efforts, d'Almeida formed a working relationship with Benin's Jean-Pierre Ezin, former Commissioner for Human Resources, Science and Technology for the African Union. Ezin is a member of the AdLS Usage and Strategic Plan Committee for Africa.

In another activity, Prosper Ngabonziza, an AdLS user who is employed at the Max-Planck-Institute for Solid State Research in Germany, visited his hometown of Kigali, Rwanda during December 2017. He gave Colloquium presentations at the African Institute for Mathematical Sciences (AIMS-Rwanda) and at the Abdus Salam ICTP-affiliated East African Institute for Fundamental Research, which is located in the College of Science and Technology (CST) at the University of Rwanda (UR). In addition to interacting with many students who expressed excitement about the *LAAAMP* initiative, Ngabonziza met with a number of top university and governmental officials, including UR's Deputy Vice-Chancellor for Academic Affairs and Research, the Principal of its CST, and the Director-General for Science, Technology and Research in the Rwandan Ministry of Education.

Michele Zema led the establishment of the first *LAAAMP* OpenLab in San José, Costa Rica during 4-9 December 2017, with approximately 80 students in attendance. During a Colloquium on the first day, Diego G. Lamas from Universidad Nacional del Comahue in Argentina lectured on the topic, *Técnicas de luz sincrotrón para caracterización avanzada de materiales*. Among those attending the Colloquium and providing welcomes were the Director of Scientific and Technological Development of Costa Rica's Ministry of Science and Technology; the Director of the Natural Science sector from UNESCO's Office for Costa Rica, El Salvador, Honduras, Nicaragua and Panama; the President of the National Research Council; and top officials from local universities and other academic institutions. Starting on the second day, the students from a number of countries in Central America and elsewhere split into two groups to take two courses, one on single crystal diffraction and the other on powder diffraction.

Objective 3:
There have been two printings of a 24-page *LAAAMP* Brochure entitled, *Advanced Light Sources and Crystallography: Tools of Discovery and Innovation*. The Editor is Ernie Malamud, who is currently living in Paris and who is a retired professor and researcher from Fermi National Accelerator Laboratory and the University of Nevada-Reno in the USA. He has extensive experience producing high quality publications, including one for the American Physical Society entitled, *Accelerators and Beams, Tools of Discovery and Innovation*, which is currently in its 4th Edition. There has now been a second printing of the *LAAAMP* Brochure in English, Spanish and French, with the translations for the latter two versions being donated by the International Atomic Energy Agency.

Objective 4:
LAAAMP annually issues a *Call for Applications* for FAculty-STudent (FAST) teams, consisting of one faculty and one graduate student to spend two months at participating AdLSs. To be eligible, applicants must have less than a year's experience in conducting research at AdLSs. For 2017, *LAAAMP* funded seven teams, namely 14 individual grants of approximately 2,000 Euros each, mainly for airline travel expenses, which were arranged through ICTP. The host AdLSs provided all lodging and meal expenses not covered by the *LAAAMP* grant. For 2018, *LAAAMP* funded 18 FAST Teams from Botswana, Cyprus, Egypt, Kenya, Mexico, Senegal, South Africa, Thailand, Trinidad and Tobago, and Uganda to visit the following AdLSs: ALBA (Spain) Canadian Light Source, Delta (Germany), Elettra (Italy), European Synchrotron Radiation Facility (France), National Synchrotron Light Source-II (USA), Siam Photon Source (Thailand), National Synchrotron Radiation Research Center (Taiwan), and Stanford Synchrotron Radiation Lightsource (USA).

Objective 5:
Discussions have begun with UNESCO to convene a meeting in December 2019 at UNESCO Headquarters in Paris consisting of the *LAAAMP* participants; Ministers of Science, Technology, Health, Education, Energy and Natural Resources; representatives from each region's research community; and other international stakeholders and interested parties. The purpose of the meeting will be to present the *Strategic Plan* for each region; set the charge for more detailed *Business Plans* with short-, medium- and long-term goals, including the charge to ascertain the feasibility of constructing an AdLS in each region that does not have one; and finalize a *Roadmap* for driving the *Business Plan* forward.

5. Conclusion
To assess its progress, *LAAAMP* convened a Midterm Workshop at ICTP in conjunction with the Annual Meeting of the IUPAP C13 Commission on Physics for Development. There were reports on the current status and future plans

of Elettra (Italy), SESAME (Jordan), and the Siam Photon Source (Thailand). Also, there were reports on the African and Mexican Light Source initiatives. Much as been accomplished, but clearly there is much more work to be done.

Appendix I:
LAAAMP COLLABORATIVE ORGANISATIONS

LEAD INSTITUTIONS:

INTERNATIONAL UNION OF PURE AND APPLIED PHYSICS (IUPAP)
Contact: Bruce McKellar, Past President

INTERNATIONAL UNION OF CRYSTALLOGRAPHY (IUCr)
Contact: Sven Lidin, President

OTHER COLLABORATIVE ORGANISATIONS:

AFRICAN LIGHT SOURCE (AFLS) STEERING COMMITTEE
Contact: Simon H. Connell, Chair

ASSOCIATION OF ASIA PACIFIC PHYSICAL SOCIETIES (AAPPS)
Contact: Seunghwan Kim, President

CUBAN LIGHT SOURCE INITIATIVE
Contact: Fidel Antonio Castro Smirnov, Advisor to the President of the University of Informatics Sciences, Havana

EUROPEAN PHYSICAL SOCIETY
Contact: Christophe Rossel, President

ICSU REGIONAL OFFICE FOR AFRICA
Contact: Daniel Nyanganyura, Acting Director

ICSU REGIONAL OFFICE FOR LATIN AMERICA & THE CARIBBEAN
Contact: Manuel Limonta, Director

INTERDISCIPLINARY CONSORTIUM FOR RESEARCH AND EDUCATIONAL ACCESS IN SCIENCE & ENGINEERING (INCREASE)
Contact: Eric Sheppard, Chair of Executive Committee

ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS (ICTP)
Contact: Sandro Scandolo, Head, Scientific Programmes and Outreach

INTERNATIONAL UNION OF MATERIALS RESEARCH SOCIETIES (IUMRS)
Contact: B.V.R. Chowdari

LABORATORY FOR PHYSICS AND APPLICATIONS OF HIGH BRIGHTNESS BEAMS
Contact: James Rosenzweig

LIGHTSOURCES.ORG
Contact: Andrea Lausi, Chair (Elettra)

PUERTO RICAN LIGHT SOURCE INITIATIVE
Contact: Carlos Cabrera, Chair

SOCIEDAD MEXICANA DE FÍSICA
Contact: Dario Nuñez, President

UNESCO - DIVISION OF SCIENCE POLICY AND CAPACITY BUILDING
Contact: Martiale Zebaze Kana

TRIANGLE SCIENCE, EDUCATION & ECONOMIC DEVELOPMENT (TRISEED CONSULTANTS), LLC
Contact: W. Estella Johnson, Managing Principal Partner

TWAS
Contact: Romain Murenzi, Director

Appendix II:
LAAAMP ADVANCED LIGHT SOURCE PARTNERS

ADVANCED LIGHT SOURCE (ALS), LAWRENCE BERKELEY NATIONAL LABORATORY (LBNL)
Contact: Stephen Kevan, Interim Director

ADVANCED PHOTON SOURCE (APS), ARGONNE NATIONAL LAB
Contact: Dennis Mills, Director

ALBA LIGHT SOURCE
Contact: Miguel Angel Garcia Aranda, Scientific Director

AUSTRALIAN SYNCHROTRON, AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION (ANSTO)
Contact: Michael James, Head of Science

CANADIAN LIGHT SOURCE
Contact: Robert Lamb, CEO

DELTA LIGHT SOURCE
Contact: Shaukat Khan, Director

ELETTRA LIGHT SOURCE
Contact: Alfonso Franciosi, President and CEO

EUROPEAN SYNCHROTRON RADIATION FACILITY (ESRF)
Contact: Ed Mitchell, Head of Business Development

MAX-IV LABORATORY
Contact: To be announced

NATIONAL SYNCHROTRON LIGHT SOURCE-II (NSLS-II), BROOKHAVEN NATIONAL LAB (BNL)
Contact: Qun Shen, NSLS-II Deputy Director for Science

PHOTON FACTORY, INSTITUTE OF MATERIALS STRUCTURE SCIENCE (IMSS) OF KEK
Contact: Hitoshi Abe

POHANG ACCELERATOR LABORATORY, SOUTH KOREA
Contact: To be announced

SESAME LIGHT SOURCE
Contact: Giorgio Paolucci, Scientific Director

SIAM PHOTON SOURCE (SPS), SYNCHROTRON LIGHT RESEARCH INSTITUTE (SLRI)
Contact: Pattanaphong Janphuang, Chief of User Office Division

SLAC NATIONAL ACCELERATOR LABORATORY
Contact: Kelly Gaffney, Director (SSRL)

TAIWAN PHOTON SOURCE (TPS), NATIONAL SYNCHROTRON RADIATION RESEARCH CENTER (NSRRC)
Contact: Chia-Hung Hsu, Secretary General and Staff Scientist

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Appendix III:
LAAAMP REGIONAL USAGE & STRATEGIC PLAN COMMITTEES

AFRICA
Simon Connell (*Chair*), University of Johannesburg, South Africa
George Amulele, Macquarie University, Sydney, Australia
Djamel Bradai, University of Sciences and Technology Houari Boumediene, Algeria
Jean-Pierre Ezin, Université d'Abomey-Calabi, Benin
Claude Lecomte, Chair of IUCr "Crystallography in Africa" initiative and University of Lorraine, France
Ernie Malamud, Fermilab, University of Nevada-Reno, USA
Brian Masara, South African Institute of Physics, Zimbabwe
Prosper Ngabonziza, Max Planck Institute, Rwanda
Ahmadou Wagué, University of Cheikh Anta Diop, Senegal

CARIBBEAN
Carlos Cabrera (*Chair*), University of Puerto Rico at Río Piedras
Fidel Antonio Castro Smirnov, Advisor to the President of the University of Informatics Sciences, Cuba

Noel Blackburn, Brookhaven National Laboratory, USA (from Trinidad and Tobago)
Eric Sheppard, Hampton University, USA

MEXICO
Matías Moreno (*Chair*), Universidad Nacional Autónoma de México
Abel Moreno Cárcamo, Coordinator of the Red de Usuarios de Luz Sincrotrón
(RedTULS) and Instituto de Quimica, UNAM
Mayra Cuellar, Universidad de Guanajuato
José Reyes Gasga, President of the Sociedad Mexicana de Cristalografía and Instituto de Física, UNAM
José Ignacio Jiménez, Universidad Nacional Autonoma de México
Tomás Viveros, Universidad Autónoma Metropolitana-Iztapalapa

MIDDLE EAST
Özgül Öztürk (*Chair*), Universität Siegen, Germany
Roy Beck-Barkai, Tel-Aviv University, Israel
Musa Mutlu Can, Istanbul University, Turkey
Ahmed Farghaly, Crystallography Lab., National Research Center, Cairo, Egypt
Jamal Ghabboun, Bethlehem University, Palestine
Kirsi Lorentz, The Cyprus Institute, Nicosia, Cyprus

SOUTHEAST ASIA
Rungrueang Phatthanakun (*Chair*), Head of Research Facility, Synchrotron Light Research Institute (SLRI), Thailand
Nuttawan Pramanpol, Protein Crystallography Beamline Scientist, SLRI, Thailand
Shangjr (Felix) Gwo, Vice President of Asia-Oceania Forum on Synchrotron Radiation Research (AOFSRR) and Director, National
Synchrotron Radiation Research Center (NSRRC), Taiwan
Chia-Hung Hsu, Secretary General and Staff Scientist, NSRRC, Taiwan
Michael James, Head of Science, Australian Synchrotron

Appendix IV:
LAAAMP STEERING COMMITTEE

Hitoshi Abe, Photon Factory, KEK
John Baglin, IBM and International Union of Materials Research Societies
Carlos Cabrera, Puerto Rican Light Source Initiative and University of Puerto Rico-Río Piedras
Simon Connell, African Light Source and University of Johannesburg
Thierry d'Almeida, Commissariat l'Energie Atomique, France
Tabbetha Dobbins, Rowan University, USA
W. Estella Johnson, Managing Principal Partner, TriSEED Consultants, LLC
Diego G. Lamas, President, Latin American Crystallographic Association
Andrea Lausi, ELETTRA and Lightsources.org
Manuel Limonta, Director, ICSU Regional Office for Latin America & Caribbean
Ernie Malamud, Fermilab and University of Nevada-Reno (Retired)
Connie McNeely, Co-Director of George Mason University's Center for Science and Technology Policy
Ed Mitchell, ESRF
Matías Moreno, Mexican Light Source Initiative
Lawrence Norris, African Light Source Interim Steering Committee
Tshepo Ntsoane, South African Nuclear Energy Corporation and African Light Source Interim Steering Committee
Daniel Nyanganyura, Director, ICSU Regional Office for Africa
Özgül Öztürk, Chair of SESAME Users Committee and Universität Siegen, Germany
Giorgio Paolucci, Scientific Director, SESAME
Eric Sheppard, INCREASE and Hampton University
Fidel Antonio Castro Smirnov, Cuban Light Source Initiative and Advisor to the
President of the University of Informatics Sciences, Cuba
Herman Winick, SLAC National Accelerator Laboratory/Stanford University

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Author's Biographical Notes:

Sekazi K. Mtingwa *is Principal Partner at TriSEED Consultants. He retired from the faculties of the Massachusetts Institute of Technology and North Carolina A&T State University and is a Fellow of the American Association for the Advancement of Science, American Physical Society, and National Society of Black Physicists. Dr. Mtingwa shares with Anton Piwinski of DESY (Germany) and James Bjorken of Stanford University (USA) the American Physical Society's 2017 Robert R. Wilson Prize for Achievement in the Physics of Particle Accelerators for developing the theory of intrabeam scattering. He is Co-Founder and serves as Chair of the Executive Committee for LAAAMP.* ■

A Survey of Knowledge Management Practices in Trinidad and Tobago Manufacturing Enterprises: Highlights of Findings

Man Yin Rebecca Yiu[1] and Kit Fai Pun[2]

Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, The University of the West Indies, St Augustine, Trinidad and Tobago, West Indies;

[1]Email: Rebecca.Yiu@sta.uwi.edu
[2]Email: KitFai.Pun@sta.uwi.edu

Abstract: *Knowledge is recognised as a vital resource and source of competitive advantage, and knowledge management (KM) is a key differentiator in today's dynamic and changing business environment. Many leading organisations are shifting their focus from excellence in quality and productivity to excellence in innovation and learning through KM. A recent survey was conducted to acquire the practitioners' views on the identification of common success factors and problematic areas of KM practices, and to explore the KM initiatives in attaining organisational performance goals in Trinidad and Tobago (T&T). This paper reviews the KM process, and discusses the factors and obstacles underpinning the success/problems of KM practices. It then explores the determinants that would affect the KM and performance measures in manufacturing enterprises, drawing upon the findings of the study in T&T. It concludes by underlining the importance of identifying the determinants that KM will be of most value to manufacturing enterprises. Research efforts are needed to examine the effectiveness of KM, and devise an integrated paradigm that could align KM practices to organisational performance measures.*

Keywords*: Knowledge management, determinants, performance, manufacturing, Trinidad and Tobago*

1. Introduction

The foundation of organisational competitiveness in the contemporary economy has shifted from tangible resources to knowledge. Organisations are beginning to recognise the need to tap into knowledge assets diffused around the organisation in order to remain agile (Khatibian et al., 2010; Yiu, et al., 2013). Knowledge has now become a kind of strategic resource in enterprises, and therefore, the management of this strategic resource shows its explicit importance (Ho, 2009). Knowledge management (KM) is thus a strategic management concept drawing from various disciplinary areas (Pillania, 2009) and has emerged as a phenomenon with wide-ranging implications for organisational performance and competitiveness (Yiu, et al., 2013).

There has been an abundance of published research related to KM since the 1990s (Serenko and Bontis, 2009; Heisig, 2009; Ma and Yu, 2010), and a growing concern about the KM adoption and its impact on performance measurements in organisations (Pun and Nathai-Balkissoon, 2011). Initiatives carried out by standardisation bodies in Australia, Britain and Germany as well as on the European Level have tried to achieve a common understanding about KM. As investments in various KM initiatives inflate, the call for coherent and comprehensible principles and practices to guide KM implementation efforts has increased (Khatibian et al., 2010). KM implementation remains an enigma and a source of frustration in many organisations irrespective of their size, business nature and locations (Wang and Ahmed, 2005; Yiu, et al., 2013). By complementing the literature base with some empirical evidence in Trinidad and Tobago (T&T), this paper aims to identify various determinants that would affect the KM performance measures in manufacturing enterprises.

2. Literature Review

2.1 The KM Process

Recent literature shows that firms use a variety of means and approaches to combine, sort, and process the environmental data to produce timely and relevant information for forming, monitoring, evaluating, and modifying organisational strategy (Khatibian et al., 2010; Yiu, et al., 2013). Wong and Aspinwall (2005) contend that KM is an emerging set of organisational design and operational principles, processes, organisational structures, applications and technologies. In particular, knowledge-related processes or activities (or in short, the KM process) are about knowledge creation, validation, presentation, distribution and application activities. Diakoulakis et al (2004) argue that the focus of KM is on the integration and coordination of individuals' knowledge, that is, the appropriate "application/management" of current organisational knowledge, and the "creation" of knowledge. Pillania (2009)

adds that KM basically involves three things – knowledge creation, knowledge dissemination and knowledge implementation.

KM processes are divisible into a number of inter-connected activities that depend on the particular industry, the nature of the firm and the strategy it adopts (Wang and Ahmed 2005). According to Diakoulakis et al. (2004), KM is considered to encompass the processes of "retention-systemisation of knowledge", "sharing-access of knowledge", "combination-creation of knowledge", "exploration of the external environment", "scanning of the internal context" and the "use of knowledge". The constituent elements are assumed to possess various cause-effect relationships between them, which are all positive but their strength differs significantly. Moreover, the strengths of these relationships vary when examining organisations with divergent characteristics. The causal nature exists among various KM processes, and has an operational and basically strategic impact on organisations. These processes depict the primary activities of the KM value adding chain and are inter-linked (Yiu, et al., 2013).

2.2 Factors and Obstacles Affecting KM Practices

Studies on KM practices have been plentiful, but have varied widely in their location, focus, application and depth (Heisig, 2009; Pun and Nathai-Balkissoon, 2011). Organisations need to assess their KM competence and examine how to integrate both technical and human aspects of knowledge acquisition, development and applications. The implementation of KM requires 1) an organisational strategy, 2) processes to carry out the strategy, and 3) measurements to evaluate how well those processes are working (Yiu and Sankat, 2007). Change through successful KM implementation requires a review of the traditional dictum that implementation follows formulation. Having regards the interdisciplinary nature of KM implementation, Dufour and Steane (2007) contend that the multiple processes (i.e., rational, structural, behavioural, and political) are operating concurrently, and the emerging of new theoretical models and practical approaches would invite a fundamental reassessment of KM implementation and the formulation of KM strategy. Maqsood et al. (2007) contend that culture, leadership, and vision issues are becoming more important to KM philosophical underpinnings.

Factors underpinning the success of KM can be identified by authors who have researched and written directly on this subject (Yiu, et al., 2013). For instance, Anantatmula and Kanungo (2010) suggest that top management involvement, KM leadership, and the culture of the organisation are the main driving factors based on which one can build a successful KM effort. Moreover, KM success factors could be grouped under four categories, namely Environmental/ Market, Company/Operational, People and Technical. Table 1 contrasts the KM success factors versus related problematic areas in respective categories (Yiu et al., 2013).

Table 1. KM success factors versus problematic areas

Categories	KM Success Factors	Related Problematic Areas	References
1. **Environmental/ Market**	1. Accessibility to markets 2. Company location 3. Competitive advantage 4. Market positioning 5. Strategic alliance with business partners	1. Dramatic changes in the marketplace 2. Few current and/or potential markets 3. Few suppliers and/or vendors 4. Local competition 5. Overseas competitors	Yiu (2012); Hariharan (2005); Wei et al. (2009); Anantatmula and Kanungo (2010); Ma and Yu (2010), Yiu et al. (2013)
2. **Company/ Operational**	6. Availability of funds and capitals 7. Company's culture and mission 8. Company's strategies 9. Costs of production and operation 10. Product and service quality	6. Cash flow problems 7. Conflicting company's goals and strategies 8. Improper management system and procedures 9. Increasing production/ operations costs 10. Inconsistent strategic planning	Yiu (2012); Hariharan (2005); Wei et al. (2009); Anantatmula and Kanungo (2010); Ma and Yu (2010), Yiu et al. (2013)
3. **People**	11. Management leadership 12. People communication 13. People involvement 14. Positive human dynamic 15. Workforce skills and abilities	11. Low productivity 12. High employee turnover 13. Lack of people training and motivation 14. People's resistance to change 15. Fragmented people efforts	Yiu (2012); Hariharan (2005); Wei et al. (2009); Anantatmula and Kanungo (2010); Yiu et al. (2013)
4. **Technical**	16. Capturing and creating knowledge 17. Information infrastructure 18. Organisational learning 19. R&D and Innovation capabilities 20. Sharing of knowledge	16. Incomplete knowledge of explicit and tacit data 17. Increasing sophistication of KM technologies 18. Insufficient R&D 19. Lack of appropriate IT supports 20. Unavailability of timely Information	Yiu (2012); Hariharan (2005); Wei et al. (2009); Anantatmula and Kanungo (2010); Ma and Yu (2010), Yiu et al. (2013)

3. A Survey of KM Practices in Manufacturing

A recent survey was conducted to acquire the practitioners' views on the identification of common success factors and problematic areas of KM practices, and to explore the KM initiatives in attaining organisational performance goals in Trinidad and Tobago (Yiu, 2012). Using a systematic sampling approach, a total of 120 organisations were selected from the database of registered members of the Trinidad and Tobago Chamber of Industry and Commerce (TTCIC). A postal questionnaire was employed to investigate the KM practices in both large enterprises and small and medium-sized enterprises (SMEs) from 1) energy-based manufacturing, 2) non-energy manufacturing, and 3) other related industries in T&T. After coding the questionnaire responses, statistical analysis was carried out. Company's profiles and basic information of the respondents were collated in Table 2.

Of 120 targeted manufacturing enterprises, 49 responses were obtained, yielding a response rate of 40.8 percent. In terms of industry representation, 8 responses were from the energy-based manufacturing sector (i.e. 16.3%), 9 from the non-energy manufacturing sector (i.e. 18.4%), and 15 from other related industries (i.e. 30.6%); whereas the rest (i.e. 34.7%) were companies providing manufacturing services (e.g. engineering support, product design, logistics, trading, and consulting) in T&T. The results show that some 10 percent of surveyed companies relied on a single market, and some had three to four markets. About 61.2 percent of respondents were local companies, and the rest were joint ventures with or owned by regional and/or foreign capitals (Yiu, 2012).

Table 2. Basic statistics of the KM Survey

Respondent Profiles *(n = 49)*	Basic Statistics
Industry Sectors	
Energy-based manufacturing (including Petroleum and Natural Gas Products, Petrochemicals and Chemicals, etc).	8 (16.3%)
Non-energy manufacturing (e.g. Consumer Goods, Food and Beverage, Cement, and Tobacco Products etc)	9 (18.4%)
Other related industries (including Printing, Packaging and Publishing, Utilities, Construction and Education, etc)	15 (30.6%)
Manufacturing Services (including Engineering and IT, Logistics and Warehousing, and Consultancy, etc)	17 (34.7%)
Total in percentage:	49/120 (40.8%)
People Hired In T&T[1]	
1-19	10 (20.4%)
20-49	13 (26.5%)
50-99	9 (18.4%)
100-199	4 (8.2%)
200 and more	13 (26.5%)
Major Markets	
Trinidad and Tobago (local market)	10 (20.0%)
The Caribbean countries (excluding Trinidad and Tobago)	20 (40.8%)
Americas (North and South)	22 (44.9%)
European Countries	13 (26.5%)
Asian Countries	7 (14.3%)
Others	2 (4.1%)
Capital Ownership	
Local ownership (T&T capital including state owned)	29 (59.2%)
Local and regional joint ownership	8 (16.3%)
Local and overseas joint ownership	8 (16.3%)
Overseas ownership	4 (8.2%)

Remarks: [1] *Companies employing less than 200 people are classified as SMEs.*

3.1 Industry Rankings of Success Factors

Senior management of respondent companies were asked to examine four categories and a list of twenty (20) factors that contributed to their KM practices. A five-point Likert scale of rating was used, ranging from 1, the least agreed, to 5, the most agreed. After calculating the mean score per factor, the weighted means (WM) of four factor categories were determined and respective factors were ranked [10]. Results show that respondents put greatest emphasis on the 'People' factors (i.e., WM = 3.84), followed by the 'Company/Operational' factors (i.e., WM = 3.71), the 'Technical' factors (i.e., WM = 3.59), and then the 'Environmental/Market' factors (i.e., WM = 3.50). The standard deviations (SD) ranged from 0.912 (i.e. Management leadership) to 1.423 (i.e. Strategic alliance with business partners). A highlight of the survey findings is depicted in Table 3.

It was found that the most important success sub-factors identified were 'Management leadership' (i.e., mean = 4.03; rank 1st), 'Workforce skills and abilities' (i.e. mean = 3.94; rank 2nd), 'Company strategies' (i.e. mean = 3.93; rank 3rd), 'Employee involvement' (i.e. mean = 3.84; rank 4th), 'Availability of funds and capital' (i.e. mean = 3.83; rank 5th) and 'Product and service quality' (i.e. mean = 3.82; rank 6th) which were grouped under the People and Company/Operational domains. These factors could assist many respondents to build capabilities enabling them to

efficiently capture the knowledge embedded in their organisations and deploy it into their operations, productions and services.

Table 3. Industry rankings of success factors

Success Factors *(n = 49)*	**Mean[1]**	**Std. Dev.**	**Ranking**
1) Environmental/Market Factors	**3.50[2]**	--	
- Accessibility to markets	3.76	1.023	7
- Company location	3.40	1.092	17
- Competitive advantage	3.63	1.162	15
- Market positioning	3.53	1.120	16
- Strategic alliance with business partners	3.20	1.423	20
2) Company/Operational Factors	**3.71[2]**	--	
- Availability of funds and capital	3.83	1.067	5
- Company culture and mission	3.73	0.972	9
- Company strategies	3.93	1.001	3
- Costs of production and operation	3.22	1.272	19
- Product and service quality	3.82	1.080	6
3) People Factors	**3.84[2]**	--	
- Employee involvement	3.84	1.020	4
- Management leadership	4.03	0.912	1
- People communication	3.71	1.139	11
- Positive human dynamics	3.70	1.144	12
- Workforce skills and abilities	3.94	0.890	2
4) Technical Factors	**3.59[2]**	--	
- Capturing and creating knowledge	3.72	1.010	10
- Information infrastructure	3.64	1.014	13
- Organisational learning	3.62	1.174	14
- R&D and innovation capabilities	3.21	1.121	18
- Sharing of knowledge	3.74	1.097	8

Remarks: [1]Mean (based on 1 = the least agreed, and 5 = the most agreed)
[2]Weighted mean (WM) of individual category of factors

Besides, two Technical sub-factors (such as 'Sharing of knowledge', rank 8th; and 'Capturing and creating of knowledge', rank 10th) together with 'Accessibility to markets' (i.e., rank 7th) and 'Company culture and mission' (i.e., rank 9th) were important contributors of KM practices in many respondent organisations. Meanwhile, almost all respondents claimed that both 'Costs of production and operation' (i.e., rank 19th) and 'Strategic alliance with business partners' (i.e. rank 20th) were the two least significant sub-factors, although some would argue that better management of production/operations costs and alliance with partners could secure profit margin and foster competitiveness.

3.2 Industry Rankings of Problematic Areas

The respondents were asked to examine four areas of problems and a list of twenty (20) obstacles that might have been impacted the KM practices and performance in their organisations (Yiu, 2012). A five-point Likert scale of rating was used ranging from 1, the least significant, to 5, the most significant. Table 4 depicts the rankings of these problematic areas and respective obstacles.

Results show that among four areas of problems, respondents put greatest concern on the 'People' problems (WM = 3.55), followed by the 'Company/Operational' problems (i.e., WM = 3.37), the 'Technical' problems (i.e., WM = 3.17) and then the 'Environmental/Market' problems (i.e., WM = 3.02). Many respondents ranked both 'People resistant to change' (i.e. mean = 3.94) and 'Fragmented people efforts' (i.e. mean = 3.84) as the two top prioritised obstacles, followed by 'Unavailability of timely information' (i.e. mean = 3.73), 'Improper management system and procedures' (i.e. mean = 3.64), and 'Increasing production/operations costs' (i.e. mean = 3.63). The mean scores of these obstacles ranged from 2.60 to 3.94. Their standard deviations fell into a range from 0.921 (i.e. People resistant to change) to 1.405 (i.e. Strong overseas competitors). Despite some variations in the rankings of importance, these obstacles were generally common among various manufacturing sectors and groups of manufacturing services companies under study.

Many respondents were concerned more with obstacles associated with the 'People' and 'Company/Operational' areas than that of 'Environmental/Market' and 'Technical' areas on KM adoption and practices in their organisations. With respect to the KM adoption, other technical obstacles of concerns included 'Insufficient research and development' and 'Lack of appropriate IT supports'. Arguably, many respondents put

lower emphasis on obstacles of 'Keen local competition' and 'Strong overseas competitors' (i.e., of the Environmental/ Market domain), and 'Incomplete knowledge of explicit and tacit data' and 'Increasing sophistication of KM technologies' (i.e. of the Technical domain).

Table 4. Industry rankings of problematic areas

Problematic Areas *(n = 49)*	**Mean[1]**	**Std. Dev.**	**Ranking**
1) Environmental/Market Problems	**3.02[2]**		
- Dramatic changes in the marketplace	3.43	1.068	6
- Few current and/or potential markets	3.04	1.087	16
- Few suppliers and/or vendors	3.24	1.072	11
- Keen local competition	2.81	1.289	18
- Strong overseas competitors	2.60	1.405	20
2) Company/Operational Problems	**3.37[2]**		
- Cash flow problems	3.12	1.267	15
- Conflicting company goals and strategies	3.32	1.031	9
- Improper management system and procedures	3.64	1.019	4
- Increasing production/operations costs	3.63	1.092	5
- Inconsistent strategic planning	3.13	1.152	14
3) People Problems	**3.55[2]**		
- Low productivity	3.33	1.032	8
- High employee turnover	3.34	1.010	7
- Lack of people training and motivation	3.31	0.977	10
- People resistant to change	3.94	0.921	1
- Fragmented people efforts	3.84	1.011	2
4) Technical Problems	**3.17[2]**		
- Incomplete knowledge of explicit and tacit data	3.03	1.176	17
- Increasing sophistication of KM technologies	2.71	1.098	19
- Insufficient research and development	3.14	1.080	13
- Lack of appropriate IT supports	3.23	1.320	12
- Unavailability of timely information	3.73	0.938	3

Remarks: [1]Mean (based on 1 = the least significant, and 5 = the most significant)
[2]Weighted mean (WM) of individual problematic areas

3.3 Industry Rankings of KM Determinants

Respondents were asked to consider five KM determinants and express their views on the relative importance of twenty (20) components using a five-point Likert scale from 1, the least important, to 5, the most important. These components were compiled as a list of sub-elements [10]. Table 5 shows that these KM determinants in order of combined industry rankings were 'Senior Management Leadership' (i.e. mean = 4.34), 'People Development' (i.e. mean = 4.24), 'Continuous Improvement' (i.e. mean = 4.23), 'Results Orientation' (i.e. mean = 4.01), and 'Knowledge Management Processes' (i.e. mean = 3.90). The computed standard deviations ranged from 0.770 to 0.889, indicating an acceptable level of data variability.

There was a slight difference found in the large organisations group where respondents put more concerns on 'Results Orientation' (i.e., mean = 4.11) than 'People Development' (i.e., mean = 4.00) and 'Continuous Improvement' (i.e., mean = 3.89), respectively. Respondents generally agreed that these five determinants are all important for organisations striving for KM practices and performance.

Table 5. Industry rankings of KM determinants

	SMEs *(n = 40)*			**Large** *(n = 9)*			**Combined** *(n = 49)*		
KM Determinants	$\mathbf{M_S}$	$\mathbf{SD_S}$	$\mathbf{R_S}$	$\mathbf{M_L}$	$\mathbf{SD_L}$	$\mathbf{R_L}$	$\mathbf{M_C}$	$\mathbf{SD_C}$	$\mathbf{R_C}$
- Senior Management Leadership	4.29	0.873	1	4.44	0.726	1	4.34	0.838	1
- KM Processes	3.90	0.860	5	3.88	0.641	5	3.90	0.811	5
- People Development	4.22	0.791	2	4.00	0.756	3	4.24	0.770	2
- Continuous Improvement	4.20	0.813	3	3.89	0.927	4	4.23	0.826	3
- Results Orientation	4.00	0.922	4	4.11	0.782	2	4.01	0.889	4

Remarks: M - Mean (based on 1 = the least important, and 5 = the most important)
SD - Standard Deviation; R - Rankings
S - SMEs Group; L - Large Organisations Group; C - Combined Group

3.4 Industry Rankings of KM Benefits/Performance

Similarly, the respondents were asked to evaluate the likeliness of the benefits that would be derived from KM practices for attaining performance goals of their organisations. A list of four anticipated benefits of KM practices was used using a five-point Likert scale from 1, the least likely, to 5, the most likely. Table 6 shows a summary of findings.

Table 6 Industry rankings of anticipated benefits from adopting KM

	SMEs *(n = 40)*			**Large** *(n = 9)*			**Combined** *(n = 49)*		
Anticipated KM Benefits	M_S	SD_S	R_S	M_L	SD_L	R_L	M_C	SD_C	R_C
- Gaining competitive advantage	3.95	1.050	4	3.88	0.835	3	3.90	1.019	4
- Improving operational efficiency	4.22	0.822	1	4.25	0.463	2	4.24	0.780	1
- Nurturing cultural changes	3.96	0.935	3	3.50	0.926	4	3.92	0.931	3
- Fostering organisational learning	4.02	0.790	2	4.50	0.535	1	4.13	0.769	2

Remarks: M - Mean (based on 1 = the least likely, and 5 = the most likely)
SD - Standard Deviation; R - Rankings
S - SMEs Group; L - Large Organisations Group; C - Combined Group

It was found that these benefits in order of combined industry rankings were 'Improving operational efficiency' (i.e. mean = 4.24), 'Fostering organisational learning' (i.e. mean = 4.13), 'Nurturing cultural changes' (i.e. mean = 3.92), and 'Gaining competitive advantage' (i.e. mean = 3.90). The computed standard deviations ranged from 0.769 to 1.019, indicating an acceptable level of data variability. Most respondents generally perceive that they are likely to derive these benefits from KM practices and consider 'Improving operational efficiency' as the most anticipated benefit from adopting KM.

The Large Organisations group put more concerns on 'Fostering organisational learning' (i.e. mean = 4.11) than 'Improving operational efficiency' (i.e., mean = 4.00). Interestingly, many respondents in this group also considered that the KM adoption would have lesser impacts on nurturing cultural changes in their organisations.

4. Discussions and Conclusion

Knowledge is regarded as the nucleus of global economic transformation and competitive advantage of an organisation. Building organisational capabilities to acquire, create, and disseminate knowledge on a continual basis has become a key challenge for strategy and organisational design experts (Yiu et al., 2013). The premise for KM is based on a paradigm shift in the business environment where knowledge is central to organisational performance. This paper sheds an effort on complementing the literature base with empirical evidence that leads to a clarification of the ways in which the field of KM can yield synergistic results in manufacturing enterprises. Various success factors, obstacles and determinants of KM were identified, drawing upon a breadth of respondents'/practitioners' opinions acquired. Based on the valid responses of 49 firms, the survey concluded that:

- Respondents shared a similar focus on common success factors and obstacles in KM practices. The most important success sub-factors were 'Management leadership', 'Workforce skills and abilities', 'Company strategies', 'Employee involvement', 'Availability of funds and capital' and 'Product and service quality' which were grouped under the People and Company/Operational domains.
- The most crucial obstacles on KM were 'People resistant to change', 'Fragmented people efforts', 'Unavailability of timely information', 'Improper management system and procedures', and 'Increasing production/operations costs'.
- The main KM determinants were 'Senior Management Leadership', 'People Development', 'Continuous Improvement', 'Results Orientation', and 'Knowledge Management Processes'. Among the core components of respective determinants were 'Management commitment', 'Management involvement', 'Customer focus', 'People education and training', and 'People well-being and satisfaction'.
- Among the most KM benefits were 'Improving operational efficiency', 'Fostering organisational learning', 'Nurturing cultural changes', and 'Gaining competitive advantage'. Interestingly, the Large Organisations group put more concerns on fostering organisational learning than improving operational efficiency.

Manufacturing enterprises in T&T or elsewhere are unique with distinctive biographies, strengths and opportunities. Presently, many manufacturing companies in T&T are leaning towards more technology-advanced and service-oriented enterprises (Yiu, 2012). The impact of KM practices on organisational performance is tied to the ability of an organisation to identify the determinants of KM. The future of KM practices is dependent significantly on the quality of the metrics and the outputs generated to provide tangible value to organisations. This necessitates research

efforts to examine the effectiveness of KM, and devise an integrated paradigm that could align KM practices to performance measures with validation of empirical evidences.

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Authors' Biographical Notes:

Man Yin Rebecca Yiu *is Researcher in the Department of Mechanical and Manufacturing Engineering at The University of the West Indies, Trinidad and Tobago. She holds an MPhil in Industrial Engineering and a Master degree in Information Systems. Her research interests are in the areas of industrial engineering, knowledge management and information systems*

Kit Fai Pun *is presently Professor of Industrial Engineering of the Faculty of Engineering and the Chair and Campus Coordinator for Graduate Studies and Research at The University of the West Indies. He is a Registered Professional Engineer in Australia, Europe, Hong Kong, and The Republic of Trinidad and Tobago. His research interests and activities include industrial engineering, engineering management, quality systems, performance measurement, innovation, and information systems.* ■

Building Local Skills to Compete in a Global Economy: The Use of a Formal Apprenticeship Programme in the Bahamas

Robert W. Robertson

Bahamas Technical and Vocational Institute, Old Trail Road, Nassau, Bahamas; Emails: robertsonr@btvi.edu.bs; rroberts905@gmail.com

Abstract: *This paper explores the current situation with respect to workforce skills in the Bahamas as an important component of the competitiveness of the Bahamian economy at a time of significantly increased global competition and economic insecurity in many markets. Specifically, the paper provides an overview of the perceived skills gap in the Bahamian labour force using secondary data sources and identifies ways that this gap can be closed including using more practical approaches such as internships, apprenticeships and technology using a case analysis methodology.*

Keywords*: Apprenticeship, workforce skills, skills gap, global competency, local economic development, training and development*

Author's Biographical Notes:

Robert W. Robertson *is the President of the Bahamas Technical and Vocational Institute in Nassau, the Bahamas; and, he is a Visiting Associate Professor of Management, Faculty of Economics, University of Ljubljana, Slovenia. Dr. Robertson holds a doctorate degree in Management and Organisation from Stirling University, Scotland and degrees from the United States, Canada and the United Kingdom. In 2016, he was named a Fulbright Scholar by the US Department of State and an Emerging Leader in the America's by Global Affairs Canada.*

■

Solving Multi-Objective Economic Dispatch Problems Incorporating Wind Units Using a Semidefinite Programming Approach

Kolapo Sulaimon Alli[1]; Abimbola Muideen Jubril[2]; Lawrence O. Kehinde[3]

[1]Faculty of Engineering, The University of the West Indies, Mona Campus, Kingston, Jamaica, West Indies; Email: Kolapo.alli@uwimona.edu.jm

[2,3] Faculty of Engineering, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria; Emails: amjubril@oauife.edu.ng; lokehinde@oauife.edu.ng

Abstract: *In practical applications on economic dispatch problem of power systems, stochastic variability is a vital issue which must be taken into consideration in order to ensure optimal operation of the power systems. Therefore, stochastic models are applicable in power dispatch problems as certain inaccurate and uncertain factors which naturally surface in system operations are readily addressed. This study has presented a semidefinite programming (SDP) optimization approach for solving reformulated extended stochastic multi-objective model for economic dispatch (ED) that incorporates combined heat and power (CHP) units and wind power units. Furthermore, the stochastic multi-objective models were converted into their deterministic equivalents through their expectation, with the assumption that involved random variables are normally distributed. The multi-objective problem was recast in matrix form as a SDP relaxation problem and subsequently solved with MATLAB Programming suite. The system inequality and equality constraints uncertainty were entered into YALMIP, which is a linear matrix inequality parser. The multi-objective problems both in stochastic and deterministic were tested on modified IEEE 6, 15 and 20 units' networks with 2 CHP units and 20 wind parks for each of the networks. A comparative study was also conducted to demonstrate the effectiveness of the proposed method by comparing the results obtained from SDP approach with the results of the existing techniques reported in the literature. The results of problem reformulations including stochastic and deterministic models of power dispatch were investigated. However, in the generation of the Pareto-front solution, a standard weighted sum method was used in generating the Pareto-optimal solution between two objectives functions. Different values of the control weight selection parameter were used in the generation of Pareto points. The optimization results are close within the order of magnitude 3.5% reductions in the case of modified IEEE six units, while SDP achieved lowest values of the optimized objectives functions compared to modified multi-objective particle swarm optimization (MOPSO), genetic algorithms (GA) and weighted aggregation, (WA) methods. In conclusion, an optimal selection of control weight selection k_1 parameter that gives a better convergence property of the algorithm was empirically determined. The SDP approach solves a stochastic problem by minimizing the expectation of the multi-objective functions using the Gaussian distribution and also Weibull probability distribution function is used in the characterization of a stochastic wind data to create suitable criteria to a better utilization of the wind power.*

Keywords*: Multi-objective economic dispatch problem, SDP, Weighted sum method*

Authors' Biographical Notes:

Kolapo Sulaimon Alli *did his B.Tech at the Department of Electronic nd Electrical Engineering, LAUTECH, Ogbomoso, Nigeria and obtained both his M.Sc and Ph.D from the Department of Electronic and Electrical Engineering, Obafemi Awolowo University. He is currently a Lecturer at the Department of Electrical and Electronic Engineering, The University of the West Indies, Mona Campus, Kingston, Jamaica. His research interests are instrumentation and control systems, virtual and online experimentations, computational intelligence and its applications, Biomedical Instrumentation.*

Abimbola Muideen Jubril *obtained his B.Sc, M.Sc and Ph.D from the Department of Electronic and Electrical Engineering, Obafemi Awolowo University, Ife-Ife, Nigeria. He is currently a Senior Lecturer working at the Department of Electronic and Electrical Engineering, Obafemi Awolowo University. Abimbola does research in Control Systems Engineering and Engineering. His current project is 'Obafemi Awolowo Laboratory Online Laboratories. His major is in Robust Control and Optimal Control, Optimal Power Flow, Computational Intelligence and its applications, Biomedical Instrumentation.*

Lawrence Kunle Kehinde *received his B.Sc 1st class Hons in Electronics (1971) at Obafemi Awolowo University (OAU), Ile-Ife, Nigeria, and a D.Phil, Control Engineering (1975), at the University of Sussex UK. He had his Post Doctoral Studies in Nuclear Instrumentation at University of California, Berkeley USA (1977-1978) as an IAEA Fellow. Professor Kehinde has spent most of his years as a Professor of Instrumentation Engineering at the OAU, Ile-Ife, Nigeria. A few years back, he concluded a 3-year Visiting Professor term at the Texas Southern University, Houston Texas USA. His major field is Instrumentation with equipment Designs.*

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Geoheritage and the Conservation of Natural Geological Sites of Interest in Guadeloupe, French West Indies

Yves Mazabraud

Université des Antilles, UMR5243 Géosciences Montpellier, Guadeloupe, France;
Email: yves.mazabraud@univ-antilles.fr

Abstract: *In 2002, the law for a Democracy of Proximity was voted by the French parliament. It stated that the State takes care of the conception, the animation and the evaluation of the Natural Heritage. This heritage shall include all ecological, fauna, flora, geological, mineralogical and paleontological items of interest. For the Geoheritage, that is to say the geological sites of natural or human-related interest, Guadeloupe (French West Indies) was chosen as a test territory. Indeed, its geology is very rich and very peculiar, with a lot of variation. It includes for example a carbonate plat-form, coral reefs (both actives and fossils), mangroves, on-shore and submarine thermal springs, a great variety of volcanic deposits, tropical erosion features typical of limestone's (karsts) and an active volcano. So, as soon as 2003, local stakeholders in Guadeloupe have been referencing several sites and created a collection of 33 outcrops' descriptions. In 2015, all these sites had been validated at the national level and entered into a national database (IGeotope). This inventory is meant to be permanent and a living collection. Starting in 2018, the DFA chapter (Guadeloupe-Martinique) of the Caribbean Academy of Sciences is re-evaluating the previous outcrops descriptions for adding new informations (especially a precise GIS mapping) to the sites. In the meantime, the CAS also starts working on new descriptions with the particularity of adding sub-marine geological sites (coral reefs, thermal springs). This project should be ongoing for four to five years. When finalized, a territorial geo-heritage catalogue reveals itself a powerful tool for policy making and education (Martin, 2013). Despite the need to inventory the underground for resource purposes (water, mining) that has motivated geological research for centuries, such an inventory is meant to be used for protecting areas of natural interest, for teaching and for developing tourism (Renau and Peissier, 2018).*

Keywords*: Geoheritage, Natural sites conservation, Environmental policy, Geo-tourism*

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Authors' Biographical Notes:

Yves Mazabraud *is a geophysicist specialized in crustal deformation. His work focuses on the precise description of the earth's deformation patterns in order to emphasise the mechanisms at the origin of stress concentrations, using a variety of tools such as seismology, geodesy, field geology and tectonics. Dr. Mazabraud also developed an expertise in geocognition and the study of geosciences related conceptions of students. He is an Assistant Professor at the Université des Antilles (Guadeloupe).*

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30 Years of JCAMP-DX Formats and Still Going Strong

Antony N. Davies[1] and Robert J. Lancashire[2]

[1]Expert Capability Group-Measurement & Analytical Science, Research, Development & Innovation, Akzo Nobel Chemicals bv, Zutphenseweg 10, 7418 AJ Deventer, The Netherlands; E-mail: tony.davies@akzonobel.com

[2]The University of the West Indies, Mona Campus, Kingston 7, Jamaica, West Indies; E-mail: rjlanc@gmail.com

Abstract: *The Joint Committee on Atomic and Molecular Physical Data formed a Task Force on Spectral Data Portability under the direction of Paul A. Wilks, Jr., at the Pittsburgh Conference (Pittcon) of 1983. The scope of JCAMP-DX was originally as follows: "The Joint Committee will generate, collect, evaluate, edit, and approve the publication and encourage the distribution of atomic and molecular physical data in suitable form to serve as references for pure compounds and mixtures". The first objective of the Task Force was to design a standard file format for exchange of infrared spectra between vendor data systems that used different proprietary file formats. Data exchange capability was in demand by end-users who wished to transfer spectra between different spectrometers in their own and other laboratories. In 1988, the first JCAMP-DX spectroscopic data format was published (for IR). Since then the protocols for a range of techniques have been developed and published, the latest being for circular dichroism (2012). A report on the IUPAC workshop "Supporting FAIR (Findable, Accessible, Interoperable, and Reusable) Exchange of Chemical Data through Standards Development" held in Amsterdam in July 2018 will be highlighted.*

Keywords*: IUPAC, spectroscopic data*

Authors' Biographical Notes:

Tony N. Davies *CChem, FRSC is Lead Scientist at the Expert Capability Group – Measurement and Analytical Science at AkzoNobel Specialty Chemicals in Deventer, the Netherlands. He also hold the position of Professor of Analytical Science at the University of South Wales, UK; is Director of LOMOX Ltd. a high-tech start-up company and founder and past director of IMSPEX Diagnostics Ltd. Professor Davies worked for 13 years in German government research before joining an instrument supplier company. He has worked for 4 years in a global pharma company on compliant analytical systems deployment and in academia developing business analytical support strategies targeting innovative start-up companies.*

Robert J. Lancashire *was Professor of Computational Chemistry at the Department of Chemistry, The University of the West Indies (UWI), Mona. He was conferred Professor Emeritus in 2016. From the early 1990's, his research focussed on applying modern computer methods, using personal computers and the Internet, to assist in the delivery of chemical information, in particular spectroscopic data. He has served on the IUPAC Committee on Printed and Electronic Publications (CPEP) as well as on its Subcommittee on Cheminformatics Data Standards (SCDS). The subcommittee develops the JCAMP-DX formats used to store spectral data that has been implemented by nearly all instrument manufacturers in their spectrometers. Professor Lancashire is the current Foreign Secretary of CAS, the Secretary of the CASJ and is a Fellow of IUPAC and CAS.*

■

Some Notable Scientists of Colonial Jamaica

Robert J. Lancashire

The University of the West Indies, Mona Campus, Kingston 7, Jamaica, West Indies;
Emails: rjlanc@gmail.com; rjlanc@caswi.org

Abstract: *A number of early "scientists" in Jamaica were people with medical backgrounds but there were others "with little or no formal scientific training. They operated in an atmosphere rarely favourable to scientific inquiry, working in isolation, without adequate libraries, apparatus, and the stimulation provided by able co-workers and by an informed, sympathetic public opinion. But their efforts led to more than a mere accumulation of crude scientific data. With time the colonial men of science emerged as scientists in their own right." A review of the Fellows of the Royal Society of London between 1661 and 1788 who spent time in Jamaica provides a useful indication of their impact. Such a list was compiled in 1951 and contained more than a dozen names such as Henry Barham, Colin Campbell, Rose Fuller, Alexander MacFarlane, John Taylor, William Wright as well as Sir Hans Sloane. In addition, the records from The University of Edinburgh show that between 1750 and 1870 about 10% of the graduating class in Medicine was from the West Indies. Many of them were described as from Jamaica and some went on to make significant contributions to Science. A selection of these scientists will be highlighted.*

Keywords*: Royal Society of London, University of Edinburgh*

Author's Biographical Notes:

Robert J. Lancashire *was Professor of Computational Chemistry at the Department of Chemistry, The University of the West Indies (UWI), Mona and in 2016 was conferred Professor Emeritus. Since retirement he has become an armchair genealogist tracing early families who settled in Jamaica, in particular those with children who went on to become successful scientists/medics. He is the current Foreign Secretary of CAS, the Secretary of the CASJ and is a Fellow of IUPAC and CAS.*

■

Temperature Effect on the Cracking Healing Potential of Asphalt Concrete Mixes

Lee P. Leon[1], Rico Nurse[2], and Shannon Noel[3]

Faculty of Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies;
[1]E-mail: Lee.Leon@sta.uwi.edu
[2]E-mail: riconurse@hotmail.com
[3]E-mail: shannon.noel@hotmail.com

Abstract: *Crack healing is characterised by the recovery of stiffness in asphalt concrete after a period of rest. Micro damage occurs in asphalt pavement layers when there is continuous reduction in its stiffness modulus, which causes the formation of micro-cracks. When loading of pavement ceases for a given period, closure of micro cracks due to molecular properties of asphalt allows for an increase in stiffness indicative of healing. This paper presents an evaluation into the healing potential of dense graded asphalt mixes through laboratory assessment of cylindrical specimens. The specimens were prepared using local aggregates of Trinidad, Trinidad Lake Asphalt (TLA) and Modified Bitumen (MB) binders. Test temperatures of 35^{o}C and 60^{o}C were used to evaluate the healing capabilities of asphalt mixes using Indirect Tensile Stiffness Modulus (ITSM) test method. Evaluation of stiffness were done, before cracking, after cracking and after healing periods of 1, 4 and 8 hours. Healing was observed in asphalt concrete and recovery of stiffness was seen after rest periods. TLA specimens showed increased healing for greater rest periods and increase in temperature. The healing of MB binder varied with rest periods and greater healing was seen at 60^{o}C. The reduction of micro-damage in a pavement, greatly defers the propagation of macro cracks, extends serviceability, reduces maintenance costs and increases the sustainability of the pavement.*

Keywords*: Crack healing, asphalt concrete, micro cracks, indirect tensile test, stiffness modulus*

1. Introduction

Underestimation of asphalt concrete performance and life are major problems that could lead to considerable economic losses. Fatigue occurs as the pavement is subjected to compressive and tensile stresses generated by wheel loads, temperature variations, and water seepage; and can often be seen in the form of potholes, rutting and cracking in flexible asphalt pavements Sarsam and Husain (2016). The term healing, when related to asphalt concrete is a phenomenon that is not fully understood; as such, indirect methods are used to relate the phenomenon to different factors such as strength recovery and time.

In this study, damage is viewed as the loss of stiffness and healing refers to its recovery of stiffness over time. There are many different approaches which can be taken to measure and quantify healing for its application to fatigue life. Some of the most common methods characterised healing by the use of Dissipated Creep Strain Energy, Continuum Damage, and Traditional Fatigue approach which makes use of stress, strain or energy, and ratios of dissipated energy change.

Stiffness recovery as a means of quantifying healing, was noted by Roque et al. (2012) and Grant (2001), who stated that an increase in stiffness upon cessation of load application may be attributed to steric hardening of the asphalt binder (hardening which occurs over time at ambient temperatures). In addition to steric hardening, relaxation of the asphalt material as stresses are no longer induced and the healing of micro-cracks cumulatively result in the increase in stiffness. Aging of the binder as concluded by Kliewer et al. (1996), results in an increase in the stiffness of the pavement; and due to the reduction in pavement elasticity, cracking is more likely to occur.

The Indirect Tensile Stiffness Modulus (ITSM) test method was previously used by Roque, Simms, Chen, Koh and Lopp (2012) for similar healing tests, and concluded that the use of the Resilient Modulus (MR) test is appropriate for both the damage phase and the healing phase since it is a convenient way to measure effective stiffness of asphalt mixture, which could indicate damage and damage recovery. It was observed that the rate of healing is not constant, and that generally, greater healing was seen in mixtures left to rest at higher temperatures.

Research such as Roque et al. (2012), Sarsam and Husain (2016) and Grant (2001), used effective stiffness, stiffness loss and their recovery as indicators of damage and healing. The same approach was utilised within this study. The merit of using stiffness to observe healing properties lies in the fact that stiffness is dependent on the binder and sample properties as mentioned by Kok and Kuloglu (2007).

There is no unified method of testing, characterising and quantifying healing of micro-cracks. A unified and more efficient approach is needed to properly assess the crack healing potential of asphalt concrete as stated by Qiu et al. (2012), and to provide repeatable results. The current study would expand on the knowledge of factors such as

temperature and rest period, observing the length of rest period most effective for healing as well as optimum temperatures. Thus, this provides more accurate predictions of fatigue life. In addition to the importance of this research implications in the integration of fatigue life estimation, which according to Shen and Lu (2012) will assist in developing and improving pavement design procedures.

This investigation was designed to focus on parameters indigenous to the Caribbean region. Mixes were fabricated with binders Modified Bitumen-MB and Trinidad Lake Asphalt-TLA. Integration of healing into fatigue life prediction may lead to a better understanding of pavement design and maintenance needs and savings.

2. Materials and Test Program

2.1. Aggregate and Binder

To ensure uniformity, aggregates (coarse limestone, limestone dust and sharp-sand) from the same sources for asphalt concrete mixes. The TLA and modified binder had penetration grades of 60/75 and 60/70 respectively.

2.2. Mix Design

The mix design was conducted using the current and commonly used method of mix design which is the Marshall Mix design procedure. Specimens were designed to satisfy the parameters for both coarse and fine dense graded mixes suitable for a Hot Mix Asphalt (HMA) wearing course. The aggregate blending results of the individual aggregates formed the basis for the selection of the final blend as presented in Figure 1. The optimum binder content for all mixes are presented in Table 1.

Table 1: Binder Content

Binder Type	Fine Dense Graded Mix	Coarse Dense Graded Mix
Modified Bitumen (MB)	5.1 %	5.0 %
Trinidad Lake Asphalt (TLA)	5.7 %	5.3 %

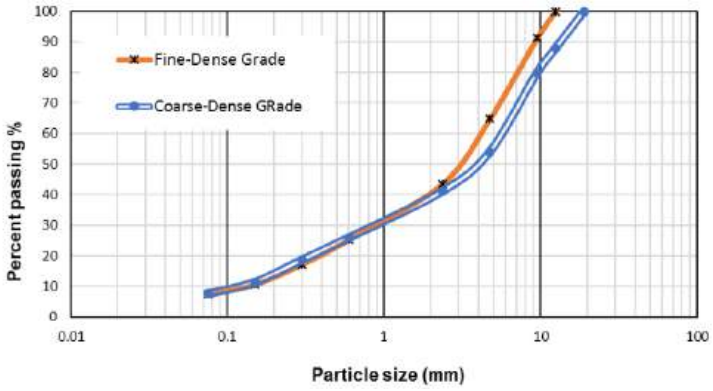

Figure 1: Diametral plane of cracking and direction of applied load pulses on specimen

2.3. Study Specimens

Final total of 88 samples for testing were prepared using the optimum and aggregate percentages from the mix design. A breakdown of the specimens' fabrication quantity and test program is given in Table 2. The Indirect Tensile Strength (ITS) test BS EN 12697-23: 2003 was performed on four specimens of each binder type and mix type to determine the average peak load applied upon cracking and failure of the specimen. Each specimen was loaded across a vertical diametral plane as shown in Figure 2. For final testing of damage and healing, 36 specimens were created for testing as summarised in Table 2. Before micro-damage was induced, the stiffness of the specimen determined according to Stiffness test BS EN 12697-26: 2004 was evaluated. The stiffness was determined in two orthogonal directions, parallel and perpendicular to the diametral plane of cracking as seen in Figure 2.

Table 2: Asphalt Concrete specimen fabricated

Mix Type	Both Coarse and Fine Dense Graded Mixes											
Binder Type	TLA						MB					
Temperature (^{0}C)	35			60			35			60		
Rest Period (hours)	1	4	8	1	4	8	1	4	8	1	4	8

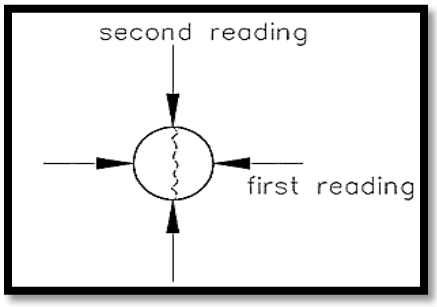

Figure 2: Two orthogonal directions, parallel and perpendicular to the diametral plane of cracking

2.4. Study Specimens

Micro-damage was induced in the specimen at 70% of the peak load to ensure that the damage in the specimen occurred within the elastic and elasto-plastic region. An evaluation of the suitable peak load showed that below 50% sufficient micro-damage was not induced in the specimen, and applying above 75% of the tensile strength value would result in macro-damage in the specimen. After micro-damage the stiffness of the specimen was immediately checked, then specimen placed in environmental chamber to begin healing at the either 35◦C or 60◦C for the given healing periods. After this period, the specimens were left to cool to 25◦C and the final stiffness tested. Evaluation of healing was conducted on batches of three specimens per binder, per temperature, per rest period.

3. Results and Analysis

3.1. Evaluation of Stiffness Modulus

The stiffness of the specimens was recorded at three intervals during the investigation: Before cracking, after cracking, and before curing. By applying 70% of the tensile strength to induce micro-damage in the specimen, there was a reduction in stiffness of all specimens, and a subsequent increase after rest, as illustrated in Figures 3 and 4.

Cracking healing was observed in specimens regardless of mix and binder type. The percentage reduction in stiffness values were calculated as a percentage change of the original stiffness to the damaged stiffness. A decrease in the stiffness values after cracking was used as an indicator that damage had occurred in the specimen.

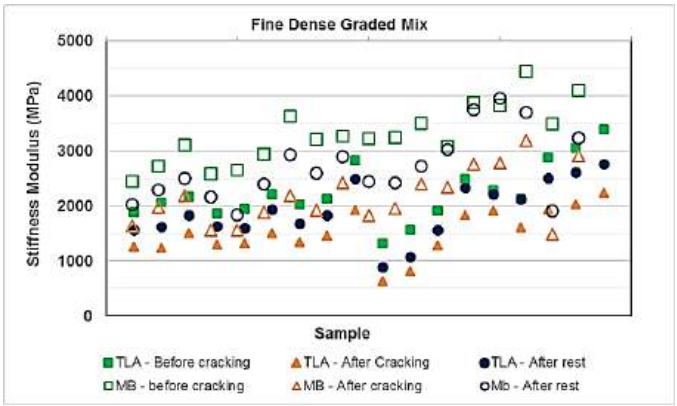

Figure 3. Stiffness modulus before and after damage of fine graded mixes

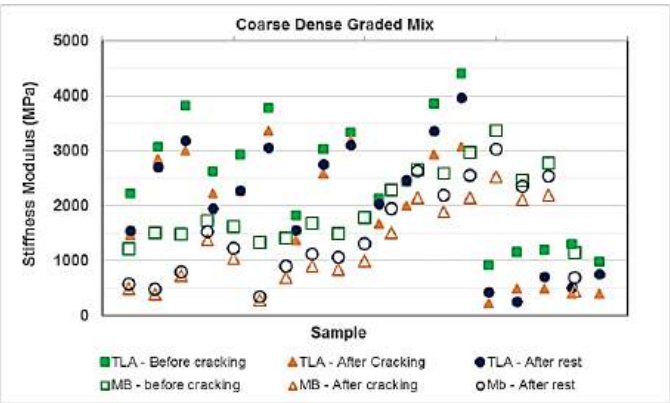

Figure 4. Stiffness modulus before and after damage of coarse graded mixes

3.2. Influence of Time and Temperature on Healing

The stiffness after cracking (damaged stiffness) was calculated based on the stiffness values after cracking and after rest. An increase in stiffness after the rest period was used as an indicator that healing had occurred. All specimen showed a percentage reduction in stiffness after cracking, and an increase after healing, indicating that damage and healing had occurred.

Percentage change in healing which occurred after damage and rest was greatest in TLA fine graded specimens at 35◦C for the 1, 4 and 8-hour rest periods, with the greatest healing occurring for the 8-hour rest period, seen in Figure 5. This would indicate that there was less healing occurring at 60◦C, which did not follow the trend of greater healing occurring at higher temperatures, as observed by Roque et al. (2012) for dense graded mixes. Based on the damage data the assumption made by Kliewer et al. (1996) that healing is proportional to the damage in the specimen was observed in this study. The TLA stiffness may also have been reduced, but TLA is known to have a high softening point, and greater stability at higher temperatures as it is a natural asphalt Feng and Zha (2011), therefore, the temperature would have a greater effect on the bitumen binder. There was a greater variation in stiffness recovery for Modified bitumen specimens, and it was observed that healing was non-linear for each temperature.

Modified Bitumen fine graded specimens showed greater recovery of stiffness at both temperatures for the 4 and 8-hour rest period. A higher percentage of healing was observed in specimen at the higher temperature of 60C for the 4 and 8-hour rest periods, with the greatest healing occurring during the 4-hour rest period. At 35◦C, greatest healing was occurred after 1 hours of rest, with a decrease in healing occurring as rest time increased.

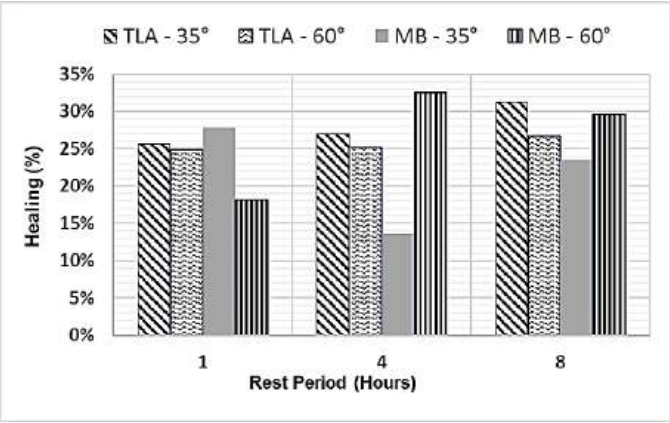

Figure 5. Healing in fine graded specimens – temperature comparison

TLA coarse graded specimens healing were significantly greater at 35◦C for 8-hour rest periods as seen in Figure 6. Percentage change in healing which occurred after damage and rest was greatest at 60◦C for the 1, 4 and 8-

hour rest periods, with the greatest healing occurring for the 8-hour rest period. This would indicate that there was greater healing occurring at 60◦C, as observed by Roque et al. (2012) for dense graded mixes. As the curing time and temperature increase so does the healing of TLA coarse graded mixes.

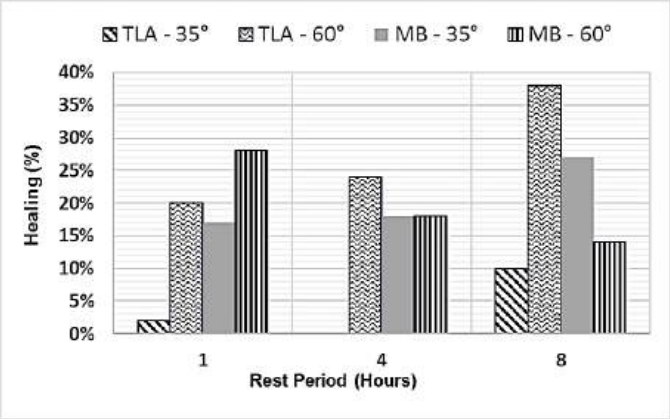

Figure 6. Healing in coarse graded specimens – temperature comparison

Modified Bitumen fine graded specimens showed greater recovery of stiffness at both temperatures for the 4 and 8-hour rest periods. A higher percentage of healing was observed in specimen at the higher temperature of 60◦C for the 4 and 8-hour rest periods, with the greatest healing occurring during the 4-hour rest period. At 35◦C greatest healing occurred after 1 hours of rest, with a decrease in healing occurring as rest time increased. The rate of healing in the Modified Bitumen specimen is non-linear with no clear trend followed.

4. Conclusions

The potential for crack healing has been identified to n be affected by many factors including the asphalt concrete mixture composition, environmental conditions, and bitumen properties which can aid or inhibit the crack healing mechanisms within the pavement. External factors such as the nature and frequency of loading, and the size of the cracks further dictates healing. Greater healing was exhibited in TLA fine graded mixes at the lower temperature of 35◦C, while greater healing was seen in the Modified Bitumen fine grade mixes at 60◦C. However, for the TLA coarse mixes greater was observed at 60◦C.

Healing was observed at increased temperatures and rest periods, however a significant linear relationship between increased healing and increased temperature and time was not identified. The findings from experimentation indicate that the healing increases with temperature increase but it does this in a non-linear manner. Additionally, greater healing will occur for increased rest periods, although excessive rest periods may not always yield better results, based on the asphalt concrete mixture composition and the inherent binder chemical properties.

Crack propagation has been identified as one of the primary failure mechanisms of the pavement. If micro-damage in a pavement can be reduced, the propagation of macro-cracks is deferred, extending serviceability, reducing maintenance costs, and increasing the sustainability of the pavement. While the major focus is on roadways, research can also be focused on flexible pavements for driveways, parking lots, access roads and other areas in which there is a low volume of vehicles per day. Greater healing may be facilitated in these environments as the two main parameters of increased temperature and availability of rest period can be satisfied.

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Authors' Biographical Notes:

Lee P. Leon *is an Assistant Lecturer in Highway Engineering in the Department of Civil and Environmental Engineering at The University of the West Indies. He is a member of the International Society for Asphalt Pavements. His research interests are in the areas of geometric designs, pavement materials, asphalt concrete performance testing and quality assurance in pavement construction.*

Rico Nurse *is a Civil Engineer employed with Belize Water Services Limited. He previously worked at the Coastal Zone Management Unit of Barbados. He graduated from the University of the West Indies with a Bachelor's of Science in Civil Engineering.*

Shannon Noel *is a recent graduate of the University of the West Indies with First Class Honours, Bachelor of Science (Eng) in Civil Engineering. She is currently employed as a Junior Civil Engineer at Barry's Engineering Company Limited, Grenada.*

■

Multi-stage Extraction and Purification of Waste *Sargassum Natans* to Produce Sodium Alginate: An Optimisation Approach

Akeem Mohammed[1], Rakesh Bissoon[2], Elisheba Bajnath[3], Kristy Mohammed[4], Thérèse Lee[5], Meera Bissram[6], Nigel John[7], Nigel K. Jalsa[8], Koon Yang-lee[9], and Keeran Ward[10]

[1,2,3,4,5,6,10]Faculty of Engineering, University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies.
[1]Email: akeem.mohammed08@gmail.com;
[2]Email: Rakesh.Bissoon@sta.uwi.edu;
[3]Email: Elisheba.Bajnath@my.uwi.edu;
[4]Email: Kristy.Mohammed@sta.uwi.edu;
[5]Email: Therese.Lee@sta.uwi.edu;
[6]Email: Meera.Bissram@sta.uwi.edu;
[10]Email: keeran.ward@sta.uwi.edu

[7,8]Faculty of Science and Technology, University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies.
[7]Email: Nigel.John@sta.uwi.edu;
[8]Email: Nigel.Jalsa@sta.uwi.edu;

[9]Department of Aeronautics, Imperial College, London, United Kingdom; Email: koonyang.lee@imperial.ac.uk

Abstract: *Sargassum in the Caribbean region has affected the livelihood of several coastal communities due to the influx of large quantities of the seaweed in recent times. This article seeks to explore how waste Sargassum natans can be utilised to produce sodium alginate. The novelty in this research lies in the optimisation process, whereby multistage extraction and precipitation were investigated over commonly used single stage processing, in an effort to maximize both yield and purity. The results showed that a maximum yield of 19% was observed after 1 stage, while the purity was 74% after 4 stages. In addition, optimisation of the multistage precipitation process using the Global Optimization Toolbox in MATLAB R2017b provided a novel model which indicated that a compromise between the maximum purity and yield can be obtained at 3 stages; 71 – 74% and 12 – 16%, respectively. Furthermore, characterisation was done using FTIR and NMR, with results comparable to a commercial sodium alginate brand, giving absorption bands at 1610 cm^{-1} and 1395 cm^{-1} and an M/G ratio of 0.51, respectively.*

Keywords*: Sodium Alginate; Sargassum natans; NMR; Multistage Extraction; Multistage Precipitation; Optimisation*

Authors' Biographical Note:

Akeem Mohammed *is a second-year MPhil student at the Department of Chemical Engineeering at The University of the West Indies, St Augustine, Trinidad and Tobago. He is currently doing research work on the fabrication of biocomposite films as an alternative plastic and material science.*

Rakesh Bissoon *is an Associate Professional at the Department of Chemical Engineeering at The University of the West Indies, St Augustine, Trinidad and Tobago. He has contributed to this work in the extraction process of sodium alginate.*

Elisheba Bajnath *is a Bachelors of Science graduate at the Department of Chemical Engineeering at The University of the West Indies, St Augustine, Trinidad and Tobago. She has contributed to this work in the extraction process of sodium alginate.*

Kristy Mohammed *is an Associate Professional at the Department of Chemical Engineeering and at The University of the West Indies, St Augustine, Trinidad and Tobago. She has done research in the formation of hydrogels from alginate*

Thérèse Lee *is an Instructor at the Department of Chemical Engineeering at The University of the West Indies, St Augustine, Trinidad and Tobago. Her research interests are in the field of process optimisation and controls.*

Meera Bissram *is a Laboratory Technician at the Department of Chemical Engineeering at The University of the West Indies, St Augustine, Trinidad and Tobago. She does work in characterisation and analytical techniques.*

Nigel John is *an Instructor at the Department of Chemistry at The University of the West Indies, St Augustine, Trinidad and Tobago. His research area is in Physical Chemistry.*

Nigel. K Jalsa *is a Lecturer at the Department of Chemistry at The University of the West Indies, St Augustine, Trinidad and Tobago. He is involved in the development of catalysts, synthesis of novel cyclodextrin derivative and synthesis of Peptide Nucleic Acids.*

Koon Yang-lee *is a Senior Lecturer at the Department of Aeronautics at Imperial College London. His research focuses on the development and manufacturing of novel polymeric materials with a focus on tailoring the interface between two (or more) phases to bridge the gap between chemistry, materials science and engineering.*

Keeran Ward *is a Lecturer at Department of Chemical Engineeering at The University of the West Indies, St Augustine, Trinidad and Tobago. His research interests are in Bioengineering/ Materials Science, Chemical Engineering and Catalysis.*

■

Fabrication of Calcium Alginate Thin Films from *Sargassum Natans* for the Adsorption of Heavy Metal Ions from Waste Water

Chantal Mohammed[1], Shivanie Mahabir[2], Kristy Mohammed[3], Nigel John[4], Koon Yang-lee[5], and Keeran Ward[6]

[1,2,3,,6] Faculty of Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies.
E-mails: Chantal.mohammed08@gmail.com, shivanie.n.mahabir@hotmail.com, kristy_m11@hotmail.com Keeran.ward@sta.uwi.edu
[4]Faculty of Science and Technology, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies; E-mail: nigel.john@sta.uwi.edu
[5]Department of Aeronautics, Imperial College, London, United Kingdom; E-mail: koonyang.lee@imperial.ac.uk

Abstract: *The Caribbean region has seen the sudden influx of Sargassum onto its shores affecting the livelihood and tourism of its rural communities. Sodium alginate extracted from sources of Sargassum are known for its enhanced gelling and cross-linking properties, making the waste seaweed potentially attractive as an adsorbent for heavy metal ions. Heavy metal ions enter the environment mainly through industrial activities and even at low concentrations can severely affect ecosystems. Calcium alginate has been exploited in previous research in the form of ion exchange beads, however, the utilisation of thin films has not been considered. Therefore, this paper seeks to explore the adsorption potential of calcium alginate thin films derived from Sargassum natans (S.natans) for Pb^{2+}, Cu^{2+} and Cd^{2+} ions. The Langmuir isotherm successfully modeled the adsorption of Pb^{2+} and Cu^{2+} with maximum capacities of 8.5 and 6.5 g/L, while the Freundlich isotherm fitted Cd^{2+} with an intensity of 1.61 for S.natans. Kinetic studies into adsorption behaviour showed that the heavy metals followed the pseudo-second-order model (R^2>0.98), elucidating that ion exchange predominantly governed the adsorption process. Characterisation using FTIR showed that binding was facilitated through bidentate chelating coordination, while SEM gave further insight into the effect of metal affinity on film morphological changes. Furthermore, NMR characterisation revealed that G-block monomers influenced kinetic parameters and promoted selectivity as follows: $Pb^{2+} > Cu^{2+} > Cd^{2+}$.*

Keywords*: Calcium alginate; Thin film; Biosorption; Heavy metal ions; M: G ratio, Sargassum natans*

Authors' Biographical Notes:

Chantal Mohammed *is a second-year MPhil student doing work on 'the use of calcium alginate derivatives from Sargassum natans for bioremediation' in the Department of Chemical Engineering at The University of the West Indies, St. Augustine, Trinidad and Tobago.*

Shivanie Mahabir *is a Masters of Science graduate in the Department of Chemical Engineering at The University of the West Indies, St.Augustine. She has contributed to the use of calcium alginate thin films for bioremediation.*

Kristy Mohammed *is an Associate Professional in the Department of Chemical Engineering at The University of the West Indies, St.Augustine. She has contributed to the extraction of sodium alginate from Sargassum natans and the use of Calcium alginate for the formation of hydrogels.*

Nigel John *is an Instructor in the Department of Chemistry at The University of the West Indies, St. Augustine. He has contributed to the field of Physical Chemistry.*

Koon Yang-lee *is a Senior Lecturer at Imperial College London in the Faculty of Engineering, Department of Aeronautics. His research focuses on the development and manufacturing of novel polymeric materials with a focus on tailoring the interface between two (or more) phases to bridge the gap between chemistry, materials science and engineering.*

Keeran Ward *is a Lecturer at The University of the West Indies, St Augustine, Trinidad and Tobago. Dr. Ward has undertaken research in Bioengineering/ Materials Science, Chemical Engineering and Catalysis. His most recent publication is 'Multistage Extraction and Purification of Waste Sargassum natans to Produce Sodium Alginate: An Optimisation Approach'.*

■

Process Simulation and Energy Analysis of Carbon Dioxide Removal from the Ammonia Process

Thérèse G. Lee[1] and Keeran Ward[2]

Faculty of Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies.
[1]E-mails: Therese.Lee@sta.uwi.edu
[2]E-mail: Keeran.ward@sta.uwi.edu

Abstract: *Carbon dioxide (CO_2) is a greenhouse gas which is known to be a major contributor to global warming. There are many separation techniques which are currently being used for carbon capture such as amine-based absorption, gas separation membranes and adsorption-based separation. Currently, the most common commercial method for capture is amine-based chemical absorption. Many studies have explored the modelling and simulation of amine absorption in the carbon dioxide removal process from pilot plant data. However, significant research has not been done in simulating the amine absorption for the CO_2 removal process for an actual large scale process, considering the impact of process changes on the energy requirements for plant. Therefore, this study investigates the use of methyl diethanolamine (MDEA) with piperazine (PZ) as the activator for the removal of CO_2 from raw synthesis gas produced from an 1800 mtpd ammonia process plant. The impact of various process changes on energy and utility requirements were investigated. For this study, the CO_2 removal for the activated MDEA processes was simulated utilising Aspen Plus® and a typical CO_2 removal configuration. The Electrolyte Non-Random Two Liquid Redlich Kwong (ENRTL-RK) was selected as the property method and the electrolyte calculations were performed utilising user specified chemistry based on models developed by Aspen. The rate-based model for the absorber and stripper was utilised for CO_2 removal. A sensitivity analysis was conducted to determine how changes in variables affected the energy consumption of the process. The manipulated variables were the lean amine's composition, flowrate and temperature, temperature of the synthesis gas and stripper duty. An economic analysis was then conducted to determine the impact of the sensitivity analysis on energy and utility changes. The results of this study showed that the simulation of the process had variances within ±10% of the design data. Furthermore, the MDEA concentration had the greatest impact on CO_2 removal as well as utility consumption and energy requirement. Therefore, a compromise should be made between operating costs and synthesis gas purity in an effort to produce the most realistic and operational process design.*

Keywords*: Process simulation, energy analysis, carbon dioxide removal, ammonia process*

Authors' Biographical Notes:

Thérèse G. Lee *is associated with the Faculty of Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies*

Keeran Ward *is associated with the Faculty of Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies*

■

Anatomy and Histology of the Digestive Tract of the Cocrico (*Oratalis ruficauda*)

Venkatesan Sundaram[1], Chantal Perryman[2], Kern Johnson[3], Avinash Lodie[4], Clive Folkes[5], and Andrew A. Adogwa[6]

Department of Basic Veterinary Sciences, School of Veterinary Medicine, Faculty of Medical Sciences, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies
[1]Email: Venkatesan.Sundaram@sta.uwi.edu; [2]Email: chantalperryman@gmail.com;
[3]Email: simply_kern@hotmail.com; [4]Email: a_lodie@yahoo.com; [5]Email: goodfolkes@yahoo.com;
[6]Email: adogwa01@yahoo.com.

Abstract: *The Cocrico (Oratalis ruficauda), one of the national birds of Trinidad and Tobago has drastically reduced in number in the recent years due to illegal hunting in Tobago. The captive rearing and breeding of these birds was in serious consideration as a part of the conservation programme. The understanding of the normal biology of this bird is essential to make better captive breeding and rearing policies. But, there is a dearth of published data related to, or describing, the detailed anatomy and histology of this bird apart from relating to commercial poultry. Therefore, the present study aimed to study the anatomy and histology of the digestive tract of the species, which in turn helps in developing suggestions for improvements in rearing, and to get a better understanding of its growth and production. Five apparently healthy adult birds (2 males and 3 females) were euthanized with the permission of the Forestry Division, Tobago House of Assembly (THA). The gross anatomical observations were made by dissection and the specimens were collected and fixed in 10% buffered formalin and processed by routine histological methods and stained with H&E and histological observations were made. The esophagus extended from the pharynx to the proventriculus with an average length of 14.1 cm and dilated at the thoracic inlet to form a crop with average breadth of 2.92 cms. The mucosa lined by stratified squamous epithelium with non-keratinized type with series of tubular mucous glands. The tunica muscularis consisted of inner and outer layer of smooth muscles. The stomach made up of a proventriculus and gizzard with a narrow isthmus between them. The proventriculus was spindle-shaped and measured an average length of 2.63 cm whereas ventriculus was lens-shaped and measured an average of 3.10 cm. The mucosa of proventriculus was extensively folded with simple tubular glands whereas the gizzard presented low folds with branched glands. The intestines consisted small intestines (duodenum, jejunum and ileum), paired ceca and small colorectum, which contributed 70.7% of the digestive tract length. The villi were well developed in duodenum and decline in number in jejunum and ileum. The anatomy and histology of the digestive tract of the cocrico showed several similarities with chicken but notable differences like poorly developed crop, the absence of an esophageal tonsil, a relatively thin gizzard, under-developed caeca and the absence of caecal tonsils.*

Keywords*: Process simulation, energy analysis, carbon dioxide removal, ammonia process*

Authors' Biographical Note:

Venkatesan Sundaram *is Senior Lecturer in Veterinary Histology and Embryology. He has more than 20 years of teaching and research experience in the field. He has published 57 research articles. His research interests are comparative vertebrate morphology, neuroanatomy, avian anatomy and reproductve biology.*

Chantal Perryman, Kern Johnson, Avinash Lodie and Clive Folkes *were the DVM students who carried out the research work.*

Andrew A. Adogwa *is Professor of Anatomy (Rtd.) who has more than 40 years of experience in teaching and research in the field of veterinary anatomy. He has published 62 research articles in the field of anatomy.*

■

Potential Use of Tropical Landfill Leachate in Manufacturing Portland Cement Concrete

Samantha Jagmohan[1], Abrahams Mwasha[2] and Winston Mellowes[3]

Faculty of Engineering, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies
[1]Email: samantha_jagmohan@yahoo.com
[4]Email: Abrahams.Mwasha@sta.uwi.edu;
[2]Email: wamello@yahoo.com

Abstract: *Landfills are known sources of environmental contamination through the formation of leachate, which is a contaminated aqueous effluent produced when water percolates through the waste in landfills. Previous research has shown that landfills pose a direct threat to water resources and health in Trinidad and Tobago, and that there is the need to find efficient ways to manage landfill leachate. A recent study showed that landfill leachate was able to be used in the production of sand-lime products. As concrete is a common construction material used within the Caribbean, it is being proposed that tropical landfill leachate can be utilised in the making of concrete products. Treated (TL) and Untreated (UTL) tropical leachate at 25, 50, 75 and 100% were used as a replacement of water in making concrete cubes. Compressive strength of these cubes was then measured against the controls at 3, 7, 14, 21 and 28 days. Cube samples were then analysed for hydrated products using Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD). The Concrete cubes made with untreated tropical leachate produced similar and even greater compressive strength than cubes made with treated leachate and the controls. It is postulated that the higher content of sodium, calcium and solids in the leachate could have possibly contributed to the higher compressive strength. This study is the first of its kind to use leachate in concrete and supports the possibility that tropical landfill leachate can serve as a replacement of water in the making of concrete products.*

Keywords*: Process simulation, energy analysis, carbon dioxide removal, ammonia process*

1. Introduction

The landfills within Trinidad and Tobago (T&T) are known sources of environmental pollution and health hazards caused by harmful contaminants resulting from the mismanagement of leachate. *Landfill leachate is a contaminated aqueous effluent produced when water percolates through the waste in the landfill caused primarily by precipitation, surface run-off, and infiltration* (Mojiri *et al.*, 2014). Currently within T&T there are three major landfill sites, namely, Beetham, Forres Park and Guanapo. The Forres Park Landfill site is the only landfill facility that was designed using engineering principles and equipped with a leachate collection system Studies carried out by the Environmental Management Authority (EMA) in December 2003 have indicated that the aquifer systems in northern Trinidad may be at risk of contamination from several sources of anthropogenic pollutants such as landfill leachate (SWMCOL and DFA Infrastructure International Inc., 2010). SWMCOL and by extension the services of a consulting firm, DFA Infrastructure International Inc. (DFA) developed a surface water and ground water monitoring program at each of the Beetham and Guanapo landfills. The values obtained exceeded certain parameters such that they are well above the values stipulated by various standards. Namely, Trinidad and Tobago Environmental Management Authority Water Pollution Rules Second Schedule, Guidelines for Canadian Drinking Water Quality, The World Health Organisation (WHO) Guidelines for Drinking Water Quality (WHO, 2008).

It was suggested that the landfill leachate is contaminating the surface and groundwater resources. The study covered an initial characterisation of the surface and groundwater quality in the vicinity of the Guanapo and Beetham Landfills and showed that the operations at the landfills and the expected generation of leachate were adversely impacting the water resources. In addition, while the results of this study indicated that the surface and ground water at both landfills is contaminated by leachate, and there is off site migration of contaminants, the extent to which this has impacted the surrounding areas of water is unknown, compared to other potential sources of contamination.

Given the environmental implications of landfill leachate runoff from the other two landfills, it is imperative that an adequate leachate collection system be developed and or that said leachate is utilised in an environmentally sensitive manner in Trinidad and Tobago. A recent study was able to show that landfill leachate can be used sustainably in the making of sand-lime bricks. However, similar investigations haven't been adopted in PCC which is the primary construction material used within the Trinidad and Tobago. As such it is imperative to determine if Landfill leachate can be utilised in the making of concrete products. This study therefore aimed to investigate the

compressive strength of concrete cubes that have been modified using treated and untreated tropical landfill leachate with emphasis on mechanical and micro-structural properties of the concrete cubes. Untreated leachate (UTL) is leachate in its fresh state (raw) and is by no means altered physically, biologically or chemically. Treated Leachate (TL) represents leachate obtained from an Engineered Biological Wetland Leachate Treatment System at the Guanapo Landfill Site as a pilot study. The usage of "tropical" denotes leachate taken from a landfill in Trinidad or elsewhere whose landfill has both solid and hazardous wastes and where the weather entails cyclic wet and dry conditions.

2. Literature Review

Globally, the practice of MSW disposal by *landfilling* is widespread due to low-cost, moderately easy operation, and landscaping re-establishing abilities (Davis and Cornwell, 2008). Likewise the current method of waste disposal in the Caribbean and in T&T is landfilling (SWMCOL). A major drawback of landfilling however is the production of leachate (Aziz *et al*., 2010). The Guanapo Landfill Site is positioned at the foothills of the northern range within the Tunapuna/Piarco Region at elevation of 457 to 610m. The natural ground surface slopes towards the south with overland flow drainage to the southeast and southwest along defined drainage swales near the south property boundary. The swales drain to rivers east and west of the site. The leachate mixes with surface runoff and groundwater seepage and is directed via swales to the east and west of the property (SWMCOL and DFA Infrastructure International Inc., 2010). The 12 ha landfill site receives approximately 270 tonnes of waste each day and is situated between El Cedro and Maturita tributaries which flow into the Guanapo River joined to the Caroni River. The surrounding area is mainly agricultural in conjunction with quarrying, residential and light industrial activities. Guanapo landfill site experiences heavy rainfall in the rainy seasons (SWMCOL, 2018).

A recent study in 2016 (Dachowski, 2016) on landfill leachate as a modifier of properties, was observed in sand-lime products. In comparison to the controls, the modified product with landfill leachate gained higher compressive strength, and, had a notable impact on bulk density. Furthermore, leachate combined with admixture exhibited similar compressive strength to the original product. SEM analysis of the modified samples with leachate and admixture revealed the occurrence of C-S-H phase, tobermorite and xonotlite. Sand-lime products are common in temperate countries whilst cement is a common material used in the construction industry in T&T and by extension the wider Caribbean. Generally potable water is needed in the mixing of concrete (Neville, 2005). Abram (1924) discovered that the polluting influence caused by impurities in non-potable water utilised in concrete can debilitate the compressive strength of concrete.

Moreover, Smith (1976) showed that non-portable water utilised for curing concrete can weaken concrete strength .Impurities and contaminating substances are most likely to inhibit hydration and effective bonding between aggregates (Smith, 1976). Scientists have conducted feasibility studies of various mixing water for concrete production using grey water (Peche *et al*., 2015), river water (Olugbenga, 2014), well water and wastewater (More and Dubey, 2014) among others and showed a positive effect on compressive strength. As such the possibility exists that landfill leachate can be used as a replacement of potable water in concrete mixing. Finding ways to replace water in the construction industry is essential as a great quantity of water is expected in the making and curing process of concretes annually worldwide. In Iran for instance, 80 MCM of concrete is produced for general cement grade and approximately require 11,000 MCM of water annually for concrete production (Shirzai *et al*., 2012). Using landfill leachate as a replacement for water in concrete mixing can possibly assist in reducing the amount of water needed for the construction industry in Trinidad and Tobago.

3. Materials and Method

3.1 Leachate Collection

Leachate samples were collected from Guanapo Landfill Site. This site is a non-engineered facility (was not designed using engineering principles) dome-shaped and overland flow occurs at the east and west sides. The cover material is northern hill. It has a liner and is not equipped with leachate collectors and by gravity it drains from the waste heaps. The leachate sample was diluted into various percentages- precisely, 100%, 75%, 50% and 25%. Experiments were carried out using UTL from pond # 1(GPS coordinates of N'06°89.657', W'11°78.327') and treated leachate from an Engineered Wetland System (GPS coordinates of N'06°89.494', N'11°78.134'). Leachate samples were collected from a depth of 3-5m, dispensed into 4 separate bottles, placed in a cooler with ice and transported to the laboratory. A number of analytical measurements of the treated and untreated leachate were conducted using the United States Environmental Protection Agency (USEPA), American Society for Testing and

Materials (ASTM) and Standard Method for Examination of Water and Wastewater (SMEWW) protocols. Table 1 shows the properties of the leachate samples.

Table 1. Properties of Tropical Landfill Leachate

Reported average			
	NTU	64	42
Turbidity	°C	27 (field); 22.9 (lab)	26 (field); 23.38 (lab)
Temperature	ppt	3.5	2.8
Salinity	mg/L	318	375
Hardness	mg/L	11.6	15.4
Nitrate	mg/L	7.96	5.35
Phosphate	mg/L	3692	2418
TDS	mg/L	200	125
TOC	mg/L	4.9	0.4
TOG	mg/L	188	65
TSS	mg/L	0.23	0.84
Dissolved oxygen	µs/cm	6209	5475
Conductivity	-	8.2	7.15
pH	g/L	4.2	3.67
TDS	mg/L	4.74	1.33
BOD_5	mg/L	1916	1474
Potassium	mg/L	3462	2118
Silicon	mg/L	4711	4317
Sodium	mg/L	1275.92	953.38
Alkalinity	mg/L	292.8	99.6
Ammonia	mg/L	186	25
COD	mg/L	24.82	34.24
Chlorides	mg/L	38.78	34.93
Magnesium	mg/L	63.75	93.05
Calcium	mg/L	<0.0001	<0.0001
Aluminum	mg/L	<0.0001	<0.0001
Barium	mg/L	0.016	0.003
Cadmium	mg/L	1.665	0.104
Chromium $^{6+}$	mg/L	6.75	19.5
Iron	mg/L	<0.0001	<0.0001
Lead	mg/L	<0.0001	<0.0001
Copper	mg/L	<0.0001	<0.0001
Mercury	mg/L	0.398	0.01
Zinc	mg/L	3.6	5.8
Manganese	NTU	64	42

- Portland cement: The cement used was a locally manufactured cement from Trinidad Cement Limited known as *Type 1P OPC (Pozzolan) Premium Plus.*
- Aggregate: Naturally-extracted Guanapo Quartzite aggregate from National Quarries limited, Guanapo Quarry in Trinidad was used in the study.
- Coarse aggregate: Crushed Guanapo quartzite of maximum nominal aggregate size 20 mm was thoroughly washed with the laboratory's tap water, oven dried at 105°C and cooled to room temperature until ready for use. The fineness modulus was 3.6.
- Fine aggregate: The fine aggregate was thoroughly washed with tap water to discard impurities such as silt particles, fine dust, clays, and other substances like organic materials. Sand was oven-dried for 24 hours and cooled to room temperature before using. The fineness modulus was found to be 3.02.
- Potable Water: The laboratory's tap water (local pipe borne) supply was used in the study. The water was free from organic substances and acid. The properties of the water used are provided in Table 2.

3.2 Mix Design

The mix design in the study was based on the principles of British Standard, part 1, BS 8500-1:2015+AI: 2016 code. The design was made for a compressive strength of 30MPa at 28 days with a slump range of 90 to 160mm belonging to class S3 (see Table 3).

Table 2. Analysis of Laboratory Water Supply

Parameters	Results	WHO Drinking Water Guidelines	Conformity
Alkalinity	60 mg/L	*≤ 200*	*Yes*
Aluminum	0.10 mg/L	*≤ 0.2*	*Yes*
Bicarbonate	73 mg/L	*≤ 1000*	*Yes*
Calcium	26 mg/L	*≤ 200*	*Yes*
Chlorides	27 mg/L	*≤ 250*	*Yes*
Colour	25 HU	***≤ 15***	*No*
Conductivity	250 umhos	-	*NA*
Magnesium	5.8 mg/L	*≤ 0.5*	*No*
pH	*6.7;7.0**	*6.5-8.5*	*Yes*
Residual Free Chlorine	0.2 mg/L	***≥ 0.5***	*No*
Total Dissolved Solids	164 mg/L	*≤ 500*	*Yes*
Total Hardness	88 mg/L	*≤ 300*	*Yes*
Total Iron	0.45 mg/L	***≤ 0.3***	*No*
Turbidity	3.2	*≤ 5*	*Yes*

Table 3. Mix proportions per concrete batch (*15 specimens*)

Mix Proportion	Water	Cement	Fine Aggregate	Coarse Aggregate
By weight (kg/m^3)	287	0.0188	1160	771
Weight (kg)	2.7	6.04	21.8	14.5
Leachate Mix: Percentage of water replaced for TL and UTL mix:				
Leachate Percent	**100%**	**75%**	**50%**	**25%**
Leachate Volume (ml)	2700	2025	1350	675
Leachate amount (kg)	2.7	2.025	1.350	0.675
Water (ml)	0	675	1350	2025
Water (kg)	0	0.675	1.350	2.025

3.3 Manufacturing of Test Specimens

Concrete cubes of 100mm sides were manufactured at the UWI Civil Engineering, Structural Laboratory using the above design mix. A minimum of thirty (30) cubes were casted for each treatment. Individual constituents were accurately measured and poured into a mechanical cement mixer (see Table 4). Mixing was performed for 3 minutes. The room temperature was 27 ± 2 °C and relative humidity 60%. Mortar was added into greased cube molds to approximately half level. During the vibration period of 3 minutes, the remaining quantity of mortar was added and prodded with a trowel. The top surface was smoothened. The compacted mix was securely stored at controlled temperature of 27 ± 2 °C and relative humidity 90% for 24 hours.

Table 4. Preparation of cubes

Mix	ID.	Matrix	Water %	Leachate %	Cubes/Batch (n)	Total cubes (n)	Weight (kg)
1	CTL	Control	100	0	15	30	3.0
2	UTL 100	Untreated	0	100	15	30	3.0
3	UTL 75	Untreated	25	75	15	30	3.0
4	UTL 50	Untreated	50	50	15	30	3.0
5	UTL 25	Untreated	75	25	15	30	3.0
6	TL 100	Treated	0	100	15	30	3.0
7	TL 75	Treated	25	75	15	30	3.0
8	TL 50	Treated	50	50	15	30	3.0
9	TL 25	Treated	75	25	15	30	3.0

3.4 Curing of Specimens

Cubes were de-molded after 24 hours and immersed into corresponding water baths to be cured until they were ready to be tested. The specimens were cured for 3-day, 7-day, 14-day, 21-day and 28-day strength.

3.5 Compressive Strength

Three representative standard-cured test specimens were tested at age breaks of 3d, 7d, 14d, 21d and 28d and average compressive strength was computed conforming to specifications in ASTM C39.

3.6 Powdered X-Ray Diffraction Analysis – Mineral Content Test

XRD is a non-destructive and non-contact method ideal for in situ study specifically nanomaterials and information about microstructural properties and crystallographic structure, chemical composition and physical properties of materials (Sharma, *et al*., 2012). Prior to testing samples were crushed mechanically using a Braun Chipmunk Crusher and then sieved using BS 410 300µm aperture laboratory test sieve to obtain a desired powder form.

3.7 Scanning Electron Microscopy (SEM)/Energy Dispersive System (EDS) Analysis – ED

In this study, the morphology of selected concrete samples was analysed through SEM-EDS to describe the micro-structural properties the degree of cement hydration and phase composition changes in test units. The equipment used was Phillips SEM 505 with EDAX Genesis Software, and images were taken from Gatan Digi scan (Digital Micrograh) System. The samples were prepared in powder form and placed in the Denton Desk II cold sputter unit to be sputter coated (with gold). Sputtering and evaporation produces a thin layer of metal on the sample surface. The sample was introduced to a vacuum chamber with a metal target to which gas- most times Argon is introduced. A potential was applied between target and sample generating an electric field which ionizes Argon gas which is accelerated at the cathode. Ar ions collided with the target and sputter off metal atoms. When the metal atoms are in the gas phase collision with Argon ions produces a metal atom "cloud". Finally metal atoms settle on the samples. SEM-EDS were done on sample of ages 3d, 7d, and 28d only.

4. Data Analysis and Results

IBM SPSS Statistics 21 software was used to conduct inferential statistics on data obtained and Microsoft Excel 2016 Software. Compressive Strength: The use of UTL had no adverse effect on compressive strength of concrete while TL 25% and 75% were denatured easily producing smaller strengths (see Table 5). As the curing time increased the compressive strength increased for control, UTL and TL groups. Statistical analysis determined that the compressive strength was greater than or equal to the controls for all the UTL samples. The highest compressive strengths were achievable with UTL 50% and TL 100%. TL 25% and 75% did not produce strengths comparable to the other percentages and to the control possibly due to sampling error. The study proved that 50% raw landfill leachate and 100% treated leachate can be used in PCC production and that it is possible that the higher content of sodium, calcium and solids in the leachate could have possibly contributed to the higher compressive strength.

Based on the results obtained for increased strength in the UTL can be attributed to the literature taken from publications by Noruzman et al. (2012), Ghrair et al. (2016) and Asadollahfardi et al. (2016). The greater compressive strength associated with UTL concrete cubes may perhaps be a result of the physical and chemical properties of UTL because not only does it differs in many respects from TL and PW, the higher concentration of solids and chloride ions could be an advantage.

Table 5. Compressive Strength Results

	N	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
CTRL	15	41.006	6.23314	1.6093	37.554	44.4585	28.00	48.40
UTL 25	15	39.506	6.42845	1.6598	35.946	43.0666	27.30	49.20
UTL 50	15	44.093	4.61526	1.1916	41.537	46.6492	35.80	51.80
UTL 75	15	43.026	5.09502	1.3155	40.205	45.8482	33.10	50.40
UTL 100	15	43.213	4.19334	1.0827	40.891	45.5355	36.60	49.60
TL 25	15	20.580	6.33180	1.6348	17.073	24.0864	12.90	29.40
TL 50	15	37.573	3.82837	.98848	35.453	39.6934	31.20	44.40
TL 75	15	8.0000	1.19523	.30861	7.3381	8.6619	5.70	9.70
TL 100	15	37.660	4.43216	1.1443	35.205	40.1144	28.20	44.60

SEM images showed gradual microscopic changes between 3 to 28 days during the hydration process for the controls as well as the treated and untreated leachate samples (see Figure 1). However, for the UTL samples there appeared to be more hydrated products being formed at the 28-day compared to the controls and TL concrete samples. Based on the conclusions from Jumante and Manea (2012) study on XRD for hydration processes of OPC it was shown that the largest peaks were produced after 3 days and corresponded to tobermorite gels, portlandite for the second peak and ettringite showed the smallest values. Therefore, tobermorite was the most abundant phase at the end of 3 days. Subsequently at 28 days, tobermorite develops as a dense and more compact mass. There will still be non-hydrated belite grains and ettringite will be difficult to recognise. A reduction in values between tobermorite and portlandite phases happens with time between 3 to 28 days. As type I Portland cement in the first 3 days of the hydration process tobermorite originates as alite is more abundant than belite and they are both sources for portlandite development which happens slowly. The results more or less dictated that trend and it was revealed that an improved C-S-H was established in the leachate specimens with highest compressive strength (Jumate and Manea, 2012).

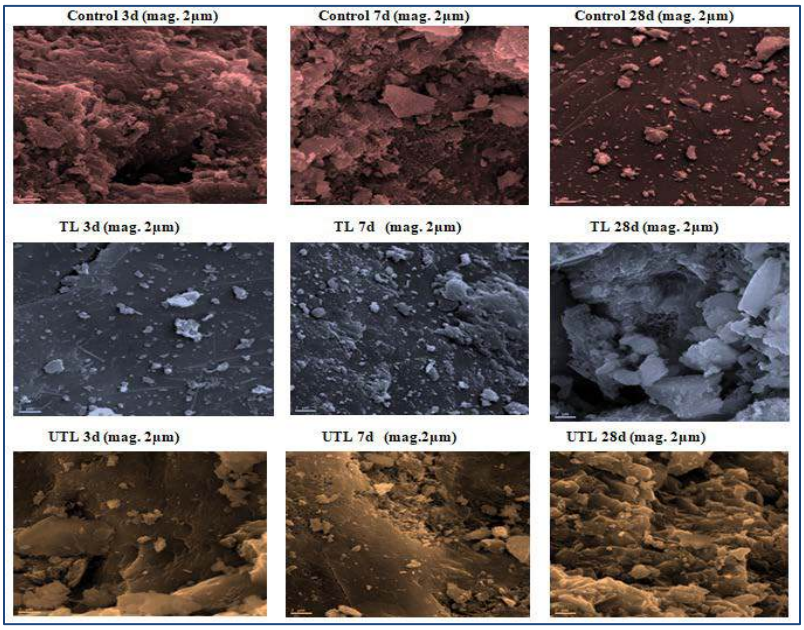

Figure 1. SEM images obtained for the samples tested

5. Conclusion

Each type of impurity found in the leachate causes a different reaction with the cement constituents. Some reactions can affect the concrete strength. Some will react in a positive way that the net outcome may be harmless and may improve the properties of concrete. Many researchers in the past have determined tolerable limits of impurities in potable and non-potable water and based on the thresholds it is safe to predict when the impurity becomes harmful. Thus, it can be suggested that tropical landfill leachate can be used as a mixing water replacement in PCC without drastic harmful impacts because most of the parameters were below the limits established. In many urbanised regions of T&T, and the wider Caribbean, with the rapidly escalating population growth and industrial expansions, the use of tropical landfill leachate as a replacement of potable water in concrete will assists in reducing water scarcity and assist greatly in sustainable development.

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Authors' Biographical Notes:

Samantha Jagmohan *is a final year student in the Master of Environmental Engineering (MSc) Programme at The University of the West Indies, St. Augustine Campus. Her research interest focuses on alternative uses of environmental contaminants.*

Abrahams Mwasha *obtained his PhD in Wolverhampton, England. His research interests include Problematic soils (expansive, collapsible, soft soils), Applications of sustainable materials in construction industry, waste management and renewable energy. He has published more than 50 peer reviewed journal and conference papers. Abrahams was first prize winner of the BIZCOM social enterprise award, organised by the MERCIA Institute of Enterprise for the idea of "Novel and Sustainable Technology", recipient of competitive Trinidad and Tobago Government research grant and many other research grants. He is presently a senior lecturer in Department of Civil and Environmental Engineering, at The University of the West Indies, Trinidad and Tobago*

Winston Mellowes *is a former Head of the Department of Chemical Engineering and Deputy Dean Postgraduate and Assistant Dean Undergraduate students at The University of the West Indies St. Augustine Campus. His major research areas have been in Sugar Technology, Environmental matters, and biomass utilisation and transport phenomena and food technology. He has a joint US patent in Xanthan Gum production from sugar cane juices. Professor Mellowes currently serves as the Chairman of the Board of Engineering of Trinidad and Tobago and President of the Caribbean Academy of Sciences (CAS). He is a Director of the Accreditation Council of Trinidad and Tobago. He has organised workshops for primary and secondary School teachers in the "Hands on Teaching of Science Methodologies"/ STEM in the Caribbean Region and as Focal Point for Science IANAS. Main theme has been sustainable development. Professor Mellowes is Fellow of APETT and the CAS and a recipient of APETT Career of Excellence Award. He has also been recognised as a Caribbean Icon in Engineering.* ■

How Returns differ by Field of Study in Trinidad and Tobago?

Roshnie Doon

The Sir Arthur Lewis Institute of Social and Economic Studies (SALISES), Faculty of Social Sciences, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies.
Email: roshnie.doon@my.uwi.edu

Abstract: *This study examines the influence that a workers' field of study has on his earning capacity. Using individual persons' data from the Continuous Sample Survey of the Population (CSSP), for the period 1991-2015, the wage returns of private and public sector workers is estimated by employing the Quantile Regression technique. This study finds that low and middle-income workers primarily in the fields of science, engineering and architecture, social science, and transport and services all benefitted from a rise in wage returns across the 2004-2015 cohort. The returns of high-income workers mainly in Science, Technology, Engineering and Mathematics (STEM) fields improved in 2004-2015. It is possible, that such an occurrence maybe related to not only changes in the concentration of high/semi-skilled workers, but also the saturation of the labour market, worker productivity, and the presence of both educational mismatch and Skill Bias Technical Change (SBTC).*

Keywords: *Human Capital, Returns to Field of Study, Quantile Regression, Instrumental Variables, SBTC.*

Author's Biographical Notes:

Roshnie Doon *is currently a PhD. candidate in Economic Development Policy at the Sir Arthur Lewis Institute of Social and Economic Studies (SALISES), The University of the West Indies (UWI), St. Augustine. She holds a BSc. in Economics and Management Studies (with honors), and a MSc in Economics. She is a current recipient of the UWI Post Graduate Scholarship. Her main research interests include Applied Econometrics, Data Analytics, Programming, Labour and Developmental Economics, with special concentration on the area of Education.*

■

Activated Charcoal Promotes Surgical Wound Healing Effects of *Musa sapientum* and *Citrus Limon* Peel Gel in *Rattus novergicus*

James Omale

Department of Biochemistry, Faculty of Natural Sciences, Kogi State University, Anyigba, Kogi State, Nigeria, West Africa. Email: james.omale123@yahoo.com

Abstract: *Musa sapientum known as banana is a rhizomatous perennial crop used as source of starchy staple food for millions world over. Some parts of the crop have been claimed to be efficacious in the management of different ailments including wounds. Similarly, lemon, Citrus limon (L) Osbeck, is a specie of small evergreen tree in the flowering plant family Rutaceae. The fruit peel has been claimed to possess wound healing activity. The purpose of this study was to assess the effects of combining activated charcoal with banana and lemon peel gel on the healing of surgical wound s in rats. All experiments were conducted following standard procedures. Thirty six (36) Wister rats were divided into nine (9) groups of four (4) rats each. Wound control groups (Paraffin base), Standard (Povidone iodine) and experimental groups (4% w/w Citrus limon and Musa sapientum peel gel ointment) and (activated charcoal mixed with Citrus limon peel and or Musa sapientum peel). Surgical wound of 40mm X 40mm was created dorsally on each rat, cleaned daily with methylated spirit and treated with the formulated drugs. Measurements of wound contractions were done on the 4, 8, and 12th day of the experiment. Wound contraction rates were found to be higher in wound treated with Citrus limon and Musa sapientum peel gel ointment formulated with activated charcoal. Order of increasing wound contraction rate (unripe M.sapientum peel gel → ripe M.sapientum peel gel → activated charcoal + ripe M.sapientum peel gel → activated charcoal + unripe M. sapientum peel gel → unripe M.sapientum peel gel + C.limon peel gel → activated charcoal + C. limon peel gel). Wound contraction or healing elicited by the drugs in this investigation following topical application clearly indicates that activated charcoal enhanced the wound healing effects of M. sapientum and C. limon peel gel ointment. The observed efficacy could be due to antibacterial and adsorption characteristics of activated charcoal.*

Keywords*: Musa sapientum, Citrus limon, activated charcoal, wound healing and Rattus norvergicus.*

1. Introduction

Various plant species have served as a source of medicine for people all over the world, for years, plant is one of the most intense areas of natural product research yet the field is far from being exhausted. Plants and their extracts have immense potential for the management and treatment of wounds. Medicinal plants have an important role for the health of the individuals and communities. These plants have great medicinal values that lie in various chemical substances which produce physiological action on human body. Medicinal plants contain many chemical compounds such as alkaloids, flavonoids, glycosides, saponins, resins, oleoresins, sequiterpenes, phenolic compounds, fats and oils (Maruti et al., 2011). The prevalence of chronic wounds in the general population is relatively high. This condition is associated with several diseases and imposes a major social and economic burden on patients and health care systems. Thus, the search for alternative therapies for the treatment of chronic wounds is of fundamental importance (Atzingen et al., 2011; Novak et al., 2003). Despite the predominance of substances of synthetic origin in the therapeutic arsenal, including anti-inflammatory drugs , in recent years there has been a renewed interest in the therapeutic practices considered by many health professionals as popular or unscientific.

Hence, herbs and other natural remedies have been used as an alternative or complementary therapy (Garros et al., 2006). The pseudo-system of the banana plant and unripe banana peels contain copper, zinc, sodium, potassium, calcium, phosphorus and iron (Selema and Farago, 1996) and the fruit contains antioxidants, including vitamin C and E and beta carotene (Someya et al., 2002). Unripe banana extract promotes increased incorporation of thymidine into cellular DNA, which enhances cell proliferation (Novak et al., 2003). Unripe banana peel contains leucocyanidin, a flavonoid that induces cell proliferation, accelerating the healing of skin wounds (Lewis *et al.*, 1999).

Citrus fruit is an important medicinal plant of the family Rutaceae. It is used mainly for its alkaloids, which are having anticancer activities and the antibacterial potential in crude extracts of different parts (leaves, stem, roots, juice, peel and flower) of lemon against various bacterial strains. Citrus fruits have a broad spectrum of biological activity including antibacterial, antifungal, antidiabetic, anticancer, and antiviral activities due to alkaloids (Akhilesh et al., 2012). This present study was designed to evaluate the effect of activated charcoal in the acceleration of the wound healing activity of *Musa sapeintum and Citrus limon* peel gel ointments in rats surgical wounds.

2. Methodology

***Animals*:** The animals were obtained from the laboratory animal facility of Salem University, Lokoja, Nigeria. The sample consisted of 36 adult male rats (*Rattus novergicus albinus*) aged about 100 days and weighing roughly 250 grams. The animals were divided into nine (9) groups of four rats each. The rats in the control and standard groups were treated with paraffin base and povidone iodine, respectively. The experimental groups were treated with the formulated drugs at 4%. A 4x4cm wound was created on the back of each animal. The wound was cleaned daily with 0.9% saline. The size of the wound was measured with a caliper on day 4, 8 and 12. The wound was treated once daily.

Banana and Lemon Gel Preparation: The gel ointment used in the study was prepared from banana (*Musa sapeintum*) and lemon (*Citrus limon*) peels. The two fruits were purchased from the retailers in the market in Abuja, Nigeria. The fruits were washed with running tap water and allowed to dry at room temperature for 30 minutes. The fruits were peeled and the pulps discarded. The peels were then diced into small pieces of $1mm^3$, and were grounded in a ceramic mortar with pestle for one hour until homogenization was achieved. Each of the fruit peel yielded 150.3g of ground peel. Next, 4% gel was obtained by mixing 4g of ground peel with 96g of paraffin base. This was then put in a sterilized container and refrigerated and used throughout experimental days.

Surgical Wound Creation: Surgical wound creation was done after anaesthetization with ketamine hydrochloride (50mg). The furs of the animals were shaved dorsally within the radius of 6x6cm area. The excision lines were marked on the skin by a pen. The skin surface was wiped with 0.9%saline and a 4x4cm surgical wound was created on the back of each rat (Morton and Melone, 1972).

Surgical Wound Management: All animals in the control, standard and experimental groups were treated daily from day zero. Before any treatment the wound surface was cleaned with 0.9% saline. Next, paraffin (control), povidine iodine (standard), 4% unripe banana peel , ripe, lemon peel, ripe banana peel and lemon peel with activated charcoal, activated charcoal alone (Experimental groups) was applied to the surgical wound using a sterilized disposable cotton buds. A portion (0.1g) of drugs was applied. Wound contraction rate was measured using the following formula.

$$\% \text{ wound contraction rate} = \frac{\text{Initial wound area - Final wound area}}{\text{Initial area}} \times 100\%$$

The reduction of wound size was recorded in centimeters

***Statistical Analysis*:** The mean value ±S.D was calculated for each treatment.

3. Results

Wound contraction rates measured at the end of treatment on days 4, 8 and 12 are shown in Table 1. Topical application of the formulated drugs increased the percentage of wound contraction and significant wound healing on day 12, which indicates rapid epithelization and collagenization leading to the observed wound healing.

Table 1: Activated charcoal enhanced wound healing effect of banana and lemon peel gel

Group/Treatment	Percentage closure of wound area After days		
	4	8	12
1. Wound control (paraffin base)	20.00±1.50	35.01±5.00	45.00±2.50
2. Povidone iodine	25.00±2.70	37.50±5.00	52.00±5.00
3. Activated charcoal + unripe banana peel	22.50±9.57	35.00±1.00	57.40±2.50
4. Unripe banana peel	20.00±8.14	35.00±5.78	37.00±5.76
5. Activated charcoal + ripe banana peel	27.50±5.00	37.50±5.00	47.50±5.01
6. Ripe banana peel	15.00±5.70	30.00±8.17	40.00±8.20
7. Activated charcoal + lemon peel	22.50±2.89	45.00±4.08	68.60±2.45
8. Unripe banana + lemon peel	15.00±5.70	32.50±5.00	62.50±5.00
9. Activated charcoal alone	15.00±5.77	30.00±8.10	45.00±1.20

Remarks: Values are mean ±S.D (N = 4)

In fact, topical administration of activated charcoal + unripe banana peel accelerated the progression of wound healing by 12^{th} day i.e. (57.00 ±2.50) compared to control (45.00 ±2.50) and standard (52.00 ±5.00). This progression of wound healing is highest in group 7 animal treated with activated charcoal mixed with lemon peel (68.60 ±2.45). There was significant increase in wound closure in this group when compared with control and standard drug used ($p < 0.05$)

4. Discussion and Conclusion

Wound healing process consists of different stages including granulation, collagenization, collagen maturation and scar maturation which are concurrent but independent of each other. These are orderly cellular and molecular processes that interact to restore tissue integrity. Medicinal plants play an important role in maintaining the health of the general populace.

Unripe banana peels are used as a food source and in research as well. The chemical composition of unripe banana peel was first described by Selema and Farago (1996). Agrawal et al. (2009) related that extract of banana was given by gavage to rats for the treatment of skin wounds and favored wound healing which could be due to its antioxidant effect and on various wound healing biochemical parameters. Best *et al*. (1984) reported on the ulcer healing and anti-ulcerogenic properties of unripe banana.

Antimicrobial activity of dried fruit peel of *Citrus limon* has been evaluated (Junab et al., 2017). *Citrus limon* peel mixed with activated charcoal produced the highest wound contraction rate when compared with the control and standard drug used. This could be due to the reported antimicrobial activity of the plant.

In this study, wound contraction observed in the experimental groups on 4, 8 and 12 days of experimentation are highest with *Citrus limon* peel mixed activated charcoal. In all the groups, wound closure was more on day 12. Atzingen et al. (2011) conducted an experimental study in which unripe banana peel gel was used at different concentrations (2%, 4% and 10%) in the treatment of surgical wounds in rats, and reported wound contraction rates similar to our findings in animals treated with 4% gel for 12 days. Further studies are necessary to determine how activated charcoal promoted wound healing effects of banana and lemon peel gel in rats.

Postoperative wounds are commonly known to be complicated by infection. Earlier studies have shown that antimicrobial activity of various plants supports wound healing. Activated charcoal, banana and lemon peels possess antimicrobial activity these must have removed possible microorganism which could have prolonged wound healing, hence promoted wound healing.

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Author's Biographical Notes:

Omale James *is a Professor of Biochemistry in the Department of Biochemistry, Kogi State University, Anyigba, Nigeria. He is a member of Nigerian Society of Biochemistry and Molecular Biology, Nigerian Society of Experimental Biology and Society for Medicinal Plant and Natural Product Research (GA). His research interests are in the areas of Biochemical toxicology, Pharmaceutical biology and nutritional Biochemistry.*

■

Mechanistic Aspects of the Aerobic Copper-catalyzed Decarboxylative Thiolation of Benzoic Acids

Kerry-Ann Green[1] and Jessica M. Hoover[2]

C. Eugene Bennett Department of Chemistry, West Virginia University, Morgantown, West Virginia 26506, USA
[1]Email: kerry.green@mail.wvu.edu
[2]Email: Jessica.Hoover@mail.wvu.edu

Abstract: *Copper-catalyzed oxidative decarboxylative cross-coupling reactions are an atom-economical and regioselective route for the construction of C-C and C-heteroatom bonds. The combination of readily available, cheap carboxylic acid substrates, with earth-abundant copper, and environmentally benign oxygen as an ideal oxidant, makes this synthetic transformation very attractive. Diaryl sulfides are important structural components of pharmaceuticals, materials and biologically relevant compounds. However, despite the development of new copper-catalyzed synthetic strategies for C-S bond formation, the underlying mechanistic principles are under-explored and poorly understood. We describe an experimental mechanistic study into the aerobic copper-catalyzed oxidative decarboxylative thiolation of benzoic acids. A variety of synthetic, reactivity and kinetic studies provide evidence supporting the relevance of phenanthroline-ligated copper-based intermediates, the disulfide as oxidant and thiolating source, as well as insight into the role of molecular oxygen. Based on these findings, a plausible mechanistic pathway is proposed.*

Keywords: *Copper, Oxidative, Decarboxylative, Thiolation, Aerobic, Mechanistic*

Authors' Biographical Notes:

Kerry-Ann Green *received her B.S. in Chemistry from The University of the West Indies, Mona (UWI) in 2006. She then completed the Ph.D. degree in Chemistry from The UWI, Mona in 2013, under the supervison of Prof. Tara Dasgupta, Dr. Kamaluddin Abdur-Rashid and Dr. Paul Maragh with work on N-heterocyclic carbene complexes in homogenous catalysis. She was Assistant Lecturer then Lecturer in Chemistry at The UWI, Mona during the period 2014-2017. Dr. Green is currently a postdoctoral research fellow in the laboratory of Jessica M. Hoover at West Virginia University, investigating the underlying mechanistic principles of aerobic copper-catalyzed decarboxylative thiolation reactions.*

Jessica M. Hoover *earned a B.S. in Chemistry from Harvey Mudd College in Claremont, CA in 2004, and completed her Ph.D. in 2009 at the University of Washington in Seattle under the direction of Professors Jim Mayer and Forrest Michael. She completed postdoctoral work with Shannon Stahl at the University of Wisconsin-Madison, developing practical copper-catalyzed aerobic alcohol oxidation reactions. Her independent academic career began at West Virginia University (WVU) in 2012 as Assistant Professor. Dr. Hoover was promoted to Associate Professor in 2018. The Hoover research group at WVU focuses on developing and understanding new reactions, particularly C-C and C-heteroatom bond forming redox reactions, employing first-row transition metal catalysts.*

■

An Assessment of Host-plant Preference of *Aphis gossypii* in Jamaica

Desireina D.S. Delancy[1], Tannice A. Hall[2] and Eric Garraway [3]

Department of Life Sciences, Faculty of Science and Technology, The University of the West Indies, Mona Campus, Kingston, Jamaica, West Indies;

[1]Email: desyreina4@gmail.com
[2]Email: tannice.hall02@uwimona.edu.jm
[3]Email: eric.garraway@uwimona.edu.jm

Abstract: *Aphis gossypii Glover 1877 (Hemiptera, Aphididae) is extremely polyphagous. The host range includes many economically significant crops such as hot pepper, cucumber, cotton and okra. It directly damages its host plant by sucking and indirectly damages it by transmission of viruses, ultimately affecting the yield of the host. To facilitate integrated pest management, it is imperative to know the biology of the aphid and its host preference. Preliminary work has indicated host difference and biological difference of the species. The present study was designed to examine fecundity and colony growth as a measure of host preference and determine genetic differences in the Jamaican context. Aphids collected in the field were acclimatized on selected host plants for two generations after which fecundity and colony size were documented daily. Seven microsatellite loci were analysed for aphids from different host plants. Results obtained from the host preference aspect of this research shows that the Aphis gossypii reaches its highest fecundity on cucumber followed by pepper. Microsatellite results for field collected aphids showed that aphids within the same family display similar microsatellite electropherograms based on hosts. Further research is still needed to reinforce these observations which are currently being carried out. This paper will highlight the Jamaican context – distinguishing features, colony characteristics, additional observations on colonies in the field biology, distribution, predators, parasitoids, hosts and host-based microsatellites electropherograms.*

Keywords*: Aphis gossypii, host-plant preference, microsatellites*

Authors' Biographical Notes:

Desireina D.S. Delancy *is associated with the Department of Life Sciences, Faculty of Science and Technology, The University of the West Indies, Mona Campus, Kingston, Jamaica, West Indies.*

Tannice A. Hall *is Assistant Lecturer in Biology in theDepartment of Life Sciences, Faculty of Science and Technology, The University of the West Indies, Mona Campus, Kingston, Jamaica, West Indies.*

Eric Garraway *is Senior Lecturer in Entomology and Conservation Biology, Department of Life Sciences, Faculty of Science and Technology, The University of the West Indies, Mona Campus, Kingston, Jamaica, West Indies.*

■

The Efficacy of Sulphur/Insecticide Treatments for *Franlinella Occidentallis* (Western Flower Thrips) under Protected Cultivated in Jamaica

St. Sanya G.L. Morrison[1], Camille C. Marks Kelly[2], Michelle A. Sherwood[3], Michael Pryce[4] and Sheldon Elliot[5]

[1,2,3,5] Bodles Research Station, Research and Development Division, Ministry of Industry Commerce, Agriculture and Fisheries Old Harbour St. Catherine, Jamaica, West Indies;
[1]Email: sgmorrison@micaf.gov.jm
[2]Email: cmarkskelly@gmail.com
[3]Email: mishanton@yahoo.com, masherwood@micaf.gov.jm
[5]Email: donshel29@gmail.com

[4]Agricultural Marketing information Division, Ministry of Industry Commerce, Agriculture and Fisheries Old Harbour St. Catherine, Jamaica, West Indies; Email: mapryce@micaf.gov.jm

Abstract*: Franklinella occidentallis (Pergande) (Thysanoptera; Thripidae) is a major pest of sweet pepper plants under protected agriculture. In Jamaica, growers have been challenged over the years in effectively controlling this pest mainly because this pest thrives in very warm tropical conditions and is too small to be managed by screen mesh alone used on these structures. The need therefore existed to identify new, effective and environmentally friendly strategies to solve this problem. Sulphur a component in major fungicides has been reported to be efficacious in controlling thrips. In collaboration with the World University Services of Canada - Promotion of Regional Opportunities for Produce through Enterprises and Linkages (WUSC-PROPEL) and cooperating farmers from the Jamaica Greenhouse Growers Association two trials were successfully conducted.*

Two trials were conducted simultaneously from December 2015 to February 2016 in the parishes of Manchester and St. Ann to examine the effectiveness of Sulphur when combined with other pesticides to control thrips population under protected agriculture. Three treatments consisting of Sulphur (Tribasic Copper Sulfate) only; Tribasic Copper Sulfate with Thiamethoxam and Lambda-cyhalothrin; and Abamectin with Tribasic Copper Sulfate were replicated three times in a randomised block design. Treatment commenced in the second week following data collection. The rates used were treatment A (Sulphur) - 30 ml per gallon (was applied at its highest rate). Treatment B (Tribasic Copper Sulfate with Thiamethoxam and Lambda-cyhalothrin) was applied at a rate of 15 ml per gallon and Treatment C was prepared as recommended by the manufacturer on the label. At the third application the rate of treatment A was reduced to 5 ml per gallon. No Treatment C was applied for the third and 4th application. At the fifth application, Treatment C (Abamectin with Tribasic Copper Sulfate) was reintroduced and the rate applied was reduced to 1.3 ml per gallon. This continued until the end of the trial. Application of pesticide was done using a knapsack sprayer.

The thrips population was monitored using blue sticky traps. One trap was vertically placed over the centre of each plot. The traps were collected once per week and taken to the laboratory to count the number of adult thrips captured. Six plants from each plot were selected randomly and the number of thrips in two flowers was counted.

In Manchester, the thrips population showed a general decline regardless of the treatments used as time progressed and the changes in thrips count over time were significant ($p = 0.002$). The Abamectin with Tribasic Copper Sulfate treatment was most effective in Manchester and gave the lowest mean thrips count with significant differences among treatments ($p = 0.003$) (see Figure 1), whereas the Tribasic Copper Sulfate with Thiamethoxam and Lambda-cyhalothrin treatment was most effective in St. Ann. In St. Ann, there was no significant difference ($p = 0.300$) in the treatments used. There was a general increase in thrips count in all treatments throughout the treatment period. However, Abamectin with Tribasic Copper Sulfate deviated significantly from the other two treatments, positively (less thrips) in the middle of the period and negatively towards the last part of the observations (see Figure 2).

Sulphur based chemicals can be used as a part of pesticide rotation programs. However it should be used cautiously so as to prevent phytotoxicity damage to the crop. Further research needs to be done on evaluating the effect of sulphur as a complement to insecticides used in greenhouse; other methods of Sulphur application could be further evaluated to determine effectiveness.

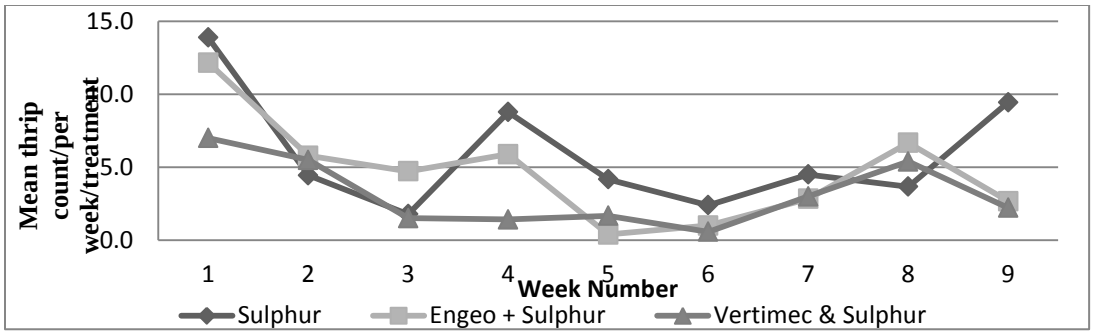

Figure 1: The mean thrip count /week per treatment in the Manchester trial

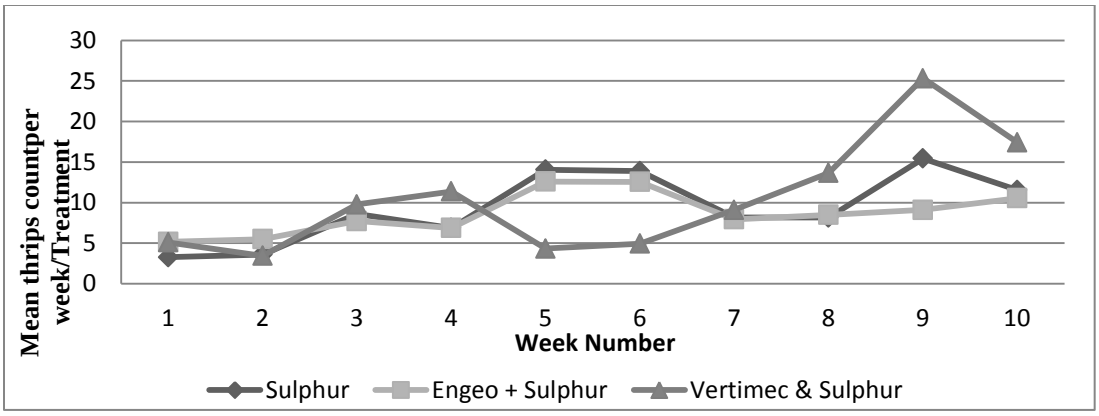

Figure 2: The mean thrip count/week per treatment in the St. Ann trial

Keywords: *Franklinella occidentallis; sweet pepper plants; Protected Agriculture; Sulphur*

Authors' Biographical Notes:

St. Sanya Morrison *oversees the Nematology Laboratory and temporarily oversees the activities of the Entomology Laboratory as a Senior Plant Protection Officer. She works in the Plant Protection Unit at Bodles Research Station (Research and Development Division in the Ministry of Industry, Commerce, Agriculture and Fisheries). Ms. Morrison has research interest in pest management and in enlightening students and farmers about plant parasitic nematodes.*

Camille Marks Kelly *is the Chief Plant Protection Officer in the Plant Protection Unit at Bodles Research Station (Research and Development Division in the Ministry of Industry, Commerce, Agriculture and Fisheries). She oversees the diagnostics and research activities for the three laboratories (Entomology, Nematology and Pathology) in the Plant Protection Unit. Mrs. Marks Kelly is also the Chairperson for the National Fruit Fly Surveillance Committee and represents the Unit on several other technical committees. She has keen interest in teaching and making paraphernalia that makes research results easy to understand and used by farmers and extension officers.*

Michelle A. Sherwood *is the Deputy Research Director for the Crop and Plant Protection Unit, Research and Development Division in the Ministry of Industry Commerce Agriculture and Fisheries. She possesses a Masters of Philosophy in Zoology specialising in the area of Entomology. Ms. Sherwood has over 22 years of contributing to agricultural research in various Technical, Administrative and Senior Management roles, by providing quality diagnostic, research and advisory services to the local, regional and international agricultural plant health sector. Her interests are in the areas of Research Entomology, Area-wide Integrated Pest Management, diagnostics and advisory, agriculture sector development and project management.*

Michael Pryce *is the Director of the Agricultural Marketing Information Division of the Ministry of Industry, Commerce, Agriculture and Fisheries in Jamaica, with the responsibility for the operation of the Division and advising the Ministry and other national and international agencies on agricultural statistics. Mr Pryce was extensively involved with the planning and execution of the last two agricultural censuses in 1996 and in 2007 as part of the Agricultural Census Technical Working Committees set up by STATIN and was the main agricultural advisor to the Committee. He has had over 30 years of experience in agricultural statistics.*

Sheldon Michael Elliott *is currently the Senior Research Director in Plant Protection Unit at Bodles Research Station under the Research and Development Division of the Ministry of Industry, Commerce, Agriculture and Fisheries, where he has worked for approximately thirty years. Mr. Elliott is a Senior Research Scientist with a wealth of experience in the disciple of Plant Pathology, which is his area of specialty. He has conducted research activities in the management of Rhizome Rot disease. Mr. Elliott has also conducted investigations into the management of mildews, late blight and leaf spot diseases in vegetable and tuber production.*

■

Evaluation of Isomate – BAW Mating Disruption Technology for the Management of Beet Armyworm (*Spodoptera exigua*) in Scallion/Welsh Onion (*Allium fistulosum*) in Todd Town, St. Elizabeth Jamaica

Michelle A. Sherwood[1], Marina Young[2], Francine Webb-Lawrence[3], and Michael Pryce[4]

[1] Crop and Plant Protection Unit, Research and Development Division (Bodles Research Station,) Old Harbour, St. Catherine, Jamaica, West Indies; Emails: mishanton@yahoo.com, masherwood@micaf.gov.jm

[2,3] Rural Agricultural Development Authority, Ministry of Industry Commerce, Agriculture and Fisheries Hope Gardens, Kingston, Jamaica, West Indies; Emails: youngm@rada.gov.jm; webbf@rada.gov.jm

[4]Agricultural Marketing information Division, Ministry of Industry Commerce, Agriculture and Fisheries, Hope Gardens, Kingston, Jamaica, West Indies; Email: mapryce@micaf.gov.jm

Abstract: *The Beet armyworm (Hübner) (Lepidoptera; Noctuidae), Spodoptera exigua, has been a serious pest on economic crops in Japan since the 1980s. Similarly, in Jamaica outbreaks and flare ups in South St. Elizabeth and Manchester began with several outbreaks since 2009 to 2012 devastating scallion and onion crops worth over J$140 million/event. The ISOMATE–BAW, a mating disruption technology made of synthetic sex pheromones strips from Japan was introduced to Jamaica for evaluation against this pest. The evaluation trial consisted of an 8-10 Ha Isomate treated area versus a 2 Ha farmer managed control scallion farm lands located in Todd Town, South St, Elizabeth. The control scallion farm was identified upwind of the Isomate scallion fields in the trial. Statistically significant differences were observed for the treatment/date interaction (p = 0.075), however, the overall mean treatment for beet armyworm population of egg masses, larvae and moth differences were not significant (p = 0.658). There was significant difference between the overall mean percentage damage for the control and Isomate treatment (p = 0.001). The Isomate strips' longevity locally was comparable to the reported time period of 60-90 days. The results are promising and do indicate the potential use of ISOMATE-BAW mating disruption technology as part of an effective area-wide protocol for the integrated pest management of the beet army worm in infested areas.*

Keywords*: Beet armyworm, Spodoptera exigua, Allium spp., Mating Disruption*

1. Introduction

Beet Armyworm (BAW) outbreaks from 2009 to 2012 in the parish of St. Elizabeth have resulted in damages to scallion and onion fields amounting to over J$140 million. If not detected early BAW infestations are difficult to control. Outbreaks occur periodically due to favourable climate conditions and also as a result of the suppression of beneficial insects by indiscriminate use of pesticides in the production system.

Female moths lay eggs in scale-covered clusters of 80-150 eggs on leaf sheaths of the scallion or onion crop. Depending on temperature, eggs can hatch in 2-5 days and larvae can feed for 10-24 days. Young larvae feed in groups on the leaf sheath but eventually disperse as they age across the crop and enter the leaf sheaths. The 5 the instar larvae emerge from the crop and pupation occurs in the soil and lasts 6-7 days. The entire life cycle takes approximately one month during warm weather. Under certain conditions there can be as many as 8 generations per year.

Through the combined efforts of Research and Development and the Rural and Agricultural and Development Authority (RADA) an Integrated Pest Management (IPM) programme was developed for this pest integrating the use of monitoring techniques (application of action thresholds and economic injury levels), sanitation measures, less susceptible varieties, cultivation practices (nutrition and irrigation), selective and environmentally friendly treatments, cultural practices and biological control. However the pest continued to flare up due to farmers' failure to follow recommended Integrated Pest Management Strategies.

In 2012, the two year FAO TCP project "Strengthening the National Beet Armyworm Programme" TCP/JAM/3401 was implemented. The project was an Area-wide management programme that focused on the development and implementation of a Pest Forecasting System and farmer training using the Farmer Field School methodology to further engage the farmers and foster adoption of the recommended practices. This approach was a season long programme which emphasised learning by doing using facilitation techniques and social intervention.

The beet arymworm, *Spodoptera exigua,* has been a serious pest of vegetables and ornamental crops in southwestern Japan since the early 1980's (HoRIKIRI, 1986; TAKAI, 1988a, 1989). This insect is difficult to control

by spraying insecticides because of the rapid development of insecticide resistance in the population (TAKAI, l988b). The beet armyworm (BAW), *Spodoptera exigua* (Hubner), (Lepidoptera: Noctuidae), is a serious pest of okra *(Abelmoschus esculentus* Moench), onion *(Allium ascalonicum* L.) and asparagus *(Asparagus officinalis* L.) in Southeast Asia, especially in Thailand (Jee-rajunya, personal communication). This insect has attacked Welsh onion *(A. fistulosum* L.) in Kochi and Kagoshima Prefectures since the early 1980's. The effectiveness of most of the insecticides used (including methomyl and EPN) to combat this pest has declined. This species similar to the diamond back moth on cabbage appears to have the potential to rapidly acquire resistance. This led to the need to identify alternative treatments for this pest. The use of sex pheromones became a consideration based on reports of its effectiveness in managing several other important pests which were also recalcitrant to pesticide treatments.

Treatments with 500 dispensers of sex pheromones in a 0.02 ha greenhouse reduced the estimated mating ratio in females to 20-50%, whereas mating rate was 95% without treatment. When the sex pheromone treatment was combined with the use of a light trap, the mating rate was reduced to 2- 3%. This latter tool may also be incorporated as a new technology in the local Beet armyworm management programme.

BAW pheromone can be an effective and economical way to combat this pest. When applied in a slow release formulation, the synthetic pheromone disrupts the normal communication between male and female moths. Males cannot locate the natural pheromone trail emitted by female moths. When used in an integrated pest management program (IPM) this technique can suppress mating and reduce beet armyworm infestation. ISOMATE-BAW is a long-life formulation of the beet armyworm pheromone. It is the most widely used mating disruption dispenser in the world. ISOMATE-BAW is designed for easy hand application directly to plant stems or to wooden stakes. The plastic dispensers slowly emit synthetic pheromone into the atmosphere. Depending on climatic conditions, a single application of ISOMATE-BAW can last between 60 - 90 days. ISOMATE-BAW is non-toxic and not harmful to beneficial parasites and predators which are conserved to help combat secondary pests.

Since the completion of the FAO TCP project 'Strengthening the National Beet Army worm (*Spodoptera exigua*) Programme in Jamaica' in October 2015 work has continued to improve the management programme for Beet Armyworm. The Research and Development Division has sought funding under the Onion Development programme and in collaboration with RADA to source and evaluate the ISOMATE BAW technology for mating disruption in Beet armyworm populations This product would provide a new tool in an Area-Wide management programme in areas where flare ups or outbreaks have occurred, such as South St. Elizabeth, South Manchester, St. Catherine and Clarendon.

For mating disruption technology to be most effective, the pheromone treatment should be applied early in the season when pest numbers are low. On this basis the trial was conducted from March 2016, when beet armyworm was typically low due to prevailing cold fronts from the North. This technology is being implemented on an area-wide basis on 8-10 Ha (approx. 20 acres) of land in Todd Town, South St, Elizabeth on scallion. The results of this experiment if successful could be applied to other affected crops including onion (*Allium cepa*) production areas and callaloo (*Amaranthus* sp.) in and outside the Agro-parks. This project report presents the outcome of two trials over a six months period in 2016.

2. Methodology

In both trials the same existing scallion fields were utilised with cooperating farmers and established on 8.09 Ha (20 acres) of farm land in Todd Town, South, St. Elizabeth. Thirteen pheromone bucket traps were distributed in scallion fields two of which were placed in the control area to monitor the moth population. Traps were serviced as needed and lures replaced every four weeks.

The dispensers were distributed using approximately 250 X 8 packs dispensers per hectare (100/acre), The dispensers were placed 20 ft apart on barbecue skewers in scallion fields, on 2ft sticks in tomato fields and tied to the stems of ornamentals, fruit tree crops, wooden fencing and shrubs.

The Isomate treated area was evaluated against a control located 1,000 km upwind to avoid pheromone drift. The control involved two adjacent scallion fields totalling 2 Ha which applied conventional insecticides treatments including Lambda cyhalothrin, Spinosad and Lufenuron (Caratrax®, Tracer® and Match® respectively). These were applied using a knapsack sprayer.

Monitoring was conducted weekly on 25 plants/field by checking five plants in five stations arranged in an X pattern spread across the fields. One leaf/plant was selected to determine the total numbers of BAW per plant and recorded by larvae 1^{st} – 2^{nd} instar and 3^{rd} to 5^{th} instar BAW. The plant damage was determined by counting the total number of damaged leaves as a percentage of total leaves per sample plant. Two weeks of monitoring were conducted for baseline data (i.e. population status before introduction of Isomate wire dispensers) on March 8 and 15, 2016 after which the dispensers were distributed on March 21. Data collection continued on March 29, 2016 on

the population of BAW eggs, larvae as well as damage levels, by monitoring the crop and BAW adult moth via pheromone trap catches The trial was ended once the weight loss of the ISOMATE became minimal at 60-90 days after the trial was established and guided by the results of the longevity tests conducted at Bodles Research Station.

After establishing the field trial ten of these Isomate strips were collected and taken back the Bodles Research Station, Old Harbour St. Catherine to conduct a longevity experiment. The wire dispensers were weighed before and after being placed on skewers after which they were placed in the sun supported by a styrofoam mat. The weight of the wire dispenser and skewer was collected once weekly and recorded. This was also repeated in the second trial. Forty nine strips were removed from the field from the first trial only and brought back to the lab to be examined and their weight determined.

The Isomate trial was continued by extending the treatment up to August 2016. Two weeks of monitoring was conducted for baseline data (i.e. population status before introduction of treatment) on June 14 and 21, 2016 and then new Isomates were placed on June 28, 2016. The first set of trial data was collected on June 28, 2016 on the population of BAW eggs, larvae as well as damage levels were also collected, by monitoring the crop and BAW adult moth in 13 trap catches.

3. Results and Discussion

3.1 Population of Beet armyworm Life stages

Analysis of the trap catches for the moth population in the Todd Town Trial showed that although some statistically significant differences were observed for the treatment/date interaction ($p = 0.075$), the overall mean treatment differences were not significant ($p = 0.658$). For both the Control and the Isomate, the counts declined over the course of the observation period and then significantly increased towards the end of the period in May. Importantly however, the significantly higher spike in numbers for the Control occurred some four weeks earlier than a similar spike in numbers for the Isomate treated plots (see Figure 1). The source of BAW may have been from the grasses grown for mulch as the traps with these elevated numbers were adjacent to such areas. As temperatures typically increase the population of the BAW is expected to increase during the May/June period which is historically the period for BAW flare ups. This period was critical in determining the effectiveness of the Isomate as contributing to mating disruption.

The spike at the end of the experiment was attributed to the Isomate strips having reached near the end of their effective life. However, the Isomate appeared to have effectively maintained the adult population at baseline or below throughout the effective period, and was successful in minimising population spikes (except at the end of the period) below the levels of the Control population.

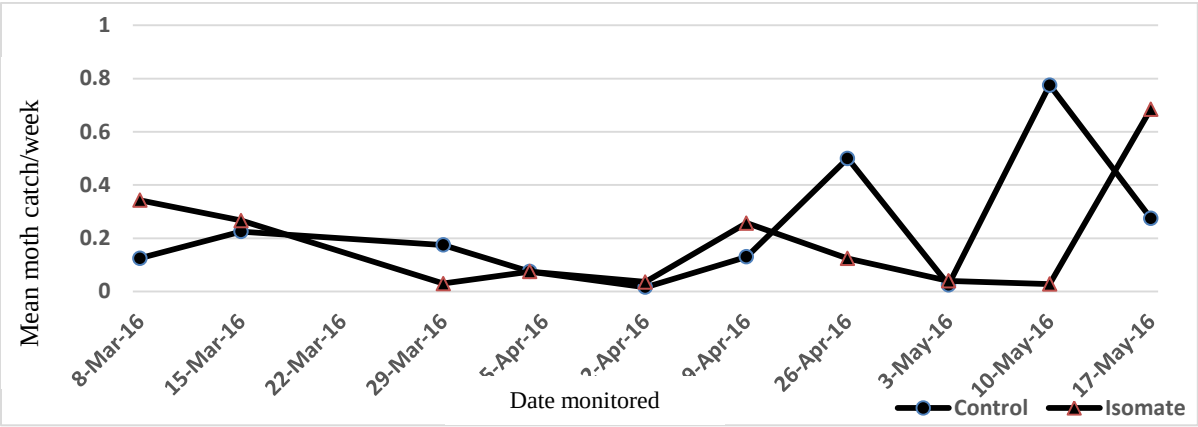

Figure 1: Weekly Mean Trap Catch of BAW Adults in Experimental Area - March to May 2016, St. Elizabeth

Number of Egg Sacs: No significant differences were observed for the number of egg sacs either for the overall mean treatments ($p = 0.618$), nor for the treatment/date interaction ($p = 0.668$). An examination of Figure 2, shows that there were two periods of an apparent spike in the number of egg sacs for the Control plots, in the early weeks of the experimental period and near the end of the period. However, during the middle of the period when the numbers were low for the Control, those plots treated with the Isomate did have a spike in numbers. This may be as

a result of migrating mated female moth which may have oviposited in the area. It should be noted however that these apparent spikes are relative, and the Control and the Isomate were not statistically significantly different from each other. Furthermore the numbers of egg sacs were low across the entire experiment with an overall mean of 0.0075 for the Control plots and 0.0052 for the Isomate treated plots.

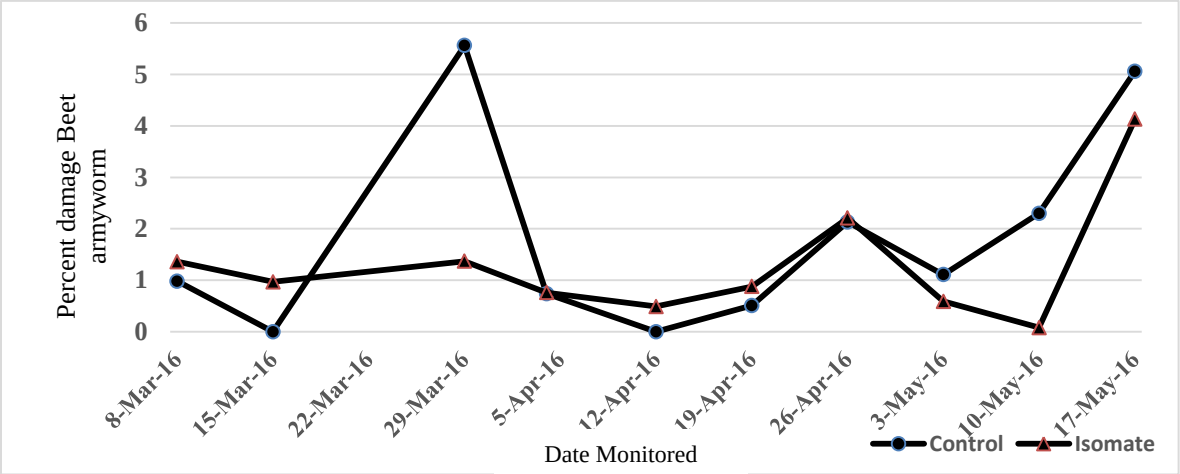

Figure 2: Percent damage of Beet armyworm larvae to scallion plants in Mating Disruption Trial, March to May, 2016

Number of Instar 1to 2: No significant differences were observed for the number of Instar 1-2 either for the overall mean treatments ($p = 0.608$), nor for the treatment/date interaction ($p = 0.550$). Generally however, the number of Instars 1-2 fell for both Isomate and Control in the initial weeks of the observation period and remained low for the most of the period for the Control. However there was a relative spike in numbers for the Isomate treated plots in early April. This rapidly declined. The low levels for both Control and Isomate continued until early May where the numbers went up significantly for the Control plot followed by a similar spike in numbers for the Isomate treated plots a week later, probably coincidental to the loss of efficacy of the strips in repelling the adults seen earlier.

Number of Instar 3 to 5: No significant differences were observed for the number of Instar 3-5 in terms of the overall mean number ($p = 0.313$), and between the treatments over time ($p = 0.126$). Expect for the last week of observation, the number of Instar 3-5 for the Isomate treated plots remained low. This corresponds to initially low numbers (statistically similar to the Isomate treatment) for the Control followed by a significant spike in numbers several weeks before the end of the experimental period.

Percentage Damage: There was significant difference between the overall mean percentage damage for the Control and Isomate ($p = 0.001$). The relative differences across the weeks between the two treatment however was not statistically significant ($p = 0.254$) despite one week in March where the damage on the Control plots was relatively much higher than the Isomate treated plots. See graph below. The overall mean percentage damage across the experiment was generally low at 1.38 %. The mean damage for those plots treated with the Isomate was 1.28 % and that for the Control 1.84 % (see Figure 2). As mentioned before, this difference in mean percentage damage was statistically significant, supporting the conclusion that mean damage was lower for the treated area as compared to the non-treated control.

These results are comparable to observations observed in the US and Japan. Beet armyworm Isomate trials were conducted in the United States in 1997 (Mitchell et al) using this formulation with two components of the sex pheromone of the female beet armyworm (Z,E)-9, 12- tetradecadien-1-yl Acetate and (Z-9-tetradecen-1-ol). This formulation was found to be effective in controlling beet armyworm in a 61 Ha cotton field located near the township of Houston in the north eastern corner of Suwannee County, Florida in the Unites states. The pheromone treatment suppressed trap captures of male BAW. On average fewer beet armyworm egg masses (57%) and larvae (95%) were recorded in the pheromone treated fields compared with the control field.

In Japan, Wakamura and Takai (1992) showed that, when a 7:3 mixture of (Z,E)-9,12-tetradecadien-I-ol acetate and (Z-9-tetradecen-I-ol was dispersed into a 155 ha field, attraction of male beet armyworm moths to sex pheromone traps was completely inhibited, and densities of egg masses and young larvae on Welsh onion (scallion) were reduced significantly relative to those in an untreated field about 9 km away. ln their study, the Welsh onion fields totalled only about 25 ha; the remainder of the pheromone-trial area included rice fields, greenhouses, orchards, home gardens, and forests. The following year, the trial was repeated in a treated area of 50 ha of which Welsh onion plots comprised 24 ha. In both years, trap captures of beet armyworm males in pheromone-treated zones were completely eliminated and densities of egg masses and young larvae were reduced >95% over control areas located about 9 km away. In fact, the beet armyworm population in the pheromone-treated area was so low the second year that Wakamura and Takai (1992) concluded that the low initial density was a possible effect of the sex pheromone treatment the previous year.

3.2 Longevity of Isomate strips in two experiments

Isomate strips were heavier in the third and 10th week than in the previous weeks as a result of rainfall which occurred the day before the weight was taken leaving moisture on the skewers and isomate strips. Data collected in the 4th to 7th week showed reduction in weight of the strips losing a mean 24.81% of its original weight and in the 10th week exactly 25 % of the weight was lost (see Figure 3 and Table 1). The strips therefore lasted for 70 days under the conditions at the Bodles Research Station. This results fall in line with the label recommendation that the dispensers last 60 to 90 days (PBC brochure). In the second test the Isomate dispenser lost 24.62 % of its weight after 12 weeks in the sun which is comparable to the results in the first test. No rain was recorded the day before the readings were taken for the second test therefore resulted in less peaks in the results.

The Forty-nine Isomate strips collected from the field in St. Elizabeth on June 28, 2016 15 weeks after the first trial started, recorded a mean loss of 22.86% of the weight when compared to the original mean weight from the two lab tests at Bodles Research Station (see Table 1). This indicates that there was a slower rate of loss of the pheromone from the dispensers in Todd Town, St. Elizabeth than at Bodles Research St. Catherine. This may be as result of difference in cooler microclimate created by vegetation in St. Elizabeth. The Isomates at Bodles did not have any vegetation in the immediate surroundings with possible higher temperratures which may cause a faster release of the pheromone.

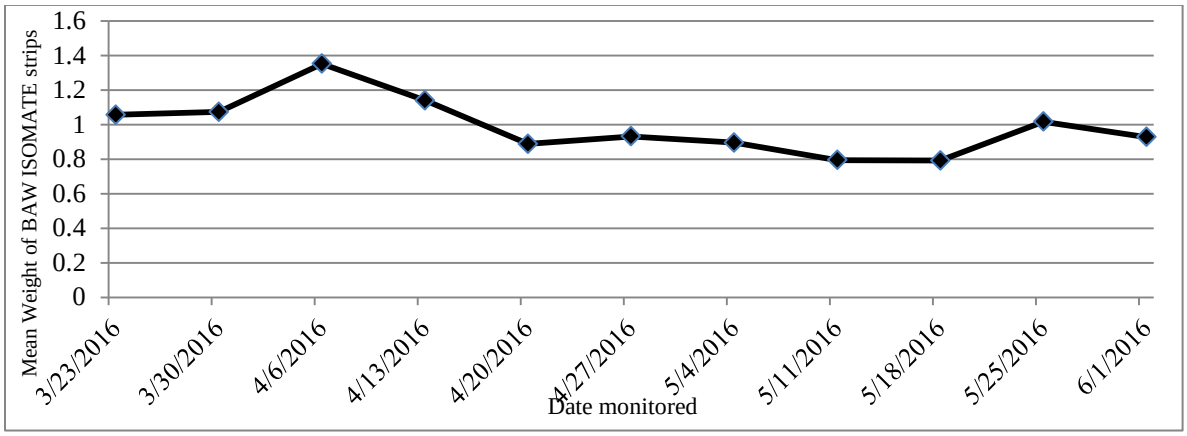

Figure 3: Mean weight of strips after twelve weeks, March 23 – June 1, 2016 at Bodles, R&D

Table 1: Results of Longevity tests for Isomate strips at Bodles Research Station

Date	Activity	Mean weight (g) at beginning	Lowest Mean Weight loss (g)	% Weight Loss
March 23 – June 1, 2016	Test 1	1.056	0.792 (10 weeks)	25
June 29 – Sept. 21, 2016	Test 2	1.07	0.799 (12 weeks)	24.62
March 23 - June 28, 2016	St. Elizabeth	1.063	0.82 (15 weeks)	22.86

Wakamura et al. (1989) examined the Isomate wires by analysing the content of the wires using qualitative changes of the sex pheromone components in the dispensers using liquid chromatography and a gas chromatograph-mass spectrometer. The results indicated that the release rate of the pheromone gradually decreased throughout the treatment period. The analysis of the contents of the dispenser showed that its decomposition rate reached 20-40% towards the end of the period. From these data, evaporating rates were estimated to have gradually decreased: (Wakamura et al., 1989).

3.3 BAW Isomate Trial 2

Three weeks after the first trial ended the second trial was established. The population of moths, larvae and eggs remained very low for the entire Isomate treated areas and the control recording mostly zero which could not be statistically analysed. This may be as a result of the continued effect of the Isomate from the 1st trial continuing into the second trial (see Figure 4).

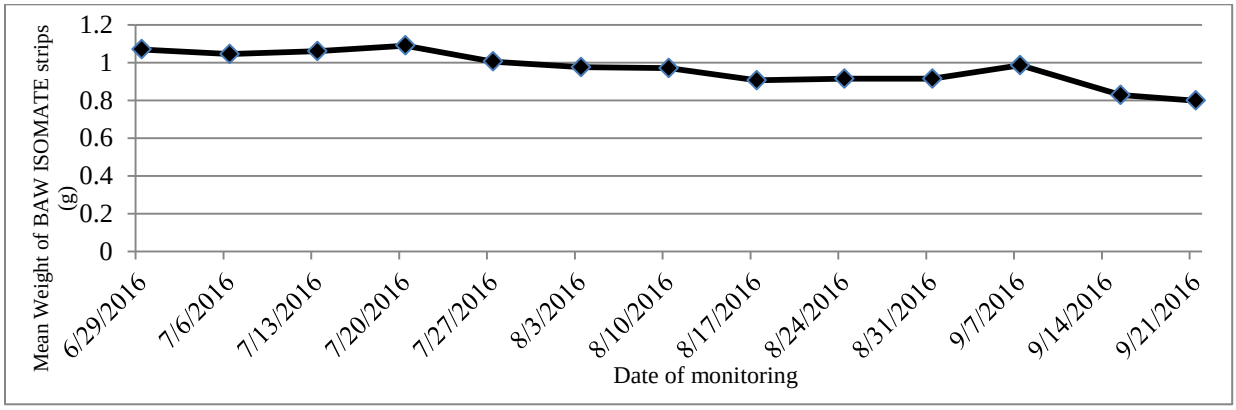

Figure 4: Mean weight of strips after thirteen weeks, June 29 – September 21, 2016 at Bodles, R&D

4. Conclusions and Recommendations

The trial though not fully conclusive from a statistical standpoint, does clearly show that the use of the Isomate strips as part of an effective area-wide protocol for the management of the beet army worm is promising. The observation does point to effective control being attained. To further examine this effect and to evaluate performance over differing environmental and seasonal conditions, it is recommended that the trial be repeated in additional seasons and in other areas that lend themselves to this type of area-wide BAW management.

To the extent that the efficacy of the strips will be affected by environmental conditions, it would be useful to measure and maintain daily records of environmental variables such as rainfall, temperature, and probably an assessment of prevailing wind conditions. One factor which led to the high variability of the overall experiment which probably masked some effects that could have been significant, was the relatively small number of control plots. Though the practicality of doing so in this type of area-wide treatment is noted, further experiments could be enhanced by a greater number of observations from non-treated plots. An earlier and longer period of observation to ascertain baseline levels may also be helpful.

The Isomate strips lasted within the 60-90 days under Jamaican conditions. Therefore, future use of this product can be managed based on this longevity period. Additionally, the cost effectiveness of the product needs to be done incorporatng into the existing programme needs to be assessed.

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Authors' Biographical Notes:

Michelle A. Sherwood *is the Deputy Research Director for the Crop and Plant Protection Unit, Research and Development Division in the Ministry of Industry Commerce Agriculture and Fisheries. She possesses a Masters of Philosophy in Zoology specializing in the area of Entomology. Ms. Sherwood has over 22 years of contributing to agricultural research in various Technical, Administrative and Senior Management roles, by providing quality diagnostic, research and advisory services to the local, regional and international agricultural plant health sector. Her interests are in the areas of Research Entomology, Area-wide Integrated Pest Management, diagnostics and advisory, agriculture sector development and project management.*

Marina Young *is the Principal Director of the Technical Services Rural Agricultural Development Authority (RADA) with a Masters in Agronomy specialising in Plant Protectiona. She has over 29 years of experience working in the agricultural sector in Jamaica. Ms. Young oversees the technical training of all extension officers in the agency and has been at the forefront of main streaming agricultural technology transfer, farmer and extension staff capacity building. She has interests food safety, farmer field school methodology, Plantwise services through RADA to all farming communities in plant health, pest surveillance, Pest and Pesticides and Integrated Pest Management.*

Francine Webb *heads the Plant Health and Food Safety Unit in the Technology, Training and Technical Information Division (TTTI) of the Rural Agricultural Development Authority (RADA) in Jamaica. in the past she worked with the biological control programme for the coffee berry borer, a programme implemented by the Caribbean Agricultural Research and Development Institute (CARDI) from 1999-2004. Ms. Webb received undergraduate and postgraduate training at the University of the West Indies (Mona) and is currently completing a Master of Advanced Studies degree in Integrated Crop Management at the University of Neuchàtel (UniNE) in Switzerland.*

Michael Pryce is *the Director of the Agricultural Marketing Information Division of the Ministry of Industry, Commerce, Agriculture and Fisheries in Jamaica, with the responsibility for the operation of the Division and advising the Ministry and other national and international agencies on agricultural statistics. Mr. Pryce was extensively involved with the planning and execution of the last two agricultural censuses in 1996 and in 2007 as part of the Agricultural Census Technical Working Committees set up by STATIN and was the main agricultural advisor to the Committee. He has had over 30 years of experience in agricultural statistics.*

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Evaluation of UV-absorbing Film for Management of Western Flower Thrips under Protected Cultivated in Jamaica

St. Sanya G.L. Morrison[1], Camille C. Marks Kelly[2], Michelle A. Sherwood[3], Michael Pryce[4] and Sheldon Elliot [5]

[1,2,3,5] Bodles Research Station, Research and Development Division, Ministry of Industry Commerce, Agriculture and Fisheries Old Harbour St. Catherine, Jamaica, West Indies;
[1]Email: sgmorrison@micaf.gov.jm, st.sanyamorrison@gmail.com
[2]Email: cmarkskelly@gmail.com
[3]Email: mishanton@yahoo.com, masherwood@micaf.gov.jm
[5]Email: donshel29@gmail.com

[4]Agricultural Marketing information Division, Ministry of Industry Commerce, Agriculture and Fisheries Old Harbour St. Catherine, Jamaica, West Indies; Email: mapryce@micaf.gov.jm

Abstract: *The Franklinella occidentallis (Pergande) (Thysanoptera; Thripidae) is challenging to control on sweet pepper (Capsicum annuum) plants grown in greenhouses and was detected as a major pest on greenhouse grown sweet pepper in a 2005 survey done by Bodles Research Station. Bodles Research Station was approached by WUSC PROPEL to examine the effectiveness of UV absorbing film in controlling the thrips population. A randomized complete block design was used on established plots with UV absorbing film in Manchester and St. Elizabeth and with non-UV absorbing film in St. Ann. Thrips were monitored using blue sticky traps and flower counts Analysis of variance (ANOVA) performed on data collected from sticky traps showed that there were significant differences ($p < 0.001$) among the treatments. Manchester (UV + antiviral mesh) had the lowest thrips count. Comparison between the St. Ann site (no UV+ shade cloth) and the St. Elizabeth site (UV + shade cloth) showed that the difference between the two sites was not directly related to the UV absorbing property of the roofing material. The shade cloth sites had a higher number of thrips trapped which varied over the experimental period. The UV absorbing property of the greenhouse film did not appear to significantly affect the thrips count, while the antiviral mesh appeared to significantly affect the number and incidence of thrips in the greenhouse. The technology's effectiveness could improve if UV-absorbing film was used along with good greenhouse practices. Further studies needed.*

Keywords*: Franklinella occidentallis, sweet pepper, Protected Agriculture, UV absorbing film*

1. Introduction

Growing crops under Protected Cultivation provides many benefits as compared to open field including higher yields, narrower range of pest problems, reduced exposure to harsh environmental conditions, less land area required, increased efficiency in the use of water, fertilizers and reduced pesticides. 2005 saw an expansion in the growth of crops under protected cultivation. One of the main crops to date is the sweet pepper.

Jamaica is a tropical country where temperatures are higher compared to temperate regions. This presents an increased issue for managing insect pests which thrive in very warm conditions. An all island survey was conducted by the Bodles Research Station's Plant Protection Unit. Baseline data collected identified aphids (*Myzus persicae*), thrips (*Franklinella occidentalis*), broadmite (*Polyphagotarsonemus latus*), whiteflies (*Trialeurodes vaporariorum*) and leafminers (*Liriomyza* spp.). The major diseases encountered were powdery mildew (*Leveillula taurica* and *Sphaerotheca fuliginea*) and early (*Alternaria solani*) and late (*Phytophthora infestans*) blight. This information is useful for identifying Integrated Pest Management (IPM) approaches that are suitable to Jamaica's climatic and socio-economic conditions.

In order to manage these pests, Integrated Pest Management Programme was recommended. This requires evaluating the effectiveness of new technologies developed in various international research institutions to enhance the existing management programmes which were mainly based on pesticide usage.

Studies in Japan have shown that the reduction of insect invasions and the spread of viral epidemics invasion of thrips (*F. occidentalis*) were 10 times lower under UV-absorbing plastics. The Plant Protection Unit was approached by World University Services of Canada - Promotion of Regional Opportunities for Produce through Enterprises and Linkages (WUSC-PROPEL) to conduct local research project to evaluate the effectiveness of these approaches in collaboration with the Jamaica Greenhouse Growers Association. UV-absorbing plastics were established as roofing

material in Manchester and St. Elizabeth. The research would examine the effectiveness of this technology to control *F. occidentallis* population as a part of IPM strategies..

Through sponsorship under the project, the research project was developed and implemented from December 2015 to February 2016. This report provides the findings of the research conducted.

2. Methodology

The experiment was conducted on an existing sweet pepper 13-14weeks old crop under 3,000 ft^2 house under protected cultivation. The experimental area consisted of a double row of plants replicated three times. Each treatment area consisted of twelve plants (with six plants in each row), and four feet between treatments along the row. The trial was laid out in a randomized complete block design.

Three existing greenhouses at three different locations in Manchester, St. Elizabeth and St. Ann were identified. Two types of plastic films were assessed for roofing and shade cloth for sides were used as the treatments (see Table 1).

Table 1: Treatments of plastic and shade cloth used in the evaluation

Type of materials	**Abbey Gardens, Manchester**	**Walkerswood, St. Ann**	**Wallingford, St. Elizabeth**
Plastic film on roof	Ultra Violet absorbing film	Non- Ultra Violet absorbing film (control)	Ultra Violet absorbing film
Shade Cloth on sides	Antiviral mesh (50 mesh)	Non-antiviral mesh	Non-antiviral mesh

The light transmitted through the films was measured using a light meter. The temperature and humidity data was also recorded using an ASTER scientific visible light SD CARD data logger was used at each visit to the farms at all three locations.

The thrips population dynamics was monitored using blue sticky traps. One trap was vertically placed over the centre of each plot. The traps were collected once per week and taken to the laboratory and examined for the number of thrips using a 2 Lens 30X 60X Pocket Magnifier. Six plants from each plot were selected randomly and the thrips population in two flowers were counted. The presence/absence of other pests and beneficial arthropods was also recorded. Treatment recommendation was made to the greenhouse manager based on the results of the monitoring data.

3. Results and Discussion

The lowest temperature was recorded in Abbey Garden, Manchester (27.3°C) whilst the highest recorded temperature was recorded in Wallingford, St. Elizabeth (34.3°C). On the other hand, the lowest relative humidity (RH) was 37% and was recorded in Wallingford and highest relative humidity (71%) was recorded in Walkerswood, St. Ann (See Figure 1 and Table 2).

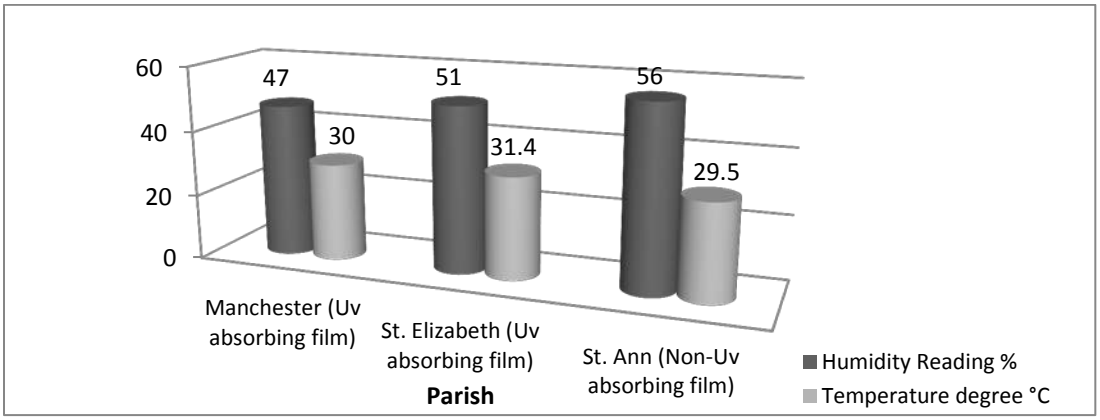

Figure 1: Mean temperature and relative humidity recorded in two greenhouses with UV absorbing film (St. Elizabeth and Manchester) and a greenhouse without UV absorbing film (St. Ann) from December 2015 to February 2016.

Table 2: Temperature and Relative Humidity (RH) ranges recorded under greenhouse conditions (UV absorbing and Non-UV absorbing film) from December 2015 - February 2016

Location	Temperature range	RH
Manchester	27.3°C to 34.4°C	39% to 50%
St. Elizabeth	29.0°C to 34.3°C	37% to 58%
St. Ann	28.0°C to 31.9°C	43% to 71%

The effect of RH on thrips count at the Manchester site was the only relationship that was found to be significant. The linear regression models of the form Y = a + bX were fitted to determine if either or both relative humidity and temperature had any explanatory effects on either of sticky trap counts or thrips population counts. There was a positive relationship between the thrips population counts and relative humidity at the Manchester site. That means the population increased whenever the relative humidity increased. This relationship explained 60.4 % of the variability observed (see Table 3).

Table 3: Linear regression on the relationship on thrip count based on the temperature and relative humidity

	Dependent Variable (Y)	Explanatory Variable (X)	Constant (a)	Slope (b)	% Variability accounted for	P-value
Manchester - UV absorbing film + antiviral mesh	Thrips Count	***RH***	***-15.41***	***0.497***	***60.4***	***0.014***
		Temp.	19.3	-0.441	2.4	0.32
	Sticky Trap Counts	RH	-0.617	0.0231	23.8	0.125
		Temp.	1.498	-0.0362	14.4	0.191
St Ann - Non-UV absorbing film + shade cloth	Thrips Count	RH	4.5	1.034	17.5	0.126
		Temp.	74.3	-0.43	-	0.788
	Sticky Trap Counts	RH	-0.63	0.0601	-	0.404
		Temp.	9.95	-0.223	16.3	0.136

Several pests were observed in the greenhouses. Secondary pests observed were caterpillars (*Spodoptera* sp.), green aphids (*Myzus persicae*), whitefly (*Bemisia tabaci*), and leaf miner (*Liriomyza* spp.), Broadmites (*Polyphagotarsonemus latus*) as well as powdery mildew (*Leveillula taurica*). Powdery Mildew was the highest secondary pest observed at all sites and was highest at the non-UV absorbing film greenhouse in St. Ann. (see Figure 2).

The major pest observed was thrips. The difference between St. Elizabeth and Manchester thrips population (see Figure 3), could be attributed to several factors including the types of shade cloth and conduct of the greenhouse workers. In St. Elizabeth the entrance to the greenhouse was frequently left open and there were holes in the shade cloth thus allowing easier access of the thrips into the greenhouse. Moreover the greenhouse trellises were blue, which is a known colour attractant for thrips as seen in Brodsgaard study (as cited in (Frey, Cortada, and Helbling, 1994)). As such these conditions can account for the higher thrips population in St Elizabeth compared with the greenhouse in Manchester which had the same roof type.

Table 4 shows the mean number of thrips trapped in the sticky traps each week. The Analysis of variance (ANOVA) that was performed on the data showed that there were significant differences ($p < 0.001$) among the treatments. The differences in the number of thrips trapped varied over time as evidenced by the significant ($p < 0.001$) Week No/Treatment interaction.

There was generally a significantly higher number of thrips trapped for the sites with shade cloth as opposed to the one with the antiviral mesh. The mean number of thrips trapped for the antiviral mesh was 0.32 compared to 2.93 for the sites with shade cloth. The shade cloth sites had a higher number of thrips trapped which varied over the experimental period. On the other hand, at the antiviral mesh site, the counts were low and remained low throughout the period of the experiment.

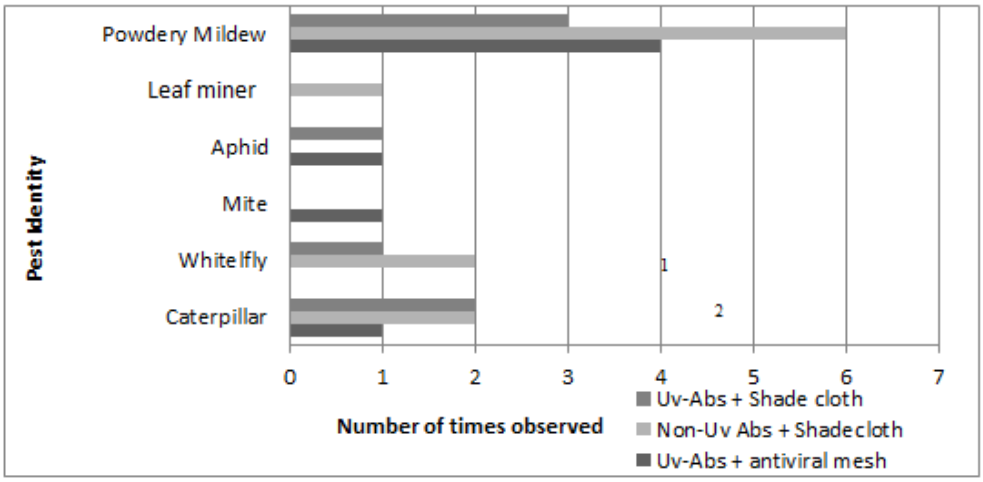

Figure 2: General pests observed in the greenhouses (December 2015-February 2016)
[1]Greenhouse roofing material with the ability to absorb ultraviolet rays
[2]Regular greenhouse roofing material unable to absorb ultraviolet rays

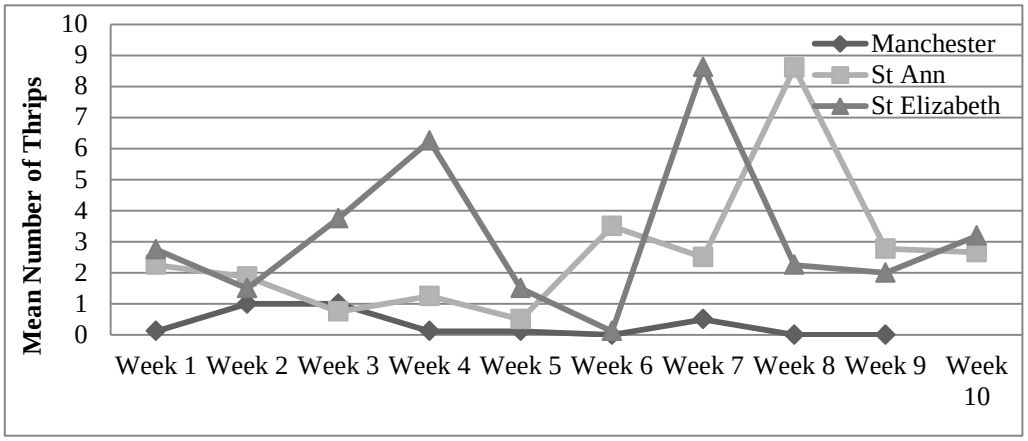

Figure 3: Mean number of thrips caught on sticky trap in St. Elizabeth, Manchester and St. Ann over a ten week period

Table 4. Mean number of thrips trapped on sticky traps per week

Site - Treatment	Manchester - UV absorbing film + antiviral mesh	St Ann - Non-UV absorbing film + shade cloth	St Elizabeth - UV absorbing film + shade cloth
Week 1	0.12	2.25	2.75
Week 2	1.00	1.87	1.50
Week 3	1.00	0.75	3.75
Week 4	0.12	1.25	6.25
Week 5	0.12	0.50	1.50
Week 6	0.00	3.50	0.12
Week 7	0.50	2.50	8.62
Week 8	0.00	8.60	2.25
Week 9	0.00	2.77	2.00
Week 10		2.66	3.19
Overall Mean	**0.32**	**2.67**	**3.19**

Lsd Main effect 1.205; Interaction 3.708

Based on the above consideration, and taking into account the comparison between the St. Ann site (non-Uv absorbing) and the St. Elizabeth site (UV absorbing) the difference in the trapped thrips is not related to the UV-absorbing property of the roofing.

It is important to note however, that the thrips trapped was much lower at the Manchester site from the start of the observations. It should be taken into consideration that this could be as a result of the treatment effect or it could be an indication that the overall thrips load at this site was lower than the other sites.

ANOVA done on the weekly mean thrips count (see Table 5) showed significant differences ($p < 0.001$) among the treatments. These differences varied over time as evidenced by the significant ($p < 0.001$) Week No/Treatment interaction.

From the onset of the data collection, the mean thrips counts were significantly higher at the St Ann site than at the other two sites (see Figure 4). However, this rapidly declined and by the third week there was no significant difference between it and the St. Elizabeth site. This trend continued throughout the observational period with the exception of the last week when the mean thrips count was significantly higher in St Ann than in St. Elizabeth. For both sites, there was a gradual increase in the mean thrips count as the experiment progressed. Even though the thrips count was similar for the Manchester and St. Elizabeth sites at the beginning of the observational period, the mean thrips count declined after the first two weeks and was significantly lower than the other two sites as of the third week. The levels continued to decline throughout the course of the observation to the point where it was almost negligible near the end of the period.

Table 5. Mean thrips counts observed weekly at the three greenhouse sites in Manchester, St. Elizabeth and St. Ann

Site - Treatment	Manchester - UV absorbing film + antiviral mesh	St Ann - Non-UV absorbing film + shade cloth	St Elizabeth - UV absorbing film + shade cloth
Week 1	19.9	104.2	24.4
Week 2	20.9	75.9	24.0
Week 3	7.6	49.0	35.6
Week 4	2.1	24.4	36.8
Week 5	4.3	58.4	37.5
Week 6	4.5	46.2	31.9
Week 7	0.60	65.9	53.4
Week 8	1.2	46.8	65.0
Week 9	0.3	55.6	59.8
Week 10		85.0	43.8
Overall Mean	**6.8**	**61.1**	**41.2**

Lsd Main effect 7.74 Interaction 23.82

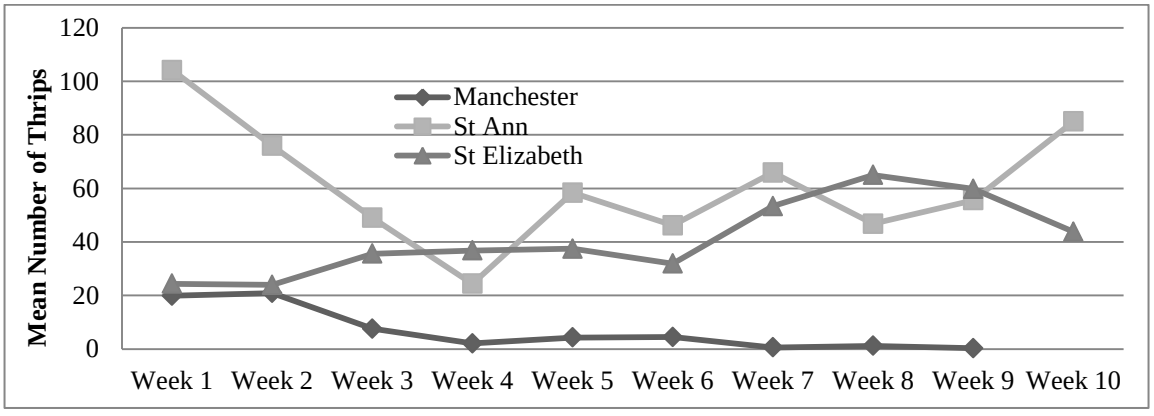

Figure 4: Mean thrips count obtained from sweet pepper flowers at Manchester, St. Elizabeth and St. Ann

4. Conclusion

The use of antiviral mesh appears to significantly affect the number and incidence of thrips in the greenhouse whereas the UV absorbency of the film did not have a significant impact on thrips population. The results are consistent with those reported by Costa et al. (2002, 2003) that found no reduction in the population of *T. vaporariorum* under commercial greenhouses covered with UV-absorbing films. The technology's effectiveness could improve if UV-absorbing film was used along with good greenhouse practices. Further studies are needed.

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Authors' Biographical Notes:

St. Sanya Morrison *oversees the Nematology Laboratory and temporarily oversees the activities of the Entomology Laboratory as a Senior Plant Protection Officer. She works in the Plant Protection Unit at Bodles Research Station (Research and Development Division in the Ministry of Industry, Commerce, Agriculture and Fisheries). Ms. Morrison has research interest in pest management and in enlightening students and farmers about plant parasitic nematodes.*

Camille Marks Kelly *is the Chief Plant Protection Officer in the Plant Protection Unit at Bodles Research Station (Research and Development Division in the Ministry of Industry, Commerce, Agriculture and Fisheries). She oversees the diagnostics and research activities for the three laboratories (Entomology, Nematology and Pathology) in the Plant Protection Unit. She is also the Chairperson for the National Fruit Fly Surveillance Committee and represents the Unit on several other technical committees. Mrs. Marks Kelly has keen interest in teaching and making paraphernalia that makes research results easy to understand and used by farmers and extension officers.*

Michelle A. Sherwood *is the Deputy Research Director for the Crop and Plant Protection Unit, Research and Development Division in the Ministry of Industry Commerce Agriculture and Fisheries. She possesses a Masters of Philosophy in Zoology specializing in the area of Entomology. Ms. Sherwood has over 22 years of contributing to agricultural research in various Technical, Administrative and Senior Management roles, by providing quality diagnostic, research and advisory services to the local, regional and international agricultural plant health sector. Her interests are in the areas of Research Entomology, Area-wide Integrated Pest Management, diagnostics and advisory, agriculture sector development and project management.*

Michael Pryce *is the Director of the Agricultural Marketing Information Division of the Ministry of Industry, Commerce, Agriculture & Fisheries in Jamaica, with the responsibility for the operation of the Division and advising the Ministry and other national and international agencies on agricultural statistics. Mr. Pryce was extensively involved with the planning and execution of the last two agricultural censuses in 1996 and in 2007 as part of the Agricultural Census Technical Working Committees set up by STATIN and was the main agricultural advisor to the Committee. He has had over 30 years of experience in agricultural statistics.*

Sheldon Michael Elliott *is currently the Senior Research Director in Plant Protection Unit at Bodles Research Station under the Research and Development Division of the Ministry of Industry, Commerce, Agriculture and Fisheries, where he has worked for approximately thirty years. Mr. Elliott is a Senior Research Scientist with a wealth of experience in the disciple of Plant Pathology, which is his area of specialty. He has conducted research activities in the management of Rhizome Rot disease.* ■

Evaluation of New Irish Potato (Solanum tuberosum L.) Varieties for High Yield Potential, Late Blight Tolerance and Market Suitability in Jamaica

Michelle A. Sherwood[1], Michael Pryce[2], Lisa R. Myers Morgan[3], Carla Douglas[4], Alexi Reid[5], Patrice Pitter[6], and Christopher A. Haughton[7]

[1,3,4,5,6,7] Crop and Plant Protection Unit, Research and Development Division (Bodles Research Station,) Old Harbour, St. Catherine, Jamaica, West Indies;
[1]Email: masherwood@micaf.gov.jm
[3]Email: lrsmyers@micaf.gov.jm
[4]Email: cpbucknordouglas@yahoo.com
[5]Email: alexi.reid107@gmail.com
[6]Email: ppitter0@gmail.com
[7]Email: haughton.chris@gmail.com

[2]Agricultural Marketing information Division, Ministry of Industry Commerce, Agriculture and Fisheries, Old Harbour St. Catherine, Jamaica, West Indies; Email: mapryce@micaf.gov.jm

Abstract: *In 2013, Irish potato (Solanum tuberosum L.) was strategically chosen by the Government of Jamaica's Agricultural Ministry as part of its import substitution policy to aid in the reduction of the country's food import bill. However, in order to ensure sustainability and continued supply locally, the need arose to diversify the types of Irish potato cultivars currently being grown. The Irish potato variety Spunta has been the most popular variety grown by Jamaican farmers. Hence in 2015, 15 new varieties with reported improved yields (>20,000 Kg/Ha), blight tolerance and suitability for the table and agro-processing markets were introduced for evaluation. The varieties were sourced from Canada and the Netherlands. The field evaluation trials were conducted in 2016 and 2017. The 2016 trial was conducted out of season in both a traditional Irish potato growing area, Chudleigh, Manchester, and a non-traditional area Ebony Park (Agro-park) in Clarendon. The trial was repeated in 2017 in three locations inclusive of a new location in Hounslow, St. Elizabeth. The field trials were laid out in a randomized block design and replicated three times. The Canadian Irish potato variety Bristol Pride was the highest yielding variety. The yield of 13 of the 15 varieties and the check Spunta exceeded >20,000Kg/Ha. Five varieties displayed variable resistance to late blight, Challenger, Diamant, Innovator, Mozart and Ronaldo.*

Keywords*: Irish potato varieties, blight tolerance, high yields, market suitability*

1. Introduction

The Ministry of Industry Commerce Agriculture and Fisheries has implemented several strategies to reduce the food import bill through its "Eat Jamaican Campaign" and import substitution programme which aims for Jamaicans to produce and eat more locally grown food. One such food is Irish potato. In 2013, a National Irish potato programme was launched by the then Ministry of Agriculture and Fisheries (MOAF) and implemented through RADA. In its first year, the National Irish Potato Expansion Programme experienced an increase in supply of local Irish potato from 32% in 2008 to 87% and by the 2016-2017 crop had achieved 100%.

The most popularly grown Irish potato variety by farmers is Spunta which is a high yielding variety, with moderate susceptibility to late and early blight and is only deemed suitable as a table or fresh potato. The dependence on one variety of Irish potato with little genetic variation for commercial production poses a high risk to the industry where diseases are a major concern and also limits its utilization for added value such as agro-processing. In ensuring that the industry remains viable, it is vital that new high yielding (>20,000 kg/Ha) blight resistant varieties are introduced and evaluated under local conditions before they are made available to the industry. The Research and Development Division of the MICAF was tasked with the responsibility of sourcing and conducting Irish potato variety trials to support the programme.

Suitable Irish potato varieties were identified from HZPC (an Irish potato seed company) in the Netherlands, and Potatoes Canada (an NGO for Canadian Seed Companies) with assistance from Glastonbury, Kujuma (local seed importers) and World University Services of Canada - Promotion of Regional Opportunities for Produce through Enterprises and Linkages (WUSC-PROPEL), respectively. In both variety trials, the locations were in different parishes which were agro-ecologically different. The objective of the trials were to determine the performance of these high yielding, blight resistant varieties under local conditions and hence their suitability for

both fresh consumption and the processing industry. This report serves to present the findings of these two variety trials.

2. Materials and Methods

In 2016, fifteen new Irish potato varieties were identified for the trials from the Netherlands (Challenger, Diamant, Innovator, Liseta, Lucinda, Mozart, Ronaldo, Santana, Farida, Victoria and unnamed HZD 04648) and Canada (Bristol Pride, Chieftain, Shepody and Kennebec) which were reported to be high yielding (>20 tonnes/Ha), with high dry matter content (>22%), late blight tolerant and early maturing to be compared against the popular locally grown variety Spunta. Irish potato varieties, Santana and HZD04-684 were not available for the 2017 repeat trial.

Year 1 Trial 1 was established in two locations Chudleigh, Manchester (traditional Irish potato growing area) and at Ebony Park, Clarendon (non - traditional Irish potato area). The Chudleigh, Manchester site was located at coordinates 18.1665410, -77.5202010 at an altitude of 766 m above sea level with maximum and minimum average temperatures of 30.5^{o}C and 24.4^{o}C respectively and annual rainfall of 1522.4 mm. The Ebony Park - Agro Park, Clarendon site was located at coordinates 17.934914, -77.352682 at altitude 32 m above sea level with maximum and minimum average temperatures of 32.2^{o}C and 24.6^{o}C respectively and annual rainfall of 803.3 mm. In the second trial a third location was added at Hounslow, St. Elizabeth located at coordinates 17.944873, -77.722071 at altitude 32 meters with maximum and minimum average temperatures of 32.2 and 24.6, respectively.

The first trial was established on in the winter January 8th & 19th in Clarendon and Manchester, respectively, outside of the ideal growing season. Sixteen and fourteen Irish potato varieties were established in 48 and 42 trial plots at Chudleigh, Manchester and Ebony Park, Clarendon respectively in a randomized complete block design. In the second trial the same experimental design was used with only 14 of the16 varieties were used in trial one and were established in three locations. One new location was added for the second trial, Hounslow, St. Elizabeth which was established on December 15th and 19, 2016, Ebony Park - Clarendon on December 23rd and 30th, 2016 and the 4H Chudleigh, Manchester property in Spring, March 28, 29 and 30, 2017.

In both trials seed potatoes of each variety were planted 30 cm apart along furrows which were 75 cm apart. The potatoes were covered with 3 cm soil. Each plot had five (5) furrows with 12 seeds each, a total of 60 plants per plot. There were 36 experimental plants from which data was collected throughout the experiment.

In both trials, the agronomic practices were the same. At Chudleigh, Manchester at the time of planting, humic acid and triple super phosphate were incorporated in the furrows at 1.6 kg per plot at a rate of 1kg triple super phosphate to 0.6 kg humic acid. Fertilizer inputs were lightly covered with soil and seeds planted. Due to late emergence of most varieties potassium nitrate was added via drip system at 6 weeks after planting. The fertilizer Grow Premium was applied with each application of pest disease control product and Production Premium added at the eighth week.

At Ebony Park with the exception of Innovator and Liseta, fertilizers were applied during the third and fifth week after establishment. First to be applied was humic acid with triple super phosphate. Then at the fifth week after establishment, potassium nitrate was fertigated onto the plot. Grow Premium was applied at each application of pest control and Production Premium added at the seventh week.

Soil testing was done to determine soil health prior to planting to guide fertilizer regimen and determine the status of nematodes and pathogens in the soil. Monitoring of the inner plant rows within each variety was conducted once weekly from emergence. Randomly selected plants within each plot were observed, counted for pest incidence and scored for visual symptoms of Late Blight, Early Blight and signs of Potato Tuber Moth Damage. A disease severity rating of 0 -100% was used for blight symptoms where 0 - no symptom, and where 100% indicating that all leaves of the plant was affected by the disease or was damaged.

Based on the outcome of the monitoring, recommendations were provided for the treatment of pests including early and late blight and mites. Experimental plots received prophylactic treatments with contact and systemic fungicides to control early and late blight. Insecticides were applied for control of potato tuber moth based on the pest levels indicated by the monitoring.

The daily temperature (^{O}C) and rainfall (mm) data for the two trial years was collected from the Climate Branch of the Meteorological Office of Jamaica. The Met stations data that were provided were from Grove Place which is 3.4 Km away and is south-southwest of Chudleigh, Bethlehem Teacher's College which is 4.3 Km northeast of Hounslow and May Pen Met Station which is 11.9 Km east-northeast of Ebony Park**.**

At harvest, data was collected at each location for each variety per plot from 10 plants from the inner three experimental rows. The data collected included the tuber numbers and weight per plant, marketable and unmarketable yields per plant. Postharvest data was collected from random samples taken from each variety at two

locations in 2017 Ebony Park and Hounslow to determine the dry matter content (DM) by the Scientific Research Council.

3. Results and Discussion

3.1 Experimental Yields, Year 1 - 2015/2016

3.1.1 Chudleigh (Fall):

There were no significant differences (p = 0.722) in yield among the varieties at this site. The overall experimental mean yield was 4.32 kg per plot. It is important to note that no final comparative interpretations can be taken from perceived differences among the mean yields, as the experimental variability indicates that none of these differences were significant. At best, these yields should be treated as indicative. The mean yields per plant for each of the varieties are presented in Figure 1.

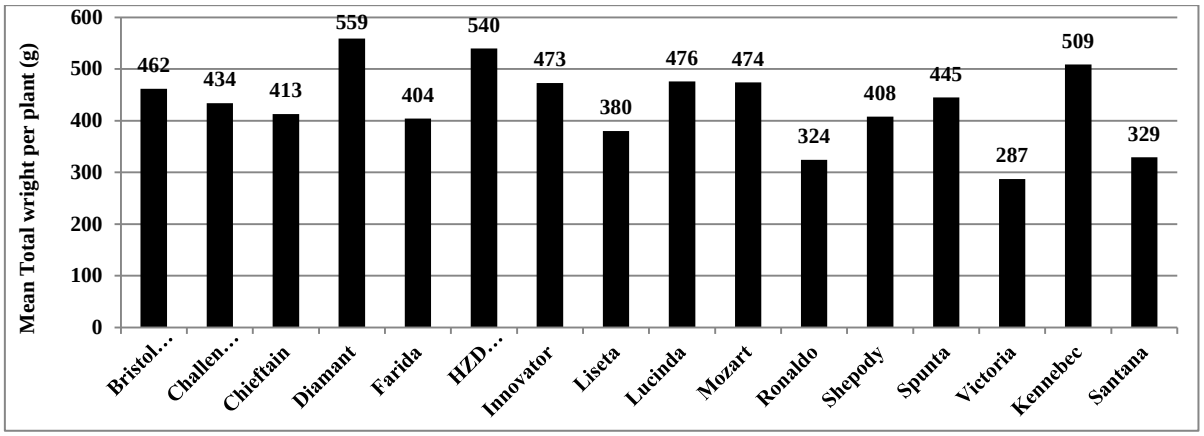

Figure 1: Year 1 Irish potato variety trial for Chudleigh, Manchester, 2015/2016

3.1.2 Ebony Park, Clarendon

At the Ebony Park site, analysis of the total yield per plant for the fourteen varieties showed that there were significant differences (p = 0.026) in yields among the varieties at this site. The overall experimental mean yield was 519 g per plant – higher than at the Chudleigh site. The mean yields achieved for each of the varieties are presented in Figure 2. The best performing variety was Bristol Pride at 837 g/plant. It statistically out-performed several of the other varieties, with the exception of Santana (756 g/plant), Kennebec (719 g/plant), Chieftain (698 g/plant), Ronaldo (6.24 g/plant) and Diamant (5.77 g/plant). The worst performers at this site, were HZD04-648 (272 g/plant), Farida (288 g/plant), and Mozart (331 g/plant).

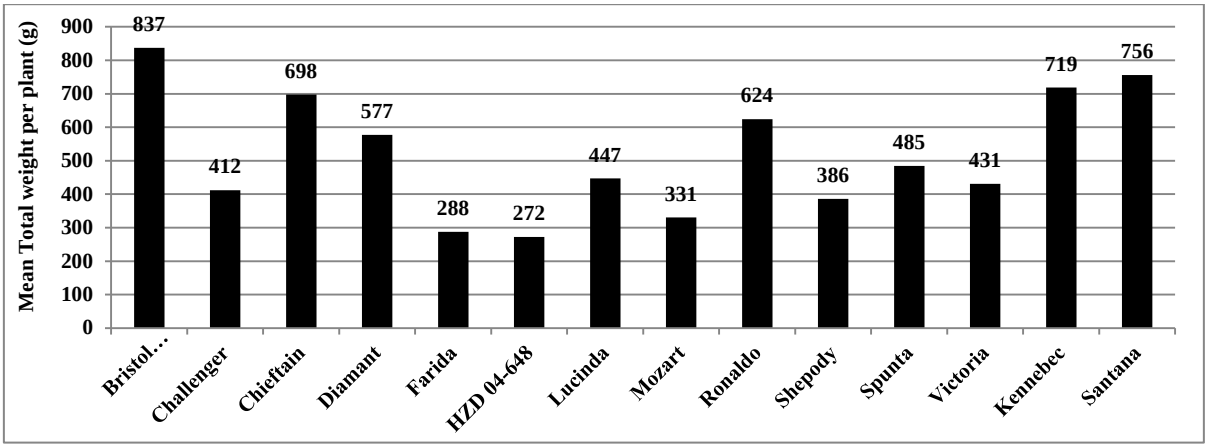

Figure 2: Year 1 Irish potato variety trial for Ebony Park, Clarendon, Fall 2015/2016

3.2 Experimental Yields, Year 2 - 2016/2017

3.2.1 Ebony Park, Clarendon

*Mean Number of Tubers***:** There were statistical differences ($p < 0.001$) among the varieties with respect to the mean number of tuber per plant. Ronaldo and Challenger out-performed all the other varieties in terms of tuber number at 8.57 tubers per plant, respectively. These two varieties were the only two varieties which performed significantly higher than Spunta. All the other varieties out-performed Mozart at 2.49 tubers per plant.

Mean Number of Marketable Tubers: In terms of the number of marketable tubers the differences were again significant ($p < 0.001$). Here again Ronaldo at 4.5 tubers per plant had the highest mean. However it was not statistically different from varieties like Bristol Pride and Liseta at 3.367 tubers per plant, respectively. Spunta recorded a mean of 1.767 tubers per plant which was significantly lower than these three high performing varieties along with Lucinda (2.73), Innovator (2.826) and Chieftain (3.3).

*Mean Number of UnMarketable Tubers***:** For the number of un-marketable tubers, here Challenger seemed particularly challenged. With on average some 6.13 tubers per plant or 71.5 % of its tubers being un-marketable. This was by far, the worst level of unmarketability. Ronaldo was second best in terms of the number of tuber being unmarketable at 4.07. Bristol Pride had the least amount of un-marketable tubers (1.13 tubers per plant) followed by Mozart (1.78 tubers per plants) and Innovator (1.97 tubers per plant). Spunta recorded 3.47 tubers per plant which is significantly higher than these latter varieties. The statistical significance of differences among the varieties was $p < 0.001$.

Mean Marketable weight /Plant (g): Here again there were significant differences ($p < 0.001$) among the varieties. The highest marketable weight of tubers per plant was achieved with Bristol Pride, at 451 g. This variety significantly outperformed all the others. Coming in second was Ronaldo at 318.3 g per plant. Both these varieties along with Liseta, Chieftain and Innovator performed significantly higher than Spunta which recorded 149 g per plant. Mozart was the worst performer, only yielding 65.3 g of marketable tubers per plant among the varieties.

Mean Total Weight/ Plant (g): Bristol Pride at 500 g per plant had the highest mean total weight per plant with Ronaldo in second place at 446.7 g per plant. These two varieties along with Liseta, Chieftain and Challenger performed significantly higher than Spunta which recorded 258 g per plant. Figure 3 shows a summary of the results at Ebony Park.

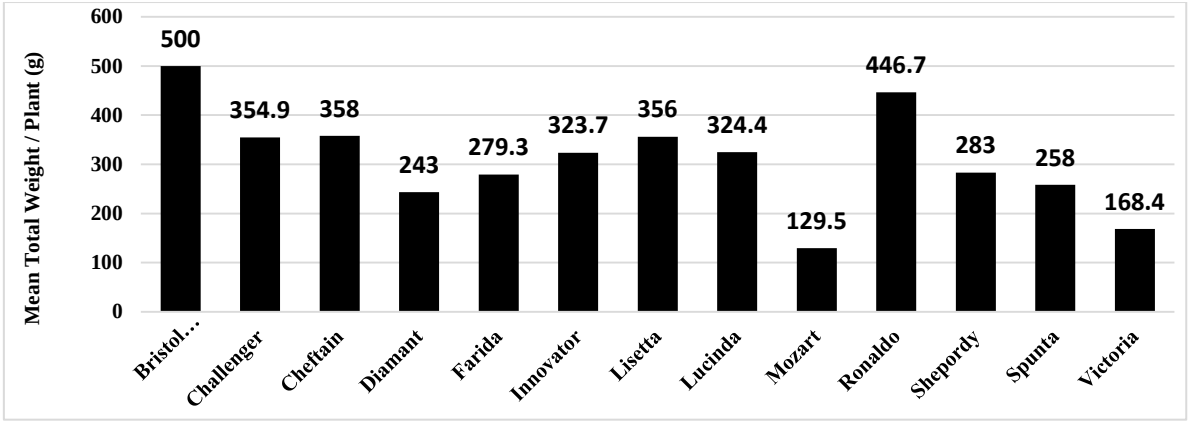

Figure 3: Year 2 Irish potato variety trial for Ebony Park, Clarendon, Fall 2016/2017

3.2.2 Chudleigh, Manchester 2017 (Spring)

Mean Number of Tubers: At the Chudleigh location there were significant differences ($p < 0.001$) among the varieties. The most prolific variety at 5.767 tubers per plant was Challenger, although it did not have a significantly higher mean than Innovator at 5.099 tubers per plant. These two varieties were the only varieties recording significantly more tubers than Spunta which was 3.518 tubers per plant. The worst performer was Farida which at 2.746 tubers per plant was significantly lower than all the other varieties along with Chieftain which gave the second lowest number of tubers recording a mean of 3.368 tubers per plant.

Mean Number of Marketable Tubers: The differences among the varieties were significant ($p < 0.001$). Challenger had the highest mean number of marketable tubers, at 4.067 tubers per plant, significantly outperforming all of the other varieties at this site. Other varieties which performed recorded significantly higher marketable tubers than Spunta were Innovator and Diamant. The variety that gave the least mean number of marketable tubers was Shepody which had a mean of <1 (0.455) tubers per plant.

Mean Number of Unmarketable Tubers: Here again, the differences were significant ($p = 0.014$). Shepody at 3.055 had the highest number of unmarketable tubers while Farida recorded the lowest number of unmarketable tubers at less than one tuber (0.986) per plant. These two varieties were the only ones which were significantly different from Spunta recording 2.005 tubers per plant.

Mean Marketable weight /Plant (g): Challenger significantly outperformed all of the other varieties in terms of the marketable weight per plant. It averaged 253.2 g per plant which was by far much higher than the second placed variety, Innovator at184.5 g per plant. These two varieties were significantly higher than Spunta which recorded 101.4 g per plant. The worst performing variety in terms of marketable yield was Shepody at only 12.9 g per plant.

Mean Total Weight/ Plant (g): As with the previous variable, Challenger had the highest mean total weight per plant at 288.2 g. It significantly out did all of the other varieties, with again, Innovator coming second and Ronaldo in third. These three varieties recorded means which were significantly different from Spunta. As in the previous case also, Shepody was the worst performer at 44.6 g of total weight per plant. Figure 4 depicts a summary of the results at the Manchester site.

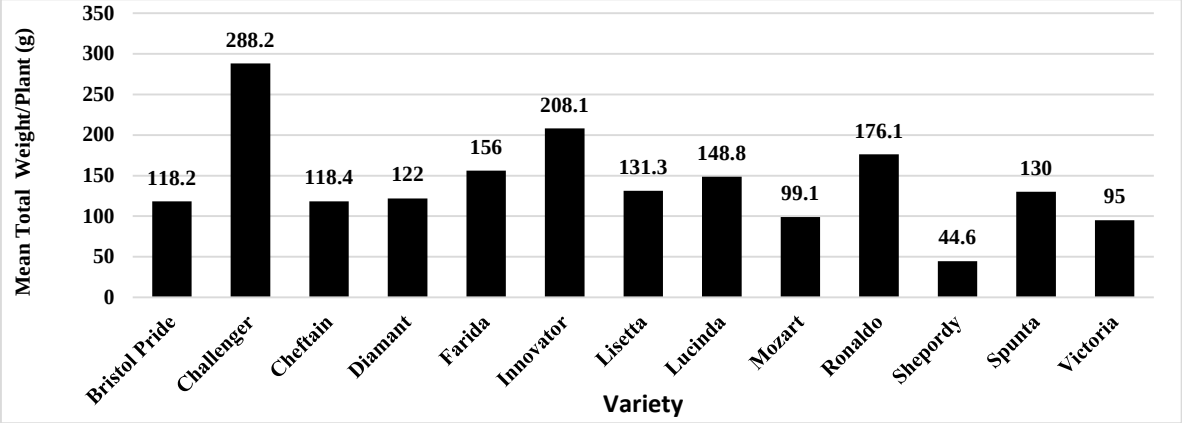

Figure 4: Year 2 Irish potato variety trial for Chudleigh Manchester, Spring 2016/2017

3.2.3 Hounslow, St. Elizabeth

Mean Number of Tubers: There were statistical differences ($p < 0.001$) among the varieties with respect to the mean number of tuber per plant. Ronaldo and Challenger out-performed all the other varieties including Spunta (4.03 tubers) in terms of tuber number at 7.83 and 7.67 tubers per plant respectively. Innovator and Farida were out-performed by all the other varieties at 3.63 tubers per plant.

Mean Number of Marketable Tubers: In terms of the number of marketable tubers the differences were again significant ($p < 0.001$). Here Liseta at 4.1 tubers per plant had the highest mean. However it was not statistically different from varieties like Ronaldo at 3.733 and Bristol Pride at 3.33 tubers per plant, respectively. All three varieties were significantly higher than Spunta which had a mean of 1.933 tubers per plant.

*Mean Number of UnMarketable Tubers***:** For the number of un-marketable tubers, here Challenger again seemed particularly challenged. With on average some 6.00 tubers per plant or 78.23 % of its tubers being un-marketable. This was by far, the worst level of unmarketability. Ronaldo was second in terms of the number of tuber being unmarketable at 4.1. Bristol Pride had the least amount of un-marketable tubers. The statistical significance of differences among the varieties was $p = 0.014$.

Mean Marketable weight /Plant (g): Here again there were significant differences ($p < 0.001$) among the varieties. The highest marketable weight of tubers per plant was achieved with Bristol Pride, at 962 g. This variety significantly outperformed all the others. Coming in second was Liseta at 702 g per plant. Both of which were more significant that Spunta which had 447 g per plant. Victoria was the worst performer, only yielding 82 g of

marketable tubers per plant among the varieties.

Mean Total Weight/ Plant (g): Similarly, Bristol Pride at 1015g per plant had the highest mean total weight per plant. Following in second place was Liseta at 888 g per plant which was significantly higher than Spunta at 747 g. Figure 5 shows a summary of the results at Ebony Park.

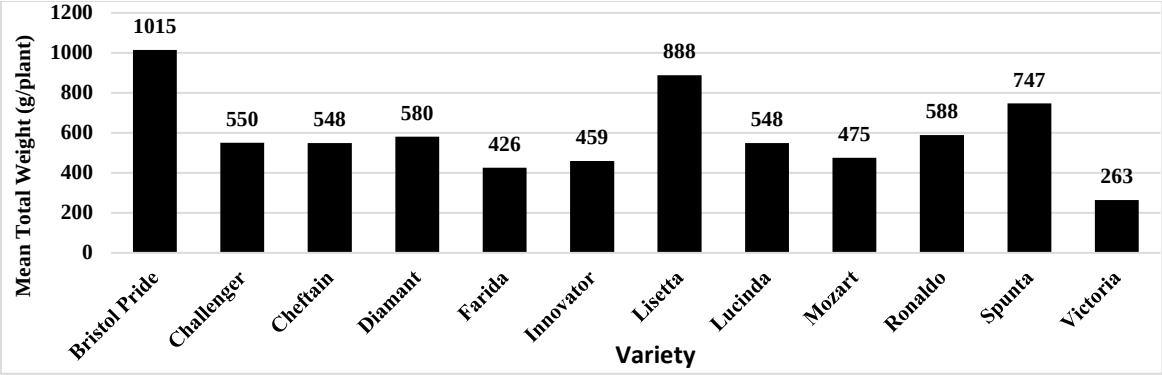

Figure 5: Year 2 Irish potato variety trial for Hounslow, St. Elizabeth, Fall 2016/2017

3.3 Potential yields (Kg/Ha) for trials 1and 2

In order to determine which varieties were high performing, > 20,000 Kg/Ha, the yields per plant (grams per plant) were converted to Kg/Ha assuming 44,444 plants per Ha (30 cm x 75 cm spacing). The yields were determined assuming 100% germination, and no mortality of plants in the entire crop (see Table 1). The local yields when compared to international yield in tropical and temperate locations were comparable.

Table 1: Results of Irish Potato variety trials (2) showing potential performance in terms of yields (Kg/Ha) for trial locations (Y1 and Y2)

Variety	Ebony Park (Fall)		Hounslow (Fall)	Manchester (Y1-Fall; Y2 Spring)		International Yields per variety, Kg/Ha
	Total Yield Kg/Ha (Y1)	Total Yield Kg/Ha (Y2)	Total Yield Kg/Ha (Y2)	Total Yield Kg/Ha (Y1)	Total Yield Kg/Ha (Y2)	
Bristol Pride	37,199.63	22,222.00	45,110.66	20,524.35	5,253.28	28,181.82[1]- 38,181.82[1]
Challenger	18,310.93	15,773.18	24,444.20	19,280.45	12,808.76	14,659.09[1] - 30,113.64[1]
Chieftain	31,021.91	15,910.95	24,355.31	18,347.53	5,262.17	21,590.91[1] - 36,477.27[1]
Diamant	25,644.19	10,799.89	25,777.52	24,833.58	5,422.17	32,955[1] - 62,200[2]
Farida	12,799.87	12,413.21	18,933.14	17,947.70	6,933.26	No data identified
Innovator	na	14,386.52	20,399.80	23,989.50	9,248.80	24,772.72[1] to 45,000[1]
Liseta	na	15,822.06	39,466.27	21,013.03	5,835.50	23,090[3] to 61,300[2]
Lucinda	19,866.47	14,417.63	24,355.31	22,612.33	6,613.27	No data identified
Mozart	14,710.96	5,755.50	21,110.90	16,881.50	4,404.40	No data identified
Ronaldo	27,733.06	19,853.13	26,133.07	21,146.30	7,826.59	No data identified
Shepody	17,155.38	12,577.65	na	21,057.45	1,982.20	15,227.27[4] - 39,318.18[2];
Spunta	21,555.34	11,466.55	33,199.67	14,393.70	5,777.72	13,296[5] to 65,000[2]
Victoria	19,155.36	7,484.37	11,688.77	14,615.83	4,222.18	4000-7000[6] with LB
Kennebec	31,955.24	na	na	18,125.40	na	19,204.55[4] to 29,370[7]
Santana	33,599.66	na	na	19,769.13	na	No data identified
HZD 04-648	12,088.77	na	na	12,749.98	na	No data identified

Sources: [1]Clough, 2017; [2]Vakis, 1990; [3]Milic, 2012; [4]NCSU, 2015; [5]MoA, 1975; [6]Ferris et al., 2002; [7]Vesna, 2012

3.4 *Pest Management and Weather Conditions*

3.4.1 Year 1- 2015/16

At Ebony Park, the disease severity was very low, with Spunta recording the highest severity of 8.2 % followed by Chieftain recording the second highest severity (4.28%) and Mozart the lowest 0.53 %. At Ebony Park, the rainfall was little or no rain for most of the crop recording <1 mm to 10mm. However there was one period of heavy rain near to harvest the week of April 4, 2016 when the rainfall peaked 39.2 mm. The temperature ranged between 19.2^{o}C and 33.6 ^{o}C for the entire trial (January to April 2016).

The results of the monitoring determined that in the case of Late blight, final disease severity remained below 8.2 % in both locations. At Chudleigh the Late Blight severity was highest on Spunta (3.8%) followed by Liseta with 3.46 % and least severe was Chieftain recording 0.11%. At Chudleigh the rainfall for most of the period was <1 mm, however two weeks after planting 52 mm of rain fell in that location on January 21st. 10.8mm,8.4mm and 10.6 mm fell on February 29, March and April 2016, respectively. At Ebony Park, Mozart had the highest incidence of Potato Tuber Moth (6.46%) followed by Spunta (5.56%) at this location. The pest incidence of PTM was very low and had low impact on the varieties for this trial.

3.4.2 Year 2 – 2016/2017

On the Spring Crop at Chudleigh, Manchester LB was detected 5 weeks after planting on 12 of 13 varieties except Innovator on which LB was detected 7 WAP. At 7 WAP at Chudleigh, Spunta exceeded 50 % severity along with Liseta, Bristol Pride, Diamant, Chieftain, Lucinda and Shepody while Innovator (8.23%), Challenger (7.21%) and Farida (17.84 %) was <20% severity. At 10 WAP, 8 of 13 varieties had a 100 % severity except Mozart (82.41 %), Challenger (92%), Ronaldo (93.1%), Farida (93.15%), and Diamant (99.31%) (see figure 7). At Chudleigh the weekly rainfall ranged between 0.4 mm (week of June 11) and 924.4 mm (week of April 22). The temperature ranged between 15.3 ^{o}C and 28.90 ^{o}C for the entire trial (March to June 2017).

The most susceptible varieties were Spunta, Liseta, Bristol Pride, Lucinda, Shepody and Chieftain. Ronaldo, Victoria, Diamant were more resistance, while Challenger, Innovator, Farida and Mozart showed the most resistance to LB. This location received the highest level of rainfall for most of the crop and temperatures above 25 ^{o}C of all three locations. A combination of Late Blight pressure and high temperatures may explain the reduction in yields at this location when compared to Ebony park and Hounslow.

Table 2: Late Blight Severity and Rainfall (mm) at Chudleigh Manchester, April to June 2017

WAP	Date	Total Rain (mm)	Spunta	Innovator	Victoria	Bristol Pride	Diamant	Liseta	Farida	Mozart	Ronaldo	Chieftain	Challenger	Lucinda	Shepody
2	**08/04/2017**	214.4	-	-	-	-	-	-	-	-	-	-	-	-	-
3	**15/04/2017**	165.2	0	0	0	0	0	0	0	0	0	0	0	0	0
4	**22/04/2017**	924.4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	**06/05/2017**	463.2	18.57	0	3.2	3.89	1.87	7.65	0.125	1.93	1.07	1.93	0.03	2.33	11.4
6	**13/05/2017**	70.8	14.67	0	6.93	17.53	11.67	9.2	1.45	3.93	4.77	9	0.3	46.21	34.17
7	**28/05/2017**	227	65.83	8.23	42.67	65.19	53.5	29.17	17.84	35.36	41.37	73	7.21	60.44	73.33
8	**04/06/2017**	1	92.72	39.17	84.67	92.43	91.33	71.67	50.54	52.41	80	92.75	53.5	70.5	91.14
9	**11/06/2017**	0.4	100	91.67	99.33	97	99.33	98.83	85	71.67	85.33	100	82	97	100
10	**18/06/2017**	145.2	100	100	100	100	99.31	100	93.15	82.41	93.1	100	92	100	100

3.5 Post Harvest – Percent Dry Matter (% DM)

In Year 1- 2015/16, the dry matter content of the 16 varieties in the two trials ranged from 38% to 69%. These values were abnormally high and vary significantly from that reported for the varieties by the manufacturers. In the international market, past processing requirements have stated that 18% DM is the minimum for processing French fries. However, industry standards now seek potatoes with a 20-25% DM. In the first trial all varieties would be suitable for processing. The data

In Year 2-2016, the DM content was less than 20% for most varieties except Innovator at Ebony Park (see Table 2). Using 18% as a minimum for processing, the DM most of the varieties was found to comparable to the

international recommendations for each of the varieties. Nine varieties were suitable for fresh and five for processing.

Table 2: Results for Dry Matter for Ebony Park and Hounslow in variety Year2/Trial 2 and local suitability for Fresh Consumption (FC) or French Fries (FF) using 18% as a minimum for processing

Variety	Ebony Park (% DM)		Hounslow (% DM)		Published data (% DM)	Intl. Market Suitability
	Trial 2	Local trial Suitability	Trial 2	Local trial Suitability		
Farida	19.9	Processing	16.6	Fresh	19 % (HZPC); 18,8% , 13%	FC
Liseta	12.1	Fresh	18.7	Processing	19.8 %, 14% (HZPC)	FC
Lucinda	15.8	Fresh	15.6	Fresh	17.4 % (HZPC)	FC
Bristol Pride	19.3	Processing	16.5	Fresh	TBD	FC, FF
Ronaldo	12.7	Fresh	14.2	Fresh	17.9 %	FC
Innovator	20.6	Processing	15.0	Fresh	TBD	FC, FF
Challenger	18.2	Processing	18.6	Processing	22.5% / 16.6%	FC, FF
Victoria	16.6	Fresh	19.0	Processing	21.1% / 15.2%	FC, FF
Diamant	19.6	Processing	16.6	Fresh	TBD	FC, FF
Spunta	19.4	Processing	17.3	Fresh	20.2 % (HZPC) ; 18.28 (Vakis, 1990)	FC
Kennebec	14.7	Fresh	17.3	Fresh	21.7 % (HZPC)	FC, FF
Mozart	13.9	Fresh	18.3	Processing	20.4% / 14.5% (HZPC)	FF
Shepody	17.0	Fresh	19.3	Processing	20.72 (Vakis, 1990)	FC, FF,
Chieftain	17.4	Fresh	17.9	Fresh	TBD	FC; FF

4. Conclusions and Recommendations

In Year 1/trial 1, seven of the varieties yielded >20,000 Kg/Ha at Ebony Park and seven in Manchester during the Fall season. Hounslow proved to be a very good non-traditional location to cultivate Irish potato during the Fall Period of Year 2 when compared to Ebony Park and Manchester. In year 2/ trial 2, 10 of the varieties yielded >20,000 Kg/Ha, none at Ebony Park and Manchester Spring Crop. Challenger, Innovator and Ronaldo varieties can be considered for Spring/Summer crop and in areas with historical high Late Blight pressure and suitable soil temperatures. Kennebec and Santana though they performed well in trial one needs to be evaluated again before making any recommendations. Victoria, Farida and HZD04-648 performed below >20,000kg/Ha and are not being recommended for further evaluations.

A commercial size 2 Ha research plot to be conducted for the six top high yielding varieties is being recommended before going into wide scale commercial production. Considerations are to be made primarily for three variable resistant (Ronaldo, Diamant and Challenger) and three susceptible (Bristol Pride, Liseta and Spunta). These six varieties are a mixture suitable for fresh and processing. The industry stakeholders are to review the data and make the final decision.

The percent severity of Late Blight experienced at the three locations was influenced by rainfall. The lower elevations experienced the least LB pressure even in the presence of rainfall during the Fall season. Chudleigh Manchester though a traditional area for Irish potato the yields did not do well in Year 2/trial 2 because of Late Blight pressure influenced by high rainfall. However, this occurrence provided an opportunity to identify the most susceptible and resistant potatoes among the varieties. A Spring or Summer Crop at Chudleigh without proper pest management for the crop can be easily destroyed especially during any of the two main rainy seasons. Every effort must be made to plant in early fall and reap before the April rainy season to reduce the impact of Late Blight.

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Author's Biographical Notes

Michelle A. Sherwood *is the Deputy Research Director for the Crop and Plant Protection Unit, Research and Development Division in the Ministry of Industry Commerce Agriculture and Fisheries. She possesses a Masters of Philosophy in Zoology specializing in the area of Entomology. Ms. Sherwood has over 22 years of contributing to agricultural research in various Technical, Administrative and Senior Management roles, by providing quality diagnostic, research and advisory services to the local, regional and international agricultural plant health sector. Her interests are in the areas of Research Entomology, Area-wide Integrated Pest Management, diagnostics and advisory, agriculture sector development and project management.*

Michael Pryce is *the Director of the Agricultural Marketing Information Division of the Ministry of Industry, Commerce, Agriculture & Fisheries in Jamaica, with the responsibility for the operation of the Division and advising the Ministry and other national and international agencies on agricultural statistics. Mr Pryce was extensively involved with the planning and execution of the last two agricultural censuses in 1996 and in 2007 as part of the Agricultural Census Technical Working Committees set up by STATIN and was the main agricultural advisor to the Committee. He has had over 30 years of experience in agricultural statistics.*

Lisa R. S. Myers Morgan *is the Principal Research Director for the Research and Development Division, Ministry of Industry Commerce Agriculture and Fisheries where she has worked for over 22 years in several capacities. She possesses a Doctor of Plant Medicine Degree from the University of Florida in Gainesville, USA and an Masters degree in Botany and Bachelors Degree in Natural Sciences majoring in Biochemistry. From The University of the West Indies. She provides leadership and direction for the execution of the National Agriculture Research and Development programme of the Ministry covering the multidisciplinary areas of Crop and Livestock research. She has provided technical and policy advice to the agricultural portfolio of the Ministry and its stakeholders in the areas of plant health and food and nutrition security.*

Carla Douglas *is the Senior Research Director for the Crop Research Unit at the Research and Development Division, Ministry of Industry Commerce Agriculture and Fisheries where she has worked for over 22 years. She has a Degree in Botany and Zoology and a Masters in Natural Resource Management.. She supervises a staff*

composed of agronomists and plant breeders with portfolio responsiblityies to develop and introduce new plant varieties, maintain and evaluate new germplasms, conduct trials to improve crop nutrition and growth. She has interests in promoting agricultural research, preserving plant biodiversity, post harvest technology, preservation and provision of seed germplasm to the agricultural sector to improve crop production and productivity.

Alexi Reid *is the Acting Chief Agronomist for the Crop Research Unit at the Research and Development Division, Ministry of Industry Commerce Agriculture and Fisheries where he has worked over 8 years. He has responsibilities to conduct agronomic research involving the introduction of new plant varieties, technologies to improve crop nutrition and growth. He is a Justice of the Peace, Entrepreneur and an Agricultural Consultant. He has a wealth of knowledge in applied research and Agriculture gained during his studies and experiences in Jamaica, Japan, China and South Korea. Finding practical agricultural solutions for farmers drives his passion.*

Patrice Pitter *is the acting Senior Plant Protection Officer, in the Plant Pathology Laboratory of the Research and Development Division, Ministry of Industry, Commerce, Agriculture and Fisheries, Jamaica where she has worked for 11 years. She has a Bachelor of Technology Degree in Environmental Science with specialization in Environmental Protection and Management. She executes various research projects providing plant health diagnostics and advisory, research and epidemiology for various diseases affecting priority crops including Irish potato, onion, scotch bonnet pepper, tomato and lettuce. She has interests in accreditation of laboratories, training of farmers and extension officer and research solutions to plant pests.*

Christopher A. Haughton *is a Plant Protection Officer in the Research & Development Division of Jamaica's Ministry of Industry, Commerce, Agriculture and Fisheries. Mr. Haughton has been working in the field of Entomology for four years primarily in the areas of Agricultural Pest Management and General Taxonomy. He wishes to assist in the development of successful bio-control programmes for more sustainable agricultural systems in the Caribbean.*

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The Efficacy of Baculovirus Bio-Pesticides in the Management of Beet Armyworm, *Spodoptera exigua* (Hübner) in Scallion, *Allium fistulosum* L. in Jamaica

Christopher A. Haughton[1], Michelle A. Sherwood[2], Francine Webb-Lawrence[3], and Dwayne Henry[4]

[1,2] Research and Development Division, Ministry of Industry Commerce, Agriculture and Fisheries, Old Harbour, St. Catherine, Jamaica, West Indies;
[1]Emails: cahaughton@micaf.gov.jm, haughton.chris@gmail.com
[2]Emails: masherwood@micaf.gov.jm; mishanton@yahoo.com

[3,4] Rural Agricultural Development Authority, Hope Gardens, Kingston, Jamaica, West Indies;
[3]Email: webbf@rada.gov.jm
[4]Email: henryd@rada.gov.jm

Abstract: *Spodoptera exigua (Lepidoptera: Noctuidae), Beet Armyworm, is a polyphagous pest, originating in South Asia and now has a worldwide distribution. It has been reported from Jamaica from as far back as the 1970's and since 2009 has caused economic damage to Allium spp. crops, mainly onion and scallion, during flare-ups and outbreaks. The current management system being employed for this pest includes: monitoring with pheromone traps, cultural practices and predominantly chemical control. This management system lacks a reliable and easily employed biological control component, as such the inclusion of a viral based insecticide was identified.*

The viral insecticide SPEXIT® SC a commercial formulation of a nucleopolyhedrovirus (NPV) specific for S. exigua, was sourced from Andermatt Biocontrol in Switzerland through linkages forged with Source Farm Foundation/USAID programme and a US based Symbiont Biological Pest Management Company. The nucleopolyhedrovirus acts very specifically against the larvae of the Beet armyworm, Spodoptera exigua. After ingestion by the larva, the virus multiplies within the cells of the host insect causing a fatal infection. Rapid virus multiplication within the host cells results in cell destruction and death of the organism, typically within 3-7 days. No maximum residue levels (MRLs) are defined for Spexit®. Contains no chemical ingredients, leaves no residues on the crop, complies with organic farming, has no side effects on mammals, beneficial insects, bees, aquatic organisms and other non-target organisms. A potential environmentally friendly solution to the Beet armyworm programme

A five week trial was conducted by the Research and Development Division, of the Ministry of Industry, Commerce, Agriculture and Fisheries in collaboration with the Rural Agricultural Development Authority on an existing scallion farm (three weeks untreated) in New Forest, South Manchester during November 2017. Twelve plots were established in a completely randomized block design with four treatments replicated three times which included Spexit at 100 and 200 ml/Ha, Bacillus thurigiensis kurstaki at manufacturers rate, and a no treatment control was employed. Treatments were applied weekly using a knapsack sprayer as would be used by most farmers and data were collected weekly before the application of the treatments. The trial was compromised in the third week by the farmer treating the field with an unregistered insecticide.

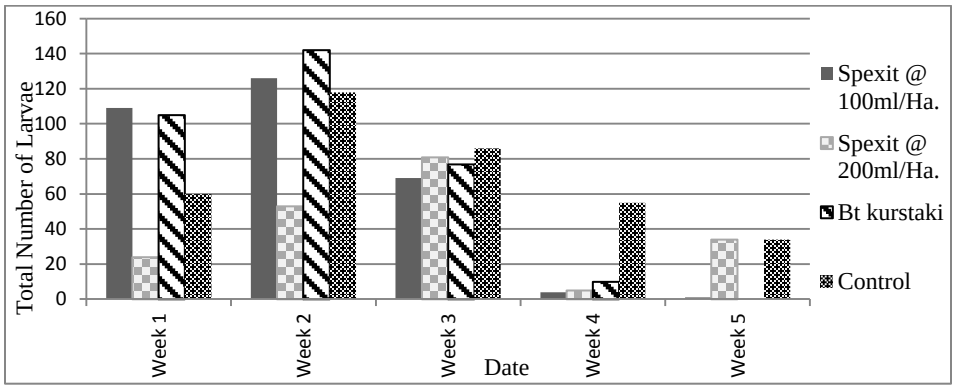

Figure 1: Change in larval population across the different treatments

It was observed that the pest population was reduced by 96.70 - 99% after the third week of the trial (see Figure 1). In plots with the baculovirus/insecticide and Bt/insecticide treatments compared to the insecticide treatment alone in the control plots only saw a decrease of 36%. The treatments of the biologicals and conventional insecticides demonstrate that, through synergistic actions the combination can reduce the Beet armyworm population. Combinations of this product with reduced rates of conventional synthetic insecticides may offer more plant protection than the virus alone. The viral agent has the potential for increasing the effectiveness of the Beet armyworm management programme.

Despite the differences seen in the observations, statistical analyses showed that there was no significant difference among the treatments (see Table 1). A repeat of this trial is to be conducted.

Table 1: Results of the statistical test showing variance among means*

Treatment Number	Number of Young larvae	Number of Old larvae	Total Number of larvae
1	20.8	61.8	2
2	15.6	39.4	2.2
3	20.8	66.8	0.4
4	18.6	70.6	0.2
p-value	**0.476**	**0.853**	**0.346**

** - Significance denoted by a p-value less than 0.05*

***Keywords**: Beet Armyworm, Spodoptera exigua, Nucleopolyhedrovirus, Biological Control*

Authors' Biographical Notes:

Christopher A. Haughton *is a Plant Protection Officer in the Research and Development Division of Jamaica's Ministry of Industry, Commerce, Agriculture and Fisheries. Mr. Haughton has been working in the field of Entomology for four years primarily in the areas of Agricultural Pest Management and General Taxonomy. He wishes to assist in the development of successful bio-control programmes for more sustainable agricultural systems in the Caribbean.*

Michelle A. Sherwood *is the Deputy Research Director for the Crop and Plant Protection Unit, Research and Development Division in the Ministry of Industry Commerce Agriculture and Fisheries. She possesses a Masters of Philosophy in Zoology specializing in the area of Entomology. Ms. Sherwood has over 22 years of contributing to agricultural research in various Technical, Administrative and Senior Management roles, by providing quality diagnostic, research and advisory services to the local, regional and international agricultural plant health sector. Her interests are in the areas of Research Entomology, Area-wide Integrated Pest Management, diagnostics and advisory, agriculture sector development and project management.*

Francine Webb *heads the Plant Health and Food Safety Unit in the Technology, Training and Technical Information Division (TTTI) of the Rural Agricultural Development Authority (RADA) in Jamaica. in the past she worked with the biological control programme for the coffee berry borer, a programme implemented by the Caribbean Agricultural Research and Development Institute (CARDI) from 1999-2004. She received undergraduate and postgraduate training at The University of the West Indies (Mona) and is currently completing a Master of Advanced Studies degree in Integrated Crop Management at the University of Neuchàtel (UniNE) in Switzerland.*

Dwayne Henry is *a Plant Health and Food Safety Specialist with the Division of Technology, Training and Technical Information (TTTI) of the Rural Agricultural Development Authority (RADA) in Jamaica. He received his undergraduate degree in agriculture at the College of Agriculture, Science and Education (CASE) and a master's of science degree in Occupational and Environmental Safety & Health from The University of the West Indies (Mona). His major focus is on Pesticide Researches with published research work on "Pesticide-handling practices of smallholder coffee farmers in Eastern Jamaica" JARTS, 2013 and was integral in the National Pesticides Use Survey 2017.* ■

A Point Prevalence Survey of Health Associated Infections and Antimicrobial Use in a Public Health Institution in Trinidad

Shinelle C. Francois[1], Patricia Sealy[2] and George Legall[3]

[1,2] Faculty of Medical Sciences, School of Pharmacy, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies;
[1]Email: shinellefrancois@gmail.com
[2]Email: patricia.sealy2@sta.uwi.edu

[3]Faculty of Agriculture and Food Production, The University of the West Indies, St Augustine, Trinidad and Tobago, West Indies;
Email: George.Legall@sta.uwi.edu

Abstract: *Antimicrobial resistance manifests when microorganisms prevent antimicrobial agent(s) from inhibiting the growth of or killing a microorganism (WTO, 2018). Resistance can lead to reduced efficacy of standard treatments or eventual loss of efficacy being of such magnitude that leads to the treatments becoming ineffective and the infection persisting for a longer period of time than is expected. Inappropriately prescribed medications contribute to resistance, which is a public health hazard worldwide. The Point Prevalence Survey is a stewardship tool and validated method for measuring the quality of prescribing in the hospital setting (NHS, 2016). The objectives of this study were to estimate the prevalence of hospital acquired infections, the nature and scope of antimicrobial use, as well as to assess if prescribers followed existing evidence-based antimicrobial policies subsequent to diagnosis of infection in patients in selected wards at a tertiary institution. Day-of-survey records of patients in the intensive care unit, and medical/surgical wards were examined at the institution. Medical records that were available on the wards at the time of survey were reviewed prospectively. The extracted clinical data were record on the standardised data collection instruments (hospital, ward and patient forms) and analysed. Of the 130 patients surveyed, 30 had an infection which occurred within 48 hours of admission. The most commonly reported infection type was urinary tract infections, evident in 9 (30.0%) patients, caused by Escherichia coli in 7 patients and Klebsiella pneumonia in 2 patients. Out of the 30 patients, 10 (33.3%) were awaiting laboratory reports at the time of survey. Resistance was noted for Staphylococcus aureus and Escherichia coli, both of which were seen in 2 patients, and Enterococcus spp. in 1 patient. Results of this survey imply that public health surveillance and prevention activities should address hospital acquired infections. Recommendations to minimise the risk of resistance include: improving the availability of alcohol-based hand rub, the provision of single room and isolation capacity, antimicrobial guidelines for treatment of infection, judicious prescribing and proper surveillance of prescribed antimicrobials.*

Keywords*: Antimicrobial Resistance, Antimicrobial Stewardship, Prosthetic devices, Healthcare Associated Infections, Multidrug Resistance, Point Prevalence Surveys*

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Authors' Biographical Notes:

Shinelle C. Francois *is currently a pre-registered pharmacist at a tertiary institution in Trinidad. Ms. Francois has successfully completed her BSc. in Pharmacy at the University of the West Indies, St Augustine Campus and is expected to graduate in October 2018. She also currently serves as a part-time Pharmacy Assistant at a community pharmacy as well as an assistant at a private pre-school during for the past four years. In addition, she volunteers for the Gift of Life Foundation, and is a member of the Down Syndrome Family Network and the Caribbean Association of Pharmacists.*

Patricia Sealy *is a Lecturer in Pharmacy Practice at The University of the West Indies, Faculty of Medical Sciences, School of Pharmacy, St Augustine Campus. She holds the Doctor of Pharmacy (PharmD, Clinical Pharmacy) and PhD (Clinical Health Sciences) degrees from Duquesne University of Pittsburgh and the University of Mississippi Medical Centre, respectively. Her research interests include Teaching Pedagogy, Antimicrobial resistance and Management of Chronic Non-Communicable Diseases. She has (co)authored over fifteen papes in peer-reviewed journals..*

George Legall *is presently a part-time lecturer in Statistics and Epidemiology at the University of the West Indies having retired from full-time teaching at the University in 2012. He has a Masters and a PhD degree in Statistics from the University of Vermont and Cornell Univeristy respectively, and taught at the University of Tennesse, Knoxville, USA prior to returning to his native Trinidad and Tobago where he has been involved in teaching and research ever since. He has co-authored over twenty papes in peer-reviewed journals.*

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Mild Steel Corrosion Inhibition in Acidic Medium by Theobroma Cacao Pod Extracts

Annacia K. Jeffers[1] and Ann M. Wilson[2]

Department of Chemistry, The University of The West Indies, St. Augustine, Trinidad and Tobago, West Indies;
[1]Email: annacia.jeffers@my.uwi.edu
[2]Email: ann.wilson@sta.uwi.edu

Abstract: *The environmental consequences of corrosion on metals are enormous and costly. Green corrosion inhibitors are sought after as the eco-friendly, cheaper alternative. The use of Theobroma cacao shell as a green corrosion inhibitor for mild steel in 2.0 M $H_2SO_{4(aq.)}$ was investigated over an 85-day period with data collected every 7 days up to the 28th day and every 28 days thereafter. Gravimetric and electrochemical analyses including weight loss and rest potential readings were used for this study. The study gave a corrosion rate of 0.029 mm/yr and an inhibition efficiency of 92% with the highest concentration of extract used.*

Keywords*: Green corrosion inhibition, cocoa shell, acidic corrosion, mild steel*

1. Introduction

Metallic corrosion is an electrochemical reaction that occurs when a material interacts with its environment which results in its gradual degradation (Olawale et al., 2015). The deterioration of materials causes huge losses in the global economy with tremendous impact in industries such as oil and gas, beverage and metallurgy to name a few (Velázquez-Gonzáles, et al., 2013). The large cost incurred to slow the effects of corrosion has prompted investigations into finding less expensive avenues and the environmental consequences that result require that alternatives also be eco-friendly (Prithiba, 2016).

Consequently, there has been a drive to discover new, effective inhibitors in the form of green corrosion inhibitors (GCI's). These substances are plant-based and abundant. As such, they are available, bio-degradable, renewable, cost-effective and less toxic to the environment. A variety of compounds are present in natural product extracts. These include terpenoids, tannins and other macromolecules rich in conjugated, aromatic structures and long aliphatic chains (Manickam et al., 2016). These organic compounds contain electronegative heteroatoms: nitrogen, sulphur and oxygen with free electron pairs that are able to form bonds with the metal surface (Manickam et al., 2016).

Cacao is one of 22 species of the genus *Theobroma L.* of the subfamily *Sterculiaceae* of the mallow family *Malvaceae*[1]. *Theobroma cacao* shell (TCS) extracts, being natural product extracts, have many organic molecules as those listed above. The pod husk is a by-product of cocoa crop harvests. It is commonly disposed to rot on plantations and may encourage the spread of disease such as black pod rot (Pedroza-Periñán et al., 2016).

Therefore, the plant parts targeted for this investigation are the pod husks since it is a true waste product and its use would neither lend to competition for food nor remove value from the environment. Although the properties of *Theobroma cacao* husks have been studied before, (Pedroza-Periñán et al., 2016) it is the aim of this work to observe the efficiency of a *Theobroma cacao* shell methanol extract as a corrosion inhibitor for mild steel in an acidic medium.

2. Materials and Methodology

2.1 Preparation of TCS Methanol Extract

Theobroma cacao shells were dried and ground to a fine powder. Ground TCS was extracted in dried methanol in a 1:2.5 m/m ratio for 48 hours. After which the mixture was filtered and the residue was extracted with a second batch of methanol as before.

2.2 Preparation of Sample Coupons

Fifteen mild steel coupons of dimensions 1.0 cm x 2.0 cm x 0.1 cm were standardly cleaned as follows: phosphate wash for 20 minutes followed by manual abrasion using emery paper, followed by micro-polishing using decreasing sizes of diamond polish alumina powder. The coupons were rinsed with de-ionised water between each sanding; they were then systematically solvent washed in trichloroethylene, acetone, propanol and de-ionised water in the

ultrasonicator for 5 minutes each. All coupons were then oven dried for 15-20 minutes at 30˚C and cooled in a desiccator until needed.

2.3 Preparation of Acidic Medium

Five beakers were set-up each containing 20.0 mL of 10.0 M $H_2SO_{4\ (aq)}$. To these, TCS extract was also added in increasing volumes of 0.0 mL, 10.0 mL, 20.0 mL, 40.0 mL and 80.0 mL. The total volume in each beaker was then made up to 100.0 mL with de-ionised water. This produced corrosive solutions of 2.0M $H_2SO_{4\ (aq)}$ with TCS extract concentrations of 0%, 10%, 20%, 40% and 80%.

2.4 Experimental

Previously cleaned and dried coupons were accurately measured before the start of the experiment. The open-circuit potentials of these coupons were also recorded using a digital multimeter. Triplicate coupons were suspended using coated hooks in beakers filled with the corrosive solutions as described earlier.

After 7 days, the masses and rest potentials of each coupon were obtained and the coupons returned to their respective beakers immediately. This was repeated three times for a total of 28 days. On the 28th day, the dimensions of the coupons were recorded again. Then dimensions, weights and rest-potential recordings were repeated on day-56 and day-85.

3. Results and Discussion

The coupons were completely immersed in solution in order to utilise their entire surface area. During the experiment, miniature holes as well as grooves were observed running along the surfaces of the coupons. This suggested that the corrosion occurring at the mild steel surfaces may not be uniform corrosion only. In fact, it could be a combination of uniform corrosion and pitting/crevice corrosion instigated by the manual abrasions performed at the start of the cleaning process. The scratches made on the metal surface during cleaning may expose more surface area to attack. These grooves may also allow for a greater concentration of corrosive species to be present at those sites. This would in turn increase the rate at which corrosion occurs at these metal sites. Surface analyses in the form of optical and/or scanning electron microscopy would be employed to further characterise the sample surfaces before and after treatment.

Additionally, there was a consistent trend of surface area decrease among all concentrations with the least change in surface area and size being observed among coupons immersed in 80% TCS extract. Figure 1 shows the average surface areas of coupons resting in acidic solutions containing TCS extract. Concentrations of 10% - 40% all had surface areas below that of the control.

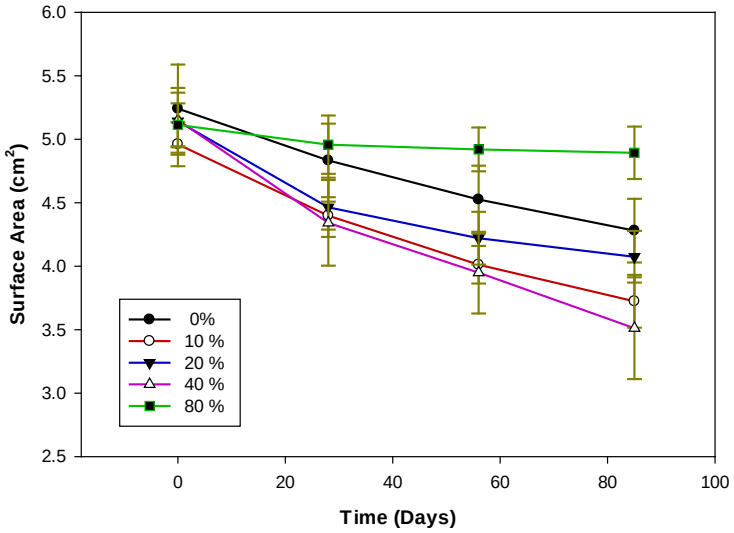

Figure 1: Change in Surface Area of coupons over 85-day period

This is supported by Figure 2 where it is shown that the smallest amount of surface area lost after the 85-day trial came from coupons treated with 80% of the TCS extract. Coupons treated with 40% TCS extract showed the largest difference in surface area. This may be due to the high number of grooves and holes present on these coupons' surfaces which appeared to be greater in number than on other coupons' surfaces.

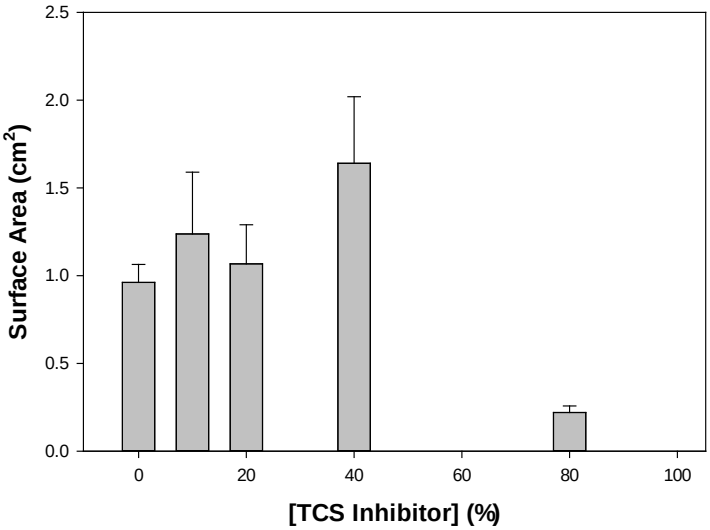

Figure 2: Total Surface Area Lost Over 85-Day Period per [TCS Inhibitor]

Figure 3 represents the average mass lost by the coupons for the 85-day period. Fluctuations in weight loss are seen for all concentrations of TCS extract added except the 80% addition which only shows minor changes in the first 28 days but appears to stabilise afterward. The negative value noticed for coupons subjected to 40% TCS extract on day 14 is most likely as a result of poor cleaning of the coupon surfaces on that day.

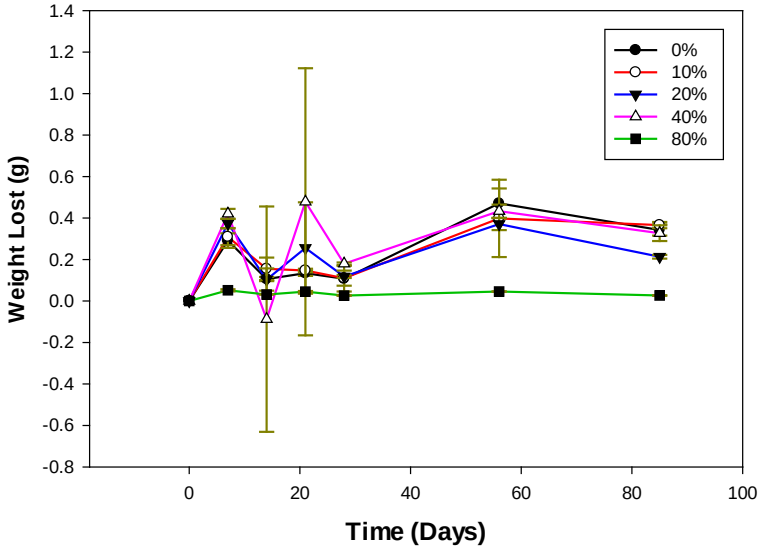

Figure 3: Weight Lost Over 85-Day Period per [TCS Inhibitor]

Moreover, Table 1 shows that the greatest percent of mass lost occurred during the first week of the study. Recall that coupons were interacted with every week for the first 4 weeks after which they were left at rest for 4 more weeks before being removed from solution for examination. As a result of this method, it is believed that by

removing the layer regularly, a proper, more stable protective coating does not form on the surface so the metal remains exposed to corrosive attack. This can explain the variations in weight loss observed in the first 4 weeks. On the other hand, concentrations of TCS inhibitor of 40% and less appear to be insufficient to produce a protective layer since coupons treated with those amounts of extract displayed inconsistency in their weight loss for the entire trial. Hence, a more sound method for monitoring weight loss during the study should be looked into.

Table 1: % of Av. Weight Lost per [TCS Inhibitor] over Time (Days) - Diff. / total Wt. Loss

[TCS Extract] (%)	7 Days	14 Days	21 Days	28 Days	56 Days	85 Days
0	20.0	7.31	9.23	7.42	32.4	23.6
10	20.8	10.4	9.89	7.42	26.8	24.6
20	26.0	7.21	17.8	8.22	25.8	14.9
40	24.0	-4.99	27.3	10.3	24.7	18.7
80	22.7	13.8	20.0	11.6	20.1	11.7

Furthermore, rest potential values, seen in figure 4 are used to determine the time taken for equilibrium to be achieved at the metal surface. The graph shows that this happens after the first 28 days for the coupons in 80% TCS extract only. Yet, this only adds to the aforementioned issue of interacting with the coupons for a stipulated time then ceasing to do so. Contrarily, it also lends support to the fact that, concentrations more than 40% are needed for favourable results to be observed.

The repeated pattern seen among the concentrations of 10% - 40% inclusive, i.e. producing results less desirable than those of the control suggests that the TCS extract is working as an anodic inhibitor. This means that the inhibitor species is targeting the anodic sites on the metal – those sites which would corrode more readily than other sites. In addition, anodic inhibitors only protect these sites efficiently at certain concentrations. If the wrong concentration were to be used then the inhibitor actually enhances the corrosion process thus increasing the rate of corrosion. This is as a result of the inhibitor molecules possibly creating a porous layer over the metal surface and producing discrete areas for corrosive attack.

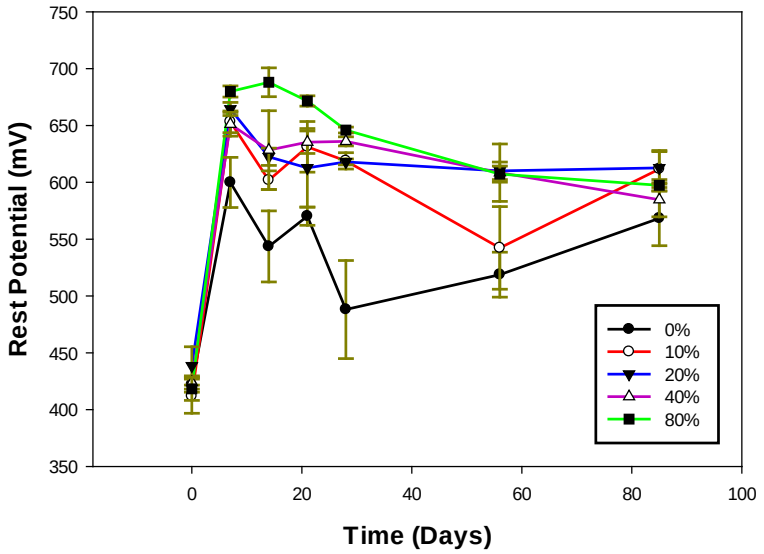

Figure 4: Rest Potentials (mV) per [TCS Inhibitor] Over 85-Day Period

Corrosion rates were calculated using the weight loss determined previously in the equation: CR = (87.6 ΔW)/ρAt where ΔW is average weight loss, ρ represents the density of the metal used (7.85 g/cm^3), A is the average

surface area of the metal (cm^2) and t is the time for which the metal was immersed in solution (taken in hours). Again, the best results are seen with the 80% TCS extract giving a corrosion rate of 0.029 mm/yr.

Table 2: Calculated Corrosion Rates (mm/yr) per [TCS Inhibitor] for 85 Days

[TCS Inhibitor](%)	Day 7	Day 14	Day 21	Day 28	Day 56	Day 85
0	3.69	0.672	0.566	0.341	0.746	0.357
10	4.14	1.04	0.656	0.369	0.667	0.404
20	4.83	0.673	1.1	0.381	0.599	0.227
40	5.42	-0.564	2.06	0.58	0.698	0.347
80	0.671	0.204	0.197	0.086	0.074	0.029

Unfortunately, inhibition efficiencies calculated for this experiment gave mostly negative values for all TCS extract amounts added with the exception of the 80% concentration. Using the equation: I. E. % = 100 (ΔW_o – ΔW_i) / ΔW_o, the 80% TCS extract gave an I. E. of 92.2% after the 85-day study.

Table 3: Calculated (I.E. /%) per [TCS Inhibitor] over Time (Days) using Wt. Loss

[TCS Extract] (%)	7 Days (168 Hrs)	14 Days (336 Hrs)	21 Days (504 Hrs)	28 Days (672 Hrs)	56 Days (1344 Hrs)	85 Days (2040 Hrs)
10	-6.308	-46.3	-9.73	-2.38	15.4	-6.87
20	-28.4	2.45	-90.8	-9.53	21.2	37.7
40	-44.4	182	-257	-67.0	8.04	4.48
80	82.3	70.4	66.0	75.5	90.3	92.2

This means that the lesser amounts of extract added to the corrosive solution increased the rate of corrosion at the metal surfaces rather than retard it. Further analysis is needed to better understand how the *Theobroma cacao* shell extract actually works as an inhibitor at these mild steel surfaces.

4. Conclusion

In conclusion, *Theobroma cacao* shell appears to be working as an anodic inhibitor and is a good corrosion inhibitor of mild steel in acidic medium only when in high concentration of around 80%, giving a corrosion rate of 0.029 mm/yr and an inhibition efficiency of approximately 90%.

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Authors' Biographical Notes:

Annacia K. Jeffers *is currently a postgraduate student of the Department of Chemistry. She is pursuing her Master of Philosophy degree in Chemistry with focus on physical chemistry and more specifically, electrochemistry and corrosion analysis.*

Ann M. Wilson *is a Lecturer in Physical Chemistry in the Department of Chemistry, at The University of the West Indies, St. Augustine Campus. Dr. Wilson's research interests are in corrosion science and electroactive polymers.*

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An Environmentally Friendly Solution to Realising ICT Sector Growth in Developing Countries

Brandon O. Campbell[1], Kaycilee S. Wright[2], and Louis-Ray O. Harris [3]

Department of Physics, The University of the West Indies, Mona, Kingston 7, Jamaica, West Indies;
[1]Email: bdoncampbell@hotmail.com
[2]Email: kaycilee2@yahoo.com
[3]Email: louisray.harris@uwimona.edu.jm

Abstract: *Modern technology has shaped the way that individuals interact and communicate with one another. The ability to understand the basic concepts of information and communication technology (ICT) and its associated skills has therefore become a core part of education curricula internationally. ICT refers not only to data and its manipulation, but also to the infrastructure and components that enable modern communication in a technologically advancing society. It is therefore necessary to educate existing students in the use of new forms of technology. However, developing countries such as Jamaica face various economic barriers, which restrict the implementation of highly effective ICT development strategies. The Jamaican government has made several attempts to facilitate initiatives, and these are embodied by the "Vision 2030", which is a joint project between the Ministry of Education and the ICT council established by the Ministry of Science, Technology, Energy and Mining. While these projects have achieved some form of development in the educational infrastructure, there remain cases where institutions are ill-equipped to properly educate their teachers and students in the use of modern technology. This paper proposes a simple and environmentally friendly solution to realising ICT sector growth in developing nations by means of repurposing electronic waste in bulk, specifically audio and visual equipment, as well as modifying the devices by removing damaged or unwanted circuitry and adding affordable single-board computers and control boards to make digital workstations. The intention is to utilise a similar model to distribute the workstations to institutions and foundations in order to foster affordable methods of facilitating economic growth through application and education. While the proposed approach has limitations with respect to the available processing power, the units will provide the end-users with wireless and/or wired connectivity, Bluetooth, and direct access to ports and pins on the computer, which will provide an interactive experience for teaching and learning in the fields of computing and electronics specifically.*

Keywords*: Single-board computer, E-learning, E-waste, environmentally friendly, Tablets in schools, Recycle, Vision 2030, Realising ICT sector growth*

1. Introduction

Following the 50-year trend with the increase in processing capabilities of modern technology and the circulation and production rates of new consumer devices, we have accumulated substantial amounts of very capable electronic waste (E-waste). This paper proposes that this 'issue' may easily be made into a solution for another problem. The rapid advances in technology have changed the traditional ways of how information is processed, communication is carried out and services that are made available (Osterwalder, 2002). Information and communication technology (ICT) is the electronic means of capturing, processing, storing and transmitting information (Oju and Onyebuka, 2016). In order to make progress with the rapid advances in technology, it is necessary to have access to the technology or ways of obtaining it; however, developing nations worldwide still face economic restrictions and barriers to entry in some of the fastest growing and most profitable industries today, specifically in the software and consumer hardware sectors, which drive and facilitate ICT. With an influx of a wide range of powerful technologies to choose from, such as Quad-core cell phone processors and solid-state hard drives, coupled with the open-source initiative, we propose a more feasible approach for countries and businesses with relatively smaller economic purchasing power.

In accordance with its Vision 2030 initiative, Jamaica has implemented a means of increasing computer literacy by providing broadband and Wi-Fi connectivity in schools as well as implementing a Tablets in Schools (TIS) initiative to provide students with the much-needed opportunity to interact with hardware (Bryan, 2017). However, in many cases, these devices become E-waste before the expected device lifetime has passed, contributing further to the E-waste problem. Many commercial bodies and educational institutions also implement multi-year hardware cycles (generally 3–5 years), where workstations are replaced with upgraded machines and old models discarded (National Center for Education Statistics (NCES), 2005). With few or no governmental policies regarding

the management of E-waste, there is therefore little to no compliance to the few stipulations that do exist. The focus of our study is to investigate ways of re-using E-waste as hardware for research and product development in the ICT, electronics and computing sectors. This would inherently allow for creative endeavours and possible entrepreneurial activities as a steady supply of redundant technology is currently available. This is an economically viable route for developing nations such as Jamaica, as it presents students at all levels with the opportunity to engage and interact with a wide range of technology to which they would otherwise have no access.

> "*Trying to address this challenge has important implications for the "transfer of technology" literature, which tends to dichotomise developed and developing countries and treats ICTs as a black box that is taken from one context and "dropped into" another*." (Tew et al., 2017).

This paper proposes guidelines for recycling the "redundant" technology at hand into workstations in order to facilitate the development of skills that are applicable to ICTs, computing, and electronics industries. The education system will play a vital role in the development of these skills via the recycling of E-waste. Recycling these materials opens opportunities for students to learn programming languages, as well as to interact with the hardware that powers the recycled devices. There are also opportunities for these students to learn new skills, such as data analysis and database creation. The aim of this approach is to foster an environmentally friendly and initiative-based spirit in resolving the E-waste issues, and to allow for a centralised E-waste management centre for sorting and assessing national E-waste.

2. Method

The recycling of E-waste will provide a gateway for smaller countries and companies with limited production/manufacturing space and start-up capital to fast track their economic development with added benefits to the environment by extending the device lifetimes and reclassifying waste that would otherwise degrade into harmful chemicals.

2.1 Hardware Acquisition

2.1.1 Collection Drive

The proposed approach involves the use of E-waste collection drives to facilitate the acquisition of components and devices, which may allow for projects to be undertaken at community centres, public facilities and schools. The GATES foundation in Jamaica has organised two successful E-waste drives, and has collected over 60 computing units from individuals and companies in the parishes of Kingston and St. Andrew. It was estimated that approximately 25 units could be reallocated as is, and over 20 units retrofitted with replacement or new parts, while the remaining units will be disassembled and used as a source of spare components. This rigorous assessment and recycling approach would result in over 90% of each machine being recycled and used for educational applications.

2.1.2 Cost

A system has been proposed that will see the quarterly collection of E-waste from hardware stations established in each parish capital. This proposed system will incur a majority of the cost from transportation to collect and store the hardware. There is the intention to pair excess monitors and input devices with affordable single-board computers, specifically the Raspberry Pi (RPi) series, as a pilot to enable students to work primarily on programming, data acquisition and interfacing electronics. The RPi was chosen over other development boards/microprocessors owing to its relatively low cost, potential for cross-platform application and wide community support. Furthermore, the model b+ was deemed most suitable as it boasts a stock 1.2-GHz processor, which is comparable to a low-end consumer-grade personal computer (PC); this would allow for a similar user experience at a very affordable cost. Each RPi (model B+) costs approximately $35 USD. The ODROID-C2, which retails at approximately $46 USD, is another board to be considered for this proposed model, and has a stock 1.5-GHz processor which can run both Linux- and Android-based operating systems (OS); however it is currently incapable of natively mounting a Windows-based OS. In comparison, the RPi was designed to support Windows 10 IoT core natively on its ARM processor. This implies that the ODROID board is not tailored for everyday PC users, but rather more advanced individuals, and it therefore would not be as effective for this application. Finally, the RPi features built-in 802.11b/g/n/ac and Bluetooth BLE 4.2 support, making the board readily compatible with wireless external peripherals, in the process adding mobility to the unit, which is not found on most single-board computers within this price range.

2.2 Application of Acquired Hardware for Educational Purposes

In an effort to make the RPi unit more user friendly, the Raspberry Pi foundation develops products such as GPIO breakout boards, dedicated cameras and sub modules to assist in project development. This allows users to garner skills in hardware troubleshooting and design implementation along with basic-to-advanced programming techniques which may be implemented in industry-based applications. In this regard, the RPi serves as a cross-disciplinary development platform which enables rapid growth in the ICT sector.

Given the low cost and opportunities for individual development, the platform also facilitates the development of leadership skills and enables users to gain necessary team and project management skills, which serves as the basis for technological community development. These skills are specifically of great significance to the growth of technological groups and institutions in developing nations as they serve as the first instance of support for beginners.

2.3 Software

2.3.1 Pre-installed Software and its Applicability to Education

The RPi is a popular open-source solution with a highly active development community and necessary documentation. This makes it a very attractive choice for implementation in educational applications as the relative popularity of open-source initiatives is usually a strong indicator of the projected revisions and updates for the supported hardware and software.

The Raspberry Pi Foundation supports and distributes a free, open-source software manager (NOOBS) that simplifies the process of mounting an OS onto a secure digital (SD) Card which serves as the primary bootable medium. Each instance of NOOBS contains the Raspbian OS, which includes pre-installed programming environments such as the Python Integrated Development Environment (IDLE) and the Scratch programming environment. The latter facilitates the introduction to programming for beginners and children as it incorporates a drag-and-drop programming interface which prioritises the content and logic of the code, while simplifying the syntax and structural requirements. Paired with a package manager specifically designed to reduce the complexity of including publicly contributed libraries and modules, the RPi systems provide the intended users with a very robust and interactive entry-level introduction to development, which may easily be adapted according to the proficiency of each user.

2.3.2 Open-source Software in Education

The use of open-source software enables users to freely edit and adjust existing projects to suit the needs of the end users. This is vital for developing nations as the projects or methods currently provided for reference are generally supplied by countries and institutions which have acquired expertise in specific areas of science and technology. This provides less experienced users with access to advanced methods of data analysis and software development which may be thoroughly analysed and segmented into basic conceptual blocks to obtain an in-depth understanding of the concepts used, and which are involved in more advanced processes.

3. Results

Figure 1 shows the variation of the temperature of the RPi with frequency during CPUBurn stress test operations. From the graph, we see that the stock RPi model B+ passes the most rigorous CPU stress test with basic aluminium heat sinks cut to fit the CPU die and a small 5-VDC computer fan attached as the cooling unit of the device. This performance is seen to have a weighted average value of 76.3°C, which borders on the thermal shutdown limit, indicating that the device would perform sufficiently well under basic computing loads. From the graph, we see that the initial idle frequency is 600 MHz, which is consistent with manufacturer's specifications. Then, as the frequency is increased to full-load frequency of 1.2 GHz, there is a rapid increase in the temperature.

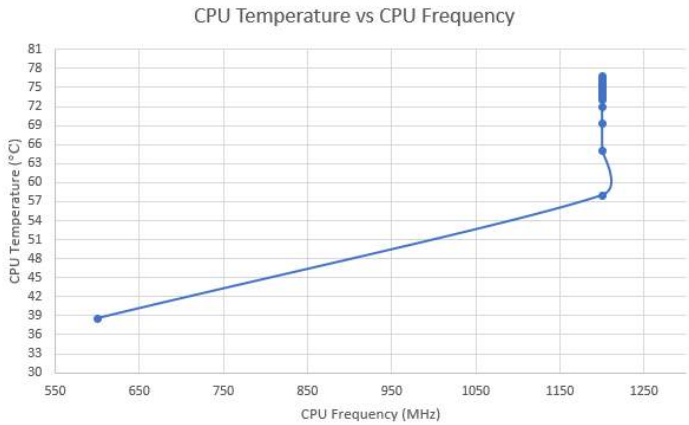

Figure 1: Variations in Raspberry Pi CPU temperature with CPU frequency during the CPUBurn stress test.

3.1 Recycled Monitor Development

3.1.1 Benefits

The monitor may be acquired from any discarded laptop or desktop computer, and as such, would be acquired at minimal cost. An example is shown in Figure 2. This allows for funds to be reallocated to areas that would increase the workstation's performance output. For instance, a solid-state drive (SSD) may be added to the RPi workstation to increase read/write speeds and increase the lifetime of the primary bootable medium, i.e., the SD cards, owing to the reduced number of read/write cycles.

Figure 2: Fully assembled Raspberry Pi workstation with wireless mouse and Bluetooth keyboard.

3.1.2 Limitations

Currently, the implementation of the specified recycling methods requires intermediate to advanced skills in electronics and computer programming as the LCD controller board itself uses both field-programmable gate array (FPGA) logic and low-voltage differential signal (LVDS) cables, which represent the technical expertise required in both software and hardware applications. However, these limitations may easily be overcome by the development of a standardised controller board unit which will have the capacity and modularity to interface with a wide array of LCD monitor models.

Figure 3: LCD Control board and LVDS cable.

3.2 Raspberry Pi PC

3.2.1 Benefits

As seen in Figure 1, the stock RPi unit with basic aluminium heat sinks and a 130-mm 5-VDC computer fan can function normally under unusually high computational and thermal stresses. The CPUBurn stress test is known to be a very rigorous test which maximises the computer's processing and graphics load to simulate overheating at temperatures close to the specified stock shutdown temperature of 80°C. This gives insight into the stability of the device at the specified clock frequency, and therefore implies its ability to withstand overclocking of the CPU to increase performance for more demanding computational processes.

However, this is of significance only to high-demand users as for the intended application, users would not be running such graphically or computationally intensive programs on the workstation. Rather, simple programming applications, such as Scratch or Python's IDLE, along with the free open-source version of Google's Chrome web browser, Chromium, represent examples of the actual processing load expected.

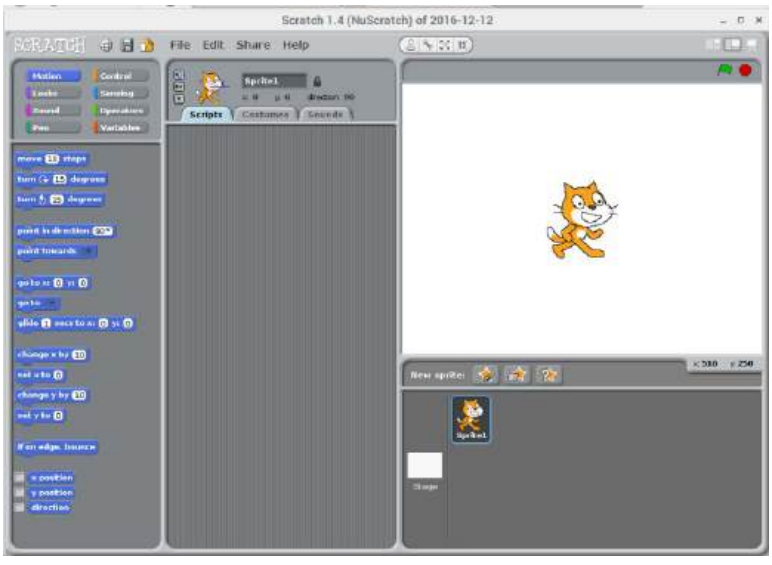

Figure 4: Scratch programming environment.

3.2.2 Limitations

In order to achieve relative efficiencies comparable to that of a consumer grade PC, the RPi unit must be overclocked to give a reasonably similar user experience. Figure 4 shows the model B+ with passive cooling technology in the form of heat sinks to increase stability under high stress by dissipating heat through conduction. This is of significance as the unit will approach its thermal limit as the individual component clock frequencies are increased. There is a balance between the CPU and GPU clocking, which must be maintained as both units exist on the same silicon die, and they therefore cannot both be overclocked to their respective maximum frequencies simultaneously. It is worth noting that each unit has a varying maximum threshold because of slight differences in the silicon crystalline structures in which the processors are embedded.

Figure 5: Raspberry Pi Model B+ with aluminium heat sinks (fan removed).

4. Future Work

4.1 Hardware Acquisition

4.1.1 Survey Phase

In order to determine the nature of E-waste that is most commonly generated within Jamaica, we intend to perform a survey comprising a sample of private and public companies which utilise computer networks in their daily operations. Information to be requested will include the type and amount of E-waste (e.g., monitors, CPUs, and printers) generated annually, the frequency with which existing hardware is replaced, and the willingness of the company to donate this hardware in order to ensure environmentally friendly disposal. The latter recognises that some entities may have concerns regarding the security of data that may be left on hard drives, and this will be taken into consideration when recycling.

4.1.2 Collection Drive

For the pilot of the project, there was one designated donation location at the Police Officer's Club in the parish of St. Andrew. The intention is to increase the number of donation sites to three sites per parish in order to maximise the rate of acquisition of devices. This will allow for a wider range of E-waste from which parts and devices may be salvaged, while greatly reducing the country's negative environmental impact. To facilitate the increased influx in recycled equipment, individuals would be trained in disassembly and troubleshooting of a wider range of E-waste. This would enable the removal or loosening of the limitations initially placed on acceptable donated items from the pilot stages of the project.

4.1.3 Servers and Network-Attached Storage (NAS) Devices

Based on the projected performance of the donated desktop computers, they may be disassembled and reconstructed to be used as servers or network-attached storage (NAS) devices to relay and store information. This is of particular interest as they may be used to store numerical data on E-waste for communities and the countries within which they are implemented. This data may then be processed and reused to help determine policies and frameworks for

reducing the recurrence of these issues. Predictive analysis may also be implemented to determine specific points of interest when incorporated with acquisition and storage plans or programmes.

5. Conclusion

Based on the information obtained and processes developed during the initial phase of this project, which includes the execution of the pilot project, it is clear that there needs to be more focus with respect to the development and application of policies regarding the recycling of E-waste and the possible extension of device lifetimes. This requires practical implementation by way of training potential volunteers or paid workers to manage and maintain standards and facilities which are developed for this specific purpose.

This in turn should allow for growth in the ICT sector of any country within which such a programme is implemented as it incorporates both an academic and environmental approach to resolving pertinent environmental issues. This includes removing existing E-waste from our landfills and recycling components to allow developing nations an opportunity to gain expertise and skills in managing technological equipment.

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Authors' Biographical Notes:

Brandon O. Campbell *is currently an undergraduate student pursuing a BSc. in Energy and Environmental Physics at the University of the West Indies, Mona campus. He currently serves as the Chair of the UWI Mona IEEE Student Chapter and as the project lead for Virtual Reality applications at the UWI Mona Alternative Energy Research Group. He has worked with the UWI Mona Climate Studies Research Group as a data analyst and the Energy Management Unit at the Mona campus as an assistant in energy auditing. His research interests are in the areas of education, computing, alternative energy and robotics.*

Kaycilee S. Wright *is currently an undergraduate student pursing a BSc.in Energy and Environmental Physics at the University of the West Indies, Mona Campus. She is currently working with the UWI Mona Climate Studies Research Group as a data analyst and is a participant in the Virtual Reality applications project for the UWI Mona Alternative Energy Research Group. She is the Founder of the Astronomical Association of the University of the West Indies and currently serves as the Treasurer of UWI Mona IEEE Student Chapter. Her research interests are in the areas of education, alternative energy, robotics, computing, and astronomy.*

Louis-Ray O. Harris *is a lecturer in the Department of Physics within the Faculty of Science and Technology at The University of the West Indies, Mona. His research interests are in the areas of wireless communications, electromagnetic compatibility (EMC), satellite technologies, and electronics applications. He is a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE).*

■

A Newly Modified QuEChERS Method for the Analysis of Pesticide Residues in Select Fruit and Vegetable Matrices in Trinidad and Tobago

Winnette A. Collimore[1] and Grace-Anne E. Bent[2]

Department of Chemistry, Faculty of Science and Technology, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies;
[1]Email: winnettecollimore@hotmail.com
[2]Email: grace-anne.bent@sta.uwi.edu

Abstract: *A newly modified QuEChERS method was developed and validated for the multiclass, multiresidue determination of organochlorine (OCP) and organophosphate (OPP) pesticide residues in fruits and vegetables. The method involved a solvent extraction with acetonitrile followed by a partitioning step with magnesium sulphate ($MgSO_4$) and sodium chloride (NaCl). The final step involved a dispersive solid phase extraction clean-up prior to GC-analysis. Various combinations of sorbents were tested in the clean-up step in both type of matrices. These combinations included: PSA and $MgSO_4$ (PM), Florisil and $MgSO_4$ (FM), Florisil, PSA and $MgSO_4$ (PMF), PSA, $MgSO_4$, charcoal (PMC), and Florisil, $MgSO_4$ and charcoal (FMC). The Florisil and $MgSO_4$ (FM) combination gave the best results with recovery values ranging from 78% to 120% (RSD ≤20%) and was selected for the analysis of OCPs and OPPs in fruits and vegetables.*

A distinctive standard addition method was applied and used as the calibration technique for the quantification of OCPs and OPPs in both food matrices. Gas Chromatography with electron capture (GC-ECD) was used for quantitative analysis of the pesticides while Gas Chromatography Mass Spectrometry (GC-MS) was used for confirmatory analysis. Linearity, limit of detection (LOD), limit of quantification (LOQ) and recovery analysis were the parameters used to evaluate the accuracy, precision and ruggedness of the newly modified QuEChERS method.

The LOD and LOQ for the OCPs were 0.01-5 µg/kg and 0.1-5000 µg/kg, respectively while the LOD and the LOQ for the OPPs were 5 µg/kg and 5-5000 µg/kg, respectively, as obtained by GC-ECD analysis. The linearity of the calibration curves of the all target pesticide standards reported R^2 values >0.96.

The efficacy of the newly modified QuEChERS method was tested on fruits and vegetables obtained from two districts within the Central Division of Trinidad and Tobago. OCP and OPP residues were detected in 93% of the samples analysed with >99% the reported values above the maximum residue limits prescribed by the Codex Alimentarius and the European Union. A few of the detected pesticides have been banned in Trinidad and Tobago due to their persistence in the environment. The significantly high levels of pesticide residues detected is an indication that stricter guidelines and penalties should be enforced by the relevant regulatory bodies. It also affirms the need for routine analysis of local and imported food commodities in Trinidad and Tobago and by extension the Caribbean before distribution to the population.

Pesticide residue analysis is expensive, and unaffordable to most farmers and consumers. As such, many are unable to test their produce to ensure that they are safe for consumption. This highlights the need for affordable pesticide residue analysis methods especially in the current economic climate. The newly modified QuEChERS method provides a cheaper alternative for the analysis of pesticide residues in fruit and vegetable matrices at a fraction of the cost of the Original QuEChERS method. The newly modified QuEChERS method provides a fast, simple, highly affordable, reliable, effective, environmental-friendly and safe option for pesticide residue analysis in food commodities.

Keywords*: Modified QuECHERS method, organochlorine, organophosphate, Florisil*

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Authors' Biographical Notes:

Winnette A. Collimore *is a PhD student at the University of the West Indies (UWI), St. Augustine Campus. Her research work focuses on the monitoring of pesticide residue levels in various food types and the development of*

affordable pesticide detection methods. She earned a BSc. Degree with a major in Chemistry and minors in Analytical Chemistry and Biology from UWI. She is an aspiring educator as she feels passionate about imparting knowledge to people and helping them to use the knowledge as building blocks for creating new ideas

Grace-Anne E. Bent *is a lecturer in the Department of Chemistry at The University of the West Indies, St. Augustine Campus, Trinidad. Her research interests include: food safety and security, food-related toxins, environmental safety and sustainability. She has published: 1 book, 5 journal articles, several newspaper and online articles. Dr. Bent is the main author of a research article which copped the Principal's Research Day Awards for Best Research Publication at the UWI, Mona campus, 2016 and a member of the research team at the St. Augustine Campus who received the awards: Most Impactful Research Project and Best Research Team – Encouraging Multidisciplinary Research (UWI-NGC Awards) in 2016.*

■

A Systems-oriented Vulnerability Approach to Flooding in Cave, Westmoreland, Jamaica

Tracy-Ann N. Hyman

Faculty of Science and Technology, the University of the West Indies, Mona Campus, Jamaica, West Indies;
Emails: tracyann.hyman02@mymona.uwi.edu; hymannic@gmail.com

Abstract: *The Community of Cave is approximately 4.8 km² and lies within the South-eastern section of the parish of Westmoreland, Jamaica. It is characterised by hilly terrain and karst geomorphology, and is approximately 12 km from the parish capital Savanna-la-Mar. Major economic activities include farming, fishing and tourism, with a total population of 1095 persons. Like many island eco-systems however, it is prone to tropical cyclones which give rise to flooding and storm surge. Of special note is the 1979 flood event in Western Jamaica, which caused significant damage to terrain, disruption to transportation systems and devastation to lives and property. 320mm of rain fell in South-eastern Westmoreland on already saturated soil. This rainfall compounded with high ground water levels and high soil moisture content, led to overland and debris flows, extending from the mountains to the coast. Many persons were marooned, or trapped in their communities, unable to evacuate, and so this flood caused 40 deaths and economic losses of US $60 Million. Still today, there are limited rainfall gauges and flood hazard maps; there are no flood gauges or early warning systems in place. Field surveys also revealed that there is no official evacuation shelter in this area, as well. With a 50 year return period, our research hypothesis is that: any recurrence of this flood event in 2018 could be worse than in 1979. The overall aim of this research is thus to construct a dynamical simulation of a 1979 flood like event assessing the 'moving vulnerability' of stakeholders to flooding based on geographical considerations, flood characteristics and the movement patterns of residents within Cave. As such, the outputs from the model include residents likely to be stuck, injured, killed or safe. This research therefore represents a first diagnostic attempt in understanding the 1979 flood event, superimposed unto a 2018 landscape, and analysed through the use of Agent-Based Models (ABMs), Geographic Information Systems (GIS), using the NetLogo software. Preliminary results from the Cave ABM reveal that loss of life takes place on each of the three days sampled, with a Friday having the most fatalities. It is expected that the results from this research will guide local government and community stakeholders in the identification of safe zones with implications for evacuation and early warning within South-East Westmoreland.*

Keywords*: Flooding, Jamaica, Agent-Based Model, vulnerability, evacuation*

Author's Biographical Notes:

Tracy-Ann N. Hyman *completed her MSc. in Sustainability Science at the University of Tokyo, Japan, with a focus on Environment Systems in September 2010. She returned to Jamaica thereafter, and is now pursuing a PhD in Environmental Management at The UWI, Mona campus in the Faculty of Science Technology, researching on extreme events and their by-products, namely hurricanes and floods.*

■

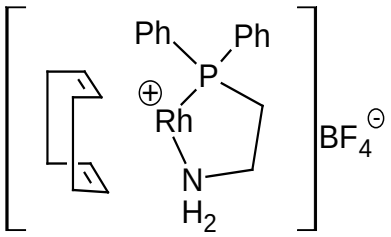
Transition-Metal Catalysis for the Production of Active Pharmaceutical Ingredients

Kadane O. Morris[1]; Paul T. Maragh[2]; Tara P. Dasgupta[3]; and Kamaluddin Abdur-Rashid[4]

[1,2,3] Department of Chemistry, The University of the West Indies, Mona, Kingston 7, Jamaica, West Indies
[1]Emails: kadane.morris@mymona.uwi.edu; komorris@hotmail.com
[2]Email: paul.maragh@uwimona.edu.jm
[3]Email: tara.dasgupta@gmail.com

[4] Kamal Pharmachem Inc., 3403 American Drive, Mississauga, Ontario L4V 1T8, Canada;
Email: krashid@kamalpharmachem.com

Abstract: *Carbonyl compounds and alcohols are important in the pharmaceutical, fine chemical, agriculture, flavour and fragrance industries where they are used as precursors and valuable end products. The syntheses of these products sometimes involve multistep processes, high reaction temperatures and/or non-environmentally friendly solvents Enol isomerisation and catalytic hydrogenation are two methods by which a variety of carbonyl compounds and alcohols, respectively, can be synthesised. Rhodium and ruthenium complexes have been successfully applied to some of these reactions and have significantly reduced the harsh reaction conditions. The rhodium (**1**) and ruthenium (**2**) aminophosphine complexes presented here have the advantages of being air-stable which allows for easier storage as well as being cationic and water-soluble, allowing reactions to proceed in "green" solvents e.g. water and isopropanol. This report will focus on some catalytic applications of these complexes for the hydrogenation and transfer hydrogenation of ketones as well as enol isomerisation. The catalytic applications of the processes will be presented, along with the preparation of a variety of pharmaceutical compounds.*



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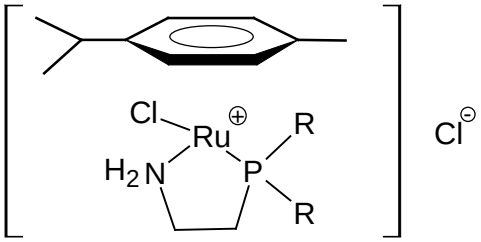

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Keywords: *Enol isomerisation, catalytic hydrogenation, transfer hydrogenation, rhodium aminophosphine, ruthenium aminophosphine, pharmaceutical compounds*

Authors' Biographical Notes:

Kadane O. Morris *is currently a 3rd year graduate student enrolled in the MPhil programme at The University of the West Indies (UWI), Mona, Jamaica. Her research interests focus on organometallic chemistry. Ms. Morris serves as the President of the UWI Chemical Society. She likes to play music with the UWI Classical and Jazz ensemble.*

Paul T. Maragh *is associated with the Department of Chemistry, University of the West Indies, Mona, Kingston 7, Jamaica, West Indies.*

Tara P. Dasgupta *is associated with the Department of Chemistry, University of the West Indies, Mona, Kingston 7, Jamaica, West Indies.*

Kamaluddin Abdur-Rashid *is associated with Kamal Pharmachem Incorporation in Canada.*

■

Entropy Analysis of Heart Rate Variability of Adult Human Diabetics and Non-diabetics Before, During and After Mild Exercise

Michelle Amoroso

Faculty of Science and Technology, The University of the West Indies, St Augustine, Trinidad and Tobago, West Indies; Email: michelle.silverwolf@gmail.com;

Abstract: *The Ziv-Lempel or Lempel-Ziv (LZ) entropy estimation method is an information entropy method that calculates an approximation of the entropy value of the signal over a period of time. The aim of this pilot study was to investigate autonomic function in adults by means of a Lempel Ziv (LZ) entropy method applied to the instantaneous heart rate trace calculated for heart rate variability in short-term recordings. R-R intervals were extracted from electroencephalogram (ECG) data recorded for 34 normal non-diabetic and 19 diabetic human subjects over a resting period of 8 minutes, subsequent exercise period of 6 minutes and recovery period of 5 minutes after exercise. LZ analysis based on the modified method used by Borowska et al. (2005) to calculate LZ complexity was applied to the instantaneous heart rate curve calculated from the R-R intervals. It was found that the calculated LZ entropy estimate in non-diabetics tended to increase during exercise and tended to decrease after exercise to the mean pre-exercise value; we observed lower predictability of the heart rate variability (HRV) trace for diabetics during and after exercise.*

Keywords*: Entropy, Lempel Ziv, diabetes, ECG, exercise, heart, HRV, variability*

1. Introduction

Human heart beats show small irregularities in the time between beats even in healthy hearts. This variation measured over a specified time is the heart rate variability (or HRV). HRV analysis is applied to investigate autonomic function in order to determine and quantify changes in a subject's state which may aid in diagnosis, patient monitoring and prognosis. Entropy estimation in HRV studies is a non-linear analysis option.

Lempel-Ziv (LZ) entropy estimation is an information entropy method based on the work of Lempel and Ziv, (1976), investigating complexity in data sequences, who suggested that applying a data compression algorithm could be used to estimate classical entropy in a system by estimating information entropy in sequential data produced by this system (Lempel and Ziv, 1976). This gave us the Lze entropy estimators based on the LZ-Welch compression algorithm. Analyses of simulated signals found Lze may be useful in indicating the frequency content of periodic and quasi-periodic signals and indicating bandwidth of random processes but is robust to changes in signal amplitude (Aboy et al., 2006). These features in particular indicated this method as interesting in potential application to biomedical signals, in this case HRV data, since HRV signal amplitude varies between adult subjects. Further considerations are that the method is non-parametric, can be applied to short data segments, and is approximately bounded between 0 and 1 ($0 < LZe < 1$), unlike some other complexity measures.

Previous applications to biomedical signals include assessing depth of anaesthesia from electroencephalogram (EEG) data, investigating ventricular tachycardia and fibrillation from ECG data, time-series data of respiration rate and angiogenic patterns of tumours in medical images (Zhang et al. 2001; Hongxuan and Yisheng 2001; Barowska et al. 2005) but these applied the estimation method to the entire data sequence.

The time domain correlation analysis (TDCA) method described by Rassi et al. (2005), applies its HRV index assessment to consecutive short segments of data recorded from each subject. However the adapted LZ estimation method of Barowska et al. (2005) is potentially applicable to selected shorter sequence lengths and windowed analysis as it instead utilises normalised LZ entropy estimation, (which makes the complexity value less dependent on length of the maximum pattern as long as the number of samples is large when estimating the entropy).

The aim of this exercise was to investigate the utility of this adapted LZ entropy estimation method as an index of HRV for data studied using a TDCA as described by Rassi et al. (2005). We applied the adapted estimation method to data recorded from a study of HRV signals of 34 diabetics and non-diabetics before, during and after periods of exercise.

2. Method

The instantaneous heart rate trace was calculated for 52 human subjects, using single channel ECG data from a pilot study of HRV in adult normal and diabetic humans at The University of the West Indies, St. Augustine (Amoroso,

2014) which applied the time domain correlation analysis method described by Rassi et al. (2005). The subjects included both males and females between 16 – 65 years, excluding subjects with clinical diagnosis of cardiac arrhythmia.

ECG data were recorded over an 8 minute period of rest while the subject lay in supine position, subsequently recorded for a 6-minute period of exercise during which subjects performed light exercise of 4 metabolic equivalents (METs) guided by instructions from a Nintendo Wii Fit exercise platform, and for a 5-minute period immediately after exercise while the patient returned to the supine resting position (Amoroso, 2014). For each subject, the time between successive R-peaks was found and instantaneous heart rate (IHR) was calculated from the RR intervals. The instantaneous heart rate was binarised, and normalised Lempel-Ziv entropy (LZe) estimates calculated as described in Barowska et al (2005) for the IHR as summarised in Figure 1. The model was used by Borowska et al. (2005) to calculate LZ complexity, modified from Hongxuan and Yisheng (2001). Entropy was estimated over two window lengths of 30 seconds (Lz30) and 60 seconds (Lz60).

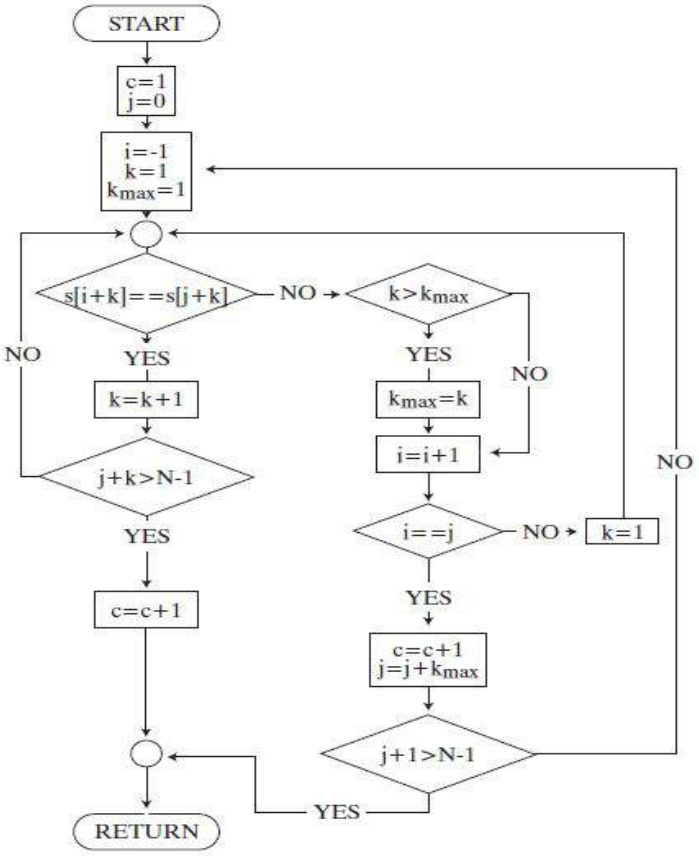

Figure 1: Flowchart of modified method
Source: Based on Borowska et al. (2005)

3. Results

Results were recorded and analysed. Figure 2 shows LZ entropy estimates (in bits) at 30-second and 60-second intervals, during successive periods of rest, steady exercise of 4 METs and post-exercise for a normal non-diabetic male subject under 30 years of age (y-axis) over time (x-axis). The duration of the period of exercise is indicated by the yellow bar parallel to the x-axis. As showed in Figure 3, LZ entropy was estimated (in bits) at 30-second and 60-second intervals for a diabetic male subject under 30 years of age (y-axis) against time in seconds (x-axis), during successive periods of rest, steady exercise of 4 METs and post-exercise. The duration of the period of exercise is indicated by the yellow bar parallel to the x-axis.

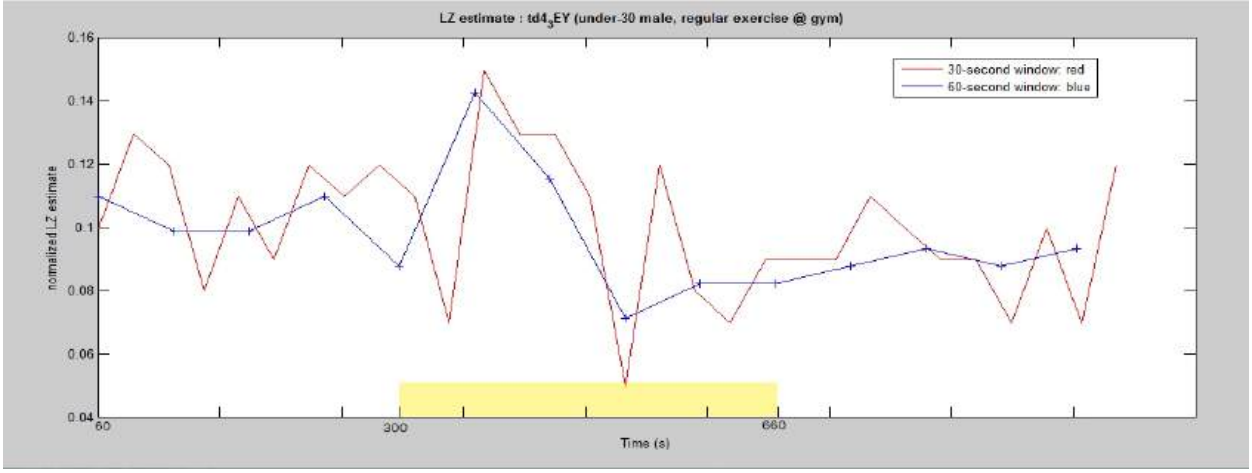

Figure 2: LZ entropy estimates (in bits) at 30-second and 60-second intervals for a normal non-diabetic male

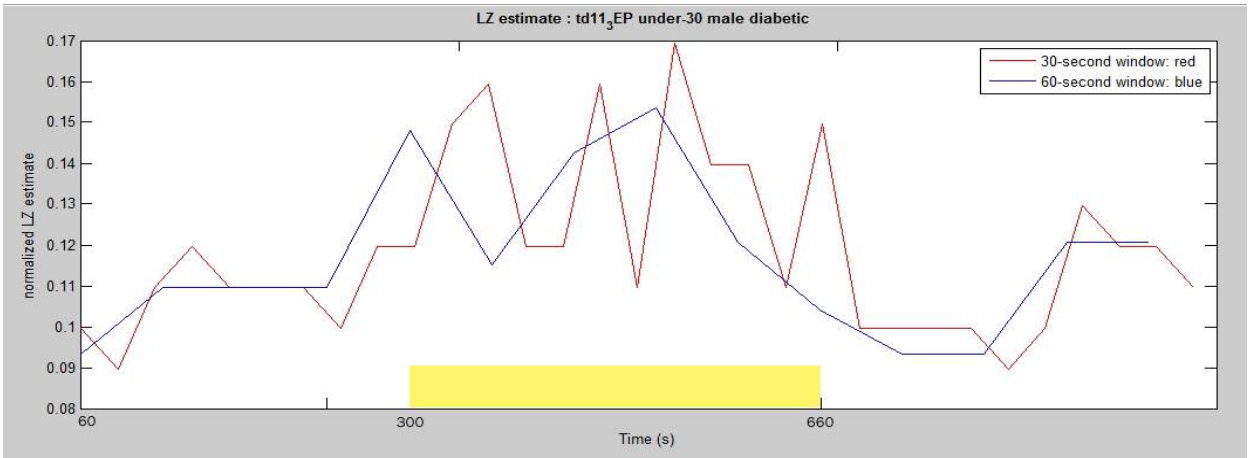

Figure 3: LZ entropy estimates (in bits) at 30-second and 60-second intervals for a diabetic male

It is showed in Table 1 that records of mean Lz60 entropy estimate were made over successive periods of rest, steady exercise of 4 METs and post-exercise for non-diabetic and diabetic subjects.

Table 1: Means of mean Lz60 entropy estimate over successive periods of rest

Means of Mean Lz estimates Lz60

Period	Diabetics	Non-diabetics	Non-diabetic females	Non-diabetic males	Diabetic females	Diabetic males
Before exercise	0.0978	0.0955	0.1025541837	0.0893798449	0.0953026343	0.095989776
During exercise	0.361	0.0977	0.1069304555	0.0992142388	0.1359757251	0.5362710957
After exercise	0.1012	0.0938	0.1008580896	0.0892710574	0.1026796165	0.0974388261

Moreover, it is showed in Table 2 that results of two-sample independent sample t-test were obtained on mean values of correlation coefficient, LF/HF ratio and Lze60 estimate over successive 5-minute periods of rest, steady exercise of 4 METs and recovery for the group of non-diabetics (of all ages) compared to those of the group of diabetics (of all ages).

Table 2: Results of two-sample independent sample t-test

	2-sample t-test : Mean index values over 5-minute period of non-diabetics compared to diabetics		
	Before exercise	during exercise	after exercise
Correlation coefficient	t(50)=-1.7047, p= 0.09446	t(50)=1.3531, p=0.1821	t(50)=1.2312, p=0.224
LF/HF ratio	t(50)=-1.2769, p=0.2075	t(50)=2.9227, p=0.005199	t(50)=-0.1558, p=0.8768
LZe estimate	t(50)=-0.2412, p=0.8104	t(50)=-1.6462, p=0.106	t(50)=-1.379, p=0.174

4. Discussion

From visual inspection of plots of entropy estimate, for adult subjects, for both 30-second window and 60-second-windowed data, the LZ entropy estimate in non-diabetics tended to increase during exercise and tended to decrease after exercise to approach the pre-exercise average. Graphically comparing Lz30 and Lz60 over the full sequence of data for each subject (see Figures 2 and 3) showed that the estimate over the longer window (Lz60) tended to show the trend of the estimate with fewer large oscillations in value compared to the adapted Lz30 estimate. The Lz60 estimate may be potentially more useful as an index in a windowed HRV analysis method; the lower variation (compared to the Lz30) may be due to the larger number of samples in the longer window. However it was not immediately apparent from inspection of graphical comparison of these estimates over time whether the subject being analysed was non-diabetic or diabetic.

The mean of Lz60 over each period of time before, during, and after exercise was investigated as some other HRV indices are summed over the selected testing periods. The calculated LZ entropy estimate in non-diabetics tended to increase during exercise and tended to decrease after exercise to approach the mean pre-exercise value. The period during exercise appears to tend towards higher entropy during exercise; however, this period was more likely to be affected by outliers, presence of ectopic beats, and movement artefacts compared to the resting periods. In the recovery period after exercise the mean Lz60 (see Table 1) and the results of two-sample independent sample t-test on mean Lze60 estimate (see Table 2) indicate higher estimated entropy for the diabetic groups (all diabetics, male diabetics and female diabetics) compared to the non-diabetics. This potentially indicates lower predictability of the HRV trace for diabetics during and after exercise.

Further investigation of this index is needed, with future work to include comparison to estimates using a longer window (and larger number of samples), increased number of subjects, and comparison to other established short-term HRV indices in the time and frequency domain, as LZ estimates indicate but do not quantify or identify the frequencies present in the signal segments tested.

5. Conclusion

The calculated LZ entropy estimate in non-diabetics tended to increase during exercise and tended to decrease after exercise to approach the mean pre-exercise value. In the recovery period after exercise the mean Lz60 (see Table 1) and the results of two-sample independent sample t-test on mean Lze60 estimate (see Table 2) indicate higher estimated entropy for the diabetic groups compared to the non-diabetics and potentially indicates lower predictability of the HRV trace for diabetics after exercise. Further investigation of this index is needed since LZ estimates indicate but do not quantify or identify the frequencies present in the signal segments tested.

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Author's Biographical Notes:

Michelle Amoroso *received her PhD in Physics from The University of the West Indies (UWI) St. Augustine in 2016. Her research interests are in the areas of biomagnetic scanning, electron microscopy, medical physics and bioengineering.*

■

Effect of 150kHz Electromagnetic Radiation on Polycystic Ovary Development (Rat Model)

Stephanie Mohammed[1], Nikolay Zyzuikov[2], Shivananda Nayak[3], and Venkatesan Sundaram[4]

[1,2] Department of Physics, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies
[1]Email: Stephanie.Mohammed@sta.uwi.edu;
[2]Email: Nikolay.Zyzuikov@sta.uwi.edu;

[3] Department of Biochemistry, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies
Email: Shivananda.Nayak@sta.uwi.edu;

[4] Department of Basic Veterinary Sciences, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies; Email: Venkatesan.Sundaram@sta.uwi.edu;

Abstract: *On a daily basis we are fully exposed to a substantial amount of non-ionizing radiation from both natural and manmade sources that emit electromagnetic radiation continuously. These invisible yet potentially damaging waves have long been a controversial issue with major regards to their deleterious effects during folliculogenesis. Our aim therefore was to investigate the changes, if any, that occurred at the microscopic level when a polycystic ovary induced rat model was exposed to 150kHz of electromagnetic radiation. Female Sprague-Dawley rats 12-15 weeks were chosen for this study and assessed prior and during experimentation for changes in their oestrus cycle. Oestradiol valerate was used for the induction of polycystic ovaries and vaginal smears provided the confirmation of cell type present in relation to what was expected for the model. The use of histology procedures after experimentation demonstrated significant findings of degenerative changes during oocyte development. Our findings also showed increases in atresia and blood congestion. These observations were able to re-highlight the significance of the invisible effects occurring during folliculogenesis when exposed to electromagnetic radiation. However, the time of exposure, frequency, wavelength and change in electric and magnetic fields over time and space are still yet to be explored.*

Keywords*: Electromagnetic radiation, Polycystic ovaries, Folliculogenesis*

Authors' Biographical Notes:

Stephanie Mohammed *is a Postgraduate student and staff undergoing her MPhil in Medical Physics at the Department of Physics, Faculty of Science and Technology, UWI. Her main research area focuses on Polycystic Ovaries and Hydroponics. She has published few articles and a book in the same area. She is the Postgraduate representative that falls under the guild for the Faculty of Science and Technology. She has been awarded 4th place in the Prime Minister's Award for Scientific Ingenuity.*

Nikolay Zyzuikov *is a Lecturer in Medical Physics at the Department of Physics, UWI. His main area of research involves Medical Physics, Radiation Biology and Radiation Physics. He has published numerous articles and a chapter in a book. He is a member of the Trinidad and Tobago Organization of Medical Physics.*

Shivananda Nayak *is a Professor of Biochemistry at the Faculty of Medical Science, UWI. He has more than 25 years of experience in both teaching and Research. He has received the UWI/Guardian lif premium teaching award in 2010 and Vachancellor award for excellence in teaching 2013. He has written textbooks for medical, dental, nursing and Allied Health students and has over 130 published articles in the field of Type 2 Diabetes and wound healing.*

Venkatesan Sundaram *is a Senior Lecturer in Veterinary Gross Anatomy, Histology and Embryology at the Department of Basic Veterinary Sciences, School of Veterinary Medicine, UWI. He has over 20 years experience in teaching and research. He has over 55 published articles in various aspects of vertebrate mophorlogy, neuroanaotmy, avian anatomy and reproductive biology and has designed various practical laboratory manuals. He has been awared the Young Scientist award at the IAVA National Symposium, India.2003.* ■

Design of a Practical, Cost-effective Real-time Surveillance System for Leptospirosis in Trinidad and Tobago

Lisa A. Benjamin

Faculty of Medical Sciences, School of Veterinary Medicine, The University of the West Indies, Trinidad and Tobago, West Indies; Emails: lisbenj@gmail.com; lisabenjamin_epi@outlook.com

Abstract: *According to the Ministry of Health in Trinidad and Tobago there was an annual average of 43 suspected cases of leptospirosis over the period 2010 to November 2017. Leptospirosis can lead to jaundice when it affects the liver, kidney failure or even death in some cases. The bacteria responsible for leptospirosis can be acquired by humans when they ingest, inhale or come into contact with urine from infected animals (wild, domestic or farm) or water contaminated with urine from infected animals. More cases (or suspected cases) of leptospirosis are observed subsequent to flooding events. As more frequent flooding events are observed in recent times in Trinidad and Tobago, it is apparent that there is a need for authorities to prevent outbreaks from occurring where possible or for them to quickly respond and resolve outbreaks which do occur. Due to the complicated epidemiology of leptospirosis which involves humans, animals and the environment, an integrated database with geographic data is under design which can be used by surveillance authorities to predict and respond to outbreaks. Human suspect and confirmed cases data as well as wild, domestic and farm animal suspect leptospirosis data from veterinarians will be collected using a mobile application with forms for data input from the field. In addition, rodent population monitoring data; environmental survey data; leptospirosis laboratory data (molecular and serology); local climate data; and geographical features layers (water, vegetation, roads, population) will be included in the GIS. The open-source program R will be used for real-time statistical and spatial analysis of big data. It is expected that this cost-effective surveillance system will increase the ability of authorities responsible for leptospirosis surveillance in Trinidad and Tobago to identify hotspots and predict outbreaks, thereby supporting decision-making regarding this disease in humans.*

Keywords*: Real-time disease surveillance, leptospirosis, zoonotic disease, geographic information*

1. Introduction

Syndromic surveillance involves real-time or close to real-time automated data acquisition with the aim of earlier detection of disease outbreaks when compared with traditional methods (Centers for Disease Control and Prevention, 2004). These surveillance data can be analysed and then disseminated to decisionmakers who are responsible for designing effective disease control/preventive measures. When resources are limited it is useful to take control/preventive actions that are economically feasible and that are likely to be effective. At this time, it is useful to understand which factors are important in increasing the prevalence or incidence of the disease in question. In the case of zoonotic diseases with an important environmental predictor, such as *Leptospirosis*, the spatial component should be considered. Geographic Information Systems (GIS) and spatial analysis present tools for examining the role of the environment in the introduction and transmission of leptospirosis. Desktop GIS has been used to develop risk maps for environmental predictors for the occurrence of leptospirosis in Samoa (Lau, 2014) dogs (Raghavan et al., 2012; Raghavan, et al. 2012; Raghavan et al., 2011), humans (Barcellos and Sabroza, 2000; Barcellos and Sabroza, 2001; Garcia-Ramirez et al., 2015); and sea-lions (Norman et al., 2008).

1.1. The Leptospirosis Problem

Leptospirosis occurs in humans and animals in the Caribbean (Adesiyun et al., 2006; Chadee et al., 2010; Petrakovsky et al., 2014; Everard et al., 1983). It is possible that leptospirosis cases are under reported, as symptoms similar to other diseases which occur in the region, such as influenza and dengue, are observed with leptospirosis. As a result, mild cases of leptospirosis might be misdiagnosed. Outcomes of leptospirosis include liver failure, kidney failure and in severe cases, even death. A retrospective study of the period 1996 to 2007 reported an average incidence of 1.84 (range 0.95 to 3.0) cases per 100 000 population in Trinidad and Tobago. Case fatality from leptospirosis in the Americas exceeds 10% [PAHO, Leptospirosis Fact Sheet]. There are more than 230 serovars of leptospirosis worldwide (Pappas and Cascio 2006) which can cause illness. In a recent survey, one serovar, Copenhageni, was found to occur predominantly in healthy and ill dogs as well as in rodents in Trinidad (Suepaul et al., 2010).

The epidemiology of leptospirosis is complex. *Leptospirosis* spp present in the environment can infect humans and animals. Risk factors for the occurrence of leptospirosis in humans include heavy rainfall (Vega-Corredor and Opadeyi, 2014); occupation, for example, farmers, veterinarians, sewer workers and; swimming in contaminated water. Outbreaks of leptospirosis in Trinidad and Tobago have been observed following flooding events, for example, a 2017 flooding in south Trinidad (Ministry of Health, 2017).

Leptospirosis has a wide host range, infecting wild and domestic animals which can shed the bacteria intermittently into the environment for several years. Humans can be infected by leptospires present in the urine of infected animals. However, human to human transmission of leptospirosis is believed to be uncommon.

1.2. Country Information

Trinidad is 4 828 sq km and Tobago is 300 sq km. Internet connectivity varies throughout the country.

1.3. Web GIS for disease surveillance

The Insect Vector Control Division of the Ministry of Health in Trinidad and Tobago uses GIS to monitor arboviruses at the national level (Felmine 2018; Webb 2018). At the level of the Caribbean region, the ARICABA, was a previous design of a GIS database, a pilot surveillance system for infectious diseases in Martinique, St Lucia and Dominica (Kim et al., 2011). Further, an online web Geographic Information System (GIS) for leptospirosis in Thailand was described (Laosuwan, 2012).

An integrated database with geographic data is required because leptospirosis is a zoonotic disease with a complex epidemiology which includes humans, animals (pets, farm and wildlife) and the environment.

1.4. Objective

The objective of this project is to design a cost-effective integrated real time Geographic Information Systems database for storage, analysis and dissemination of information on the distribution and spread of leptospirosis, a zoonotic disease, in Trinidad and Tobago to support decision-making regarding the prevention/control of leptospirosis.

2. Material and Methods

Definition of leptospirosis will facilitate decisions about which cases should be included in the GIS. The World Health Organisation's definition for Suspected and Confirmed human cases of leptospirosis will be adopted (WHO Emerging Diseases and Pandemic Response Department, 2001). According to the WHO definition, suspected cases are compatible with the clinical description of disease, which includes, a fever with headache, muscle pain, prostration any of a number of listed symptoms/signs. In addition to the clinical diagnosis, a presumptive laboratory diagnosis because of a positive rapid screening test, such as latex agglutination test, is requested for a case to be considered a Suspect. It is also important to differentiate leptospirosis from other diseases which occur commonly in Trinidad and Tobago with non-specific flu-like clinical signs, such as dengue.

Formative evaluation of the GIS for leptospirosis will involve stakeholder engagement from the early stages of development to prevent development proceeding along costly unfeasible avenues. System acceptability by stakeholder is important in implementing a sustainable solution. The system should also be easily adaptable to new settings and should be flexible to accommodate differences between settings.

Metadata will be added to data to facilitate identification of data sources. Attention will be paid to assessing data quality as it is important to understand the limitations of the data upon which information is based. Case data will be coded for confidentiality.

2.1. Design of GIS

Data will be collected using a mobile application with forms for data input from the field (human suspects and confirmed cases; wild domestic and farm animal suspect data from veterinarians and environmental survey data). In addition, rodent population monitoring data; leptospirosis laboratory data (genetics, serology); local climate data; and geographical features layers (water, vegetation, roads, population). Global positioning systems (GPS) units will be used to record coordinates of relevant locations.

Individuals without access to the GIS or the internet will also be able to submit hard or soft copies for example, on flash drive with data to designated locations for input into the database. These data should not be older than one week.

2.2. Data analysis

The Web processing Service (WPS) specification, of the OGC specification, will allow users to access spatial processing functions.

3. Results

3.1. Design

3.1.1. Data sources

Data relevant to leptospirosis is collected by several different agencies or departments in Trinidad and Tobago. The Ministry of Health and the Ministry of Rural Development and Local Government receive reports relevant to leptospirosis in humans. The Veterinary Public Health Unit (VPH) of the Ministry of Health is responsible for leptospirosis Surveillance. The VPH investigates yellow fever outbreaks and collects data on the number of cases and deaths. Human cases are seen at hospital and, health centres in the Public healthcare system and by Private hospitals/clinics and private practitioners.

Veterinarians employed by the Ministry of Agriculture and those in Private Practice observe cases of leptospirosis in farm animals and pets. Hunting dogs presented to veterinarians with leptospirosis acquired from the forest environment, for example, water sources or from wild animals. Data collected from veterinarians on a regular basis can be analysed to identify temporal and spatial patterns in disease occurrence.

The Insect Vector Division of the Ministry of Health are involved in the control of rodents in the case of an infestation. Also, the Ministry of Rural Development and Local Government conducts routine enquiries regarding sightings of rodents and distribution of rodent control bait.

3.1.2. Data collection, dissemination and analysis

Data will be collected from the various sources using the Epi Info android mobile app (https://www.cdc.gov/epiinfo/mobile.html) from which it is available. Data will be disseminated via the web and so be accessible to those involved in leptospirosis control/prevention decision-making.

3.2. Development

Free and open source software (FOSS), that is, software source code which tends to be free of charge can be modified and shared legal constraints, will be used to minimise project cost. Quantum GIS (QGIS), a FOSS GIS program, will be used to preview and manipulate datasets prior to web launching. Because datasets will be frequently edited and relational tables will be used to link datasets, databases will be stored using the PostGIS extension which facilitates management of spatial data and processing in the relational database PostgreSQL.The web client application will run on desktops and clients will make web requests through HTTP (see Figure 1).

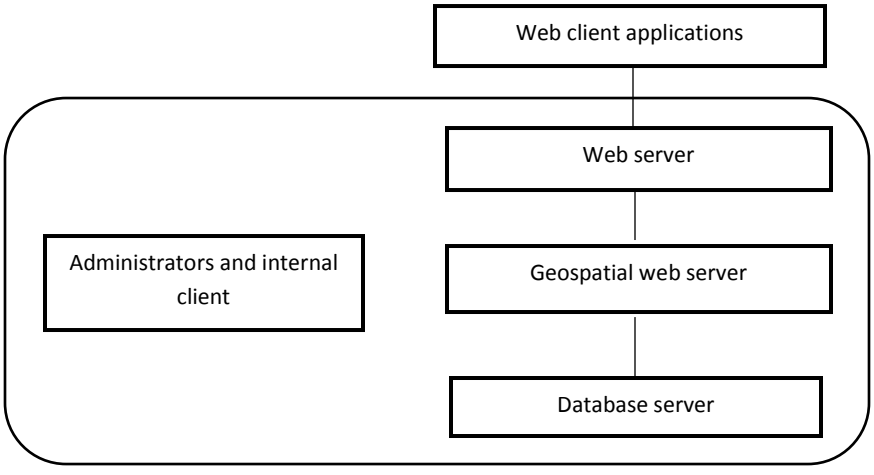

Figure 1. Web map architecture

At the webserver, the entry point to the network, Apache will forward requests to Geoserver. The Geospatial web server will draw maps, respond to queries and carry out GIS analysis. The Database server, PostgreSQL, will store GIS data. Administrators and internal clients will use QGIS at desktop workstations to prepare data and construct maps. The Application Programming Interface, OpenLayers, will be used to build the web map application and so display map layers together on the web page.

The GIS map will include a basemap from OpenStreetMap, thematic layers and interactive layers. Thematic layers will include human cases, animal cases, rodent population monitoring data. The leptospirosis thematic layers will be placed above the basemap layer. Interactive elements will include charts and graphs as well as a slider bar to display data from a particular period of time on the map.

Normalisation of data will be carried out so that temporal and spatial variability of data will be taken into consideration. Techniques which will be used to study the effects of variability include time series analysis, cluster analysis and simulation modelling.

4. Discussion

The effectiveness of decisions about which areas should be targeted and when control and surveillance activities should be carried out will all benefit from current information provided by the online GIS. It is known that there are different serovars involved in leptospirosis in Trinidad and Tobago. Molecular methods such as polymerase chain reaction (Cosate et al., 2017) or genome sequencing (Jorge et al. 2018) together with spatial analysis will provide further information on the relationships between outbreaks, thereby presenting authorities with enhanced ability to develop control programs.

Behavioural changes are important in reducing risk of acquiring leptospirosis, however, Mohan et al. (2011) identified a low level of awareness about leptospirosis amongst householders throughout Trinidad and Tobago. Limitations to this approach to syndromic surveillance include variations in internet connectivity throughout the islands. Use of web GIS will require reliable internet connection at speeds that will allow for viewing of maps. The consequence of variations in internet accessibility and speed through the islands is that some areas might be under represented because there is less frequent upload of data from these areas. Different regions might also collect and collate data at different frequencies. Map performance can be constrained by the speed of the different servers from which data is pulled.

5. Conclusion

The use of this GIS will increase the capacity of authorities responsible for decision-making regarding leptospirosis surveillance in Trinidad and Tobago to engage in evidenced based decision making. The information available via this GIS will allow for the identification of hotspots for leptospirosis in humans and animals. In addition, it is expected that the predictive ability of authorities will increase, and they will be able to develop more timely and targeted responses to outbreaks. It is expected that a web GIS using FOSS will be a cost-effective approach to developing a syndromic surveillance system for leptospirosis, a zoonotic disease which is endemic to Trinidad and Tobago

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Author's Biographical Notes:

Lisa A. Benjamin *is a Lecturer in Veterinary Public Health/Epidemiology in the Department of Basic Veterinary Sciences (Faculty of Medicine) at The University of the West Indies. She is a Certified Associate in Project Management with the Project Management Institute (USA) and a Veterinarian. Her research interests include disease surveillance, food safety and antibiotic resistance.*

■

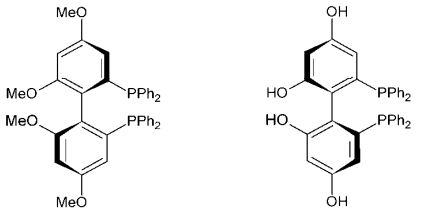
Chiral Transition Metal Diphosphine Complexes and Their Applications in Asymmetric Catalysis

Shannen C. Lorraine[1], Paul T. Maragh[2], Tara P. Dasgupta[3], and Kamaluddin Abdur-Rashid[4]

[1,2,3] Department of Physics, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies
[1]Email: s_lorraine13@yahoo.com;
[2]Email: anjel4sure@yahoo.com
[3]Email: tara.dasgupta@gmail.com;

[4] Kamal Pharmachem Inc, 3403 American Drive, Mississauga, Ontario, L4V 1T4 Canada; Email: krashid@kamalpharmachem.com;

Abstract: *(R)-(4,4',6,6'-tetramethoxybiphenyl-2,2'-diyl)bis(diphenylphosphine) (R-Ph-Garphos), and (S)-(4,4',6,6'-tetramethoxybiphenyl-2,2'-diyl)bis(diphenylphosphine) (S-Ph-Garphos) are novel, nucleophilic, chiral atropisomeric ligands. This work seeks to highlight the successful synthesis and characterisation of chiral transition metal complexes containing these ligands. Herein, the Ph-Garphos transition metal complexes having ruthenium(II), rhodium(I) and iridium(I) metal centres and their applications to asymmetric hydrogenations will be discussed. Biaryl diphosphines are considered versatile ligands due to the facile modification of the ligand scaffold. With a burgeoning demand for "greener" catalysts in catalytic transformations, the Ph-Garphos ligands were subjected to O-demethylation thereby introducing hydroxy moieties unto the backbone of the ligand. Consequently, two novel nucleophilic diphosphines were isolated, (R)-(4,4',6,6'-tetrahydroxybiphenyl-2,2'-diyl)bis(diphenylphosphine) (R-Ph-Garphos-OH), and (S)-(4,4',6,6'-tetrahydroxybiphenyl-2,2'-diyl)bis(diphenylphosphine) (S-Ph-Garphos-OH) ligands (see Figure 1). These were successfully characterised by CHN analysis, ^{1}H, ^{13}C, and ^{31}P NMR spectroscopy, and polarimetry. The use of the Ph-Garphos-OH ligands and their transition metal complexes in asymmetric hydrogenations will be reported. Additionally, the scope of the research will highlight and compare the applicability of the Ph-Garphos-OH ligand and its transition metal complexes as potential "green" catalysts in asymmetric hydrogenations.*



(*R*)-Ph-Garphos **1** (*S*)-Ph-Garphos **2**

Figure 1

Keywords*: Organometallic catalysis, diphosphines, asymmetric hydrogenations, green chemistry*

Authors' Biographical Notes:

Shannen C. Lorraine *is associated with the Department of Physics, The University of the West Indies, St. Augustine, Trinidad and Tobago, West Indies.*

Paul T. Maragh *is associated with the Department of Chemistry, University of the West Indies, Mona, Kingston 7, Jamaica, West Indies.*

Tara P. Dasgupta *is associated with the Department of Chemistry, University of the West Indies, Mona, Kingston 7, Jamaica, West Indies.*

Kamaluddin Abdur-Rashid *is associated with Kamal Pharmachem Incorporation in Canada.*

■

Theoretical Study of the Interaction of Two Chloride Pesticides with Superficial Amines of Activated Carbon

Kenia Melchor-Rodríguez[1], Chayan Carmenate-Rodríguez[2], Juan J. Gamboa-Carballo[3], Nady Passe-Coutrin[4], Sarra Gaspard[5] and Ulises. J. Jáuregui-Haza[6]

[1,2,3,6] Instituto Superior de Tecnologías y Ciencias Aplicadas (InSTEC), Universidad de La Habana, La Habana, Cuba, West Indies
[1]Email: keniamr@instec.cu;
[2]Email: ccarmenate@instec.cu;
[3]Email: jjgamboa@instec.cu
[6]Emails: ulises.jauregui@infomed.sld.cu; ulisesjhaza@yahoo.com

[4,5] Laboratoire COVACHIM M2E, Université des Antilles, Guadeloupe, France;
[4]Email: nady.passe-coutrin@univ-antilles.fr;
[5]Email: sarra.gaspard@univ-antilles.fr
[6]Instituto Tecnológico de Santo Domingo (INTEC), República Dominicana; Email: ulises.jauregui@intec.edu.do

Abstract: *Chlordecone (CLD) and hexachlorocyclohexane (HCH) are synthetic organochlorine compounds that have been used as pesticides and, because of their harmful effects on the environment, were identified and classified as persistent organic pollutants by the Stockholm Convention. When the technical HCH is used, β-hexachlorocyclohexane (β-HCH) is the most persistent isomer due to the presence of chlorine atoms in the equatorial position. Due to the persistence of CLD and β-HCH in the environment, the drinking water production plants have been equipped with filters of activated carbon (AC), for the purification of water contaminated with these pesticides. For this reason in the present work, a theoretical study to evaluate the interaction between CLD and β-HCH with basic surface groups (SG) of activated carbon under different pH conditions is carried out. A simplified AC model consisting of the coronene molecule was used, with primary, secondary and tertiary amine as basic functional groups. Multiple Hypersurface Methodology (MMH) using the semi-empirical Hamiltonian PM7 was used to study the interactions of the CLD and β-HCH with the different AC SGs under study. The obtained results showed a greater association of both pesticides with the primary amine in comparison with the secondary and tertiary amine in the absence and presence of water molecules. On the other hand, it is suggested a weak association of the pollutants with the basic SG, and that the interactions are basically of dispersive type between the chlorine atoms present in the structure of the CLD and the β-HCH and the π cloud of the modified coronene, evidencing a mechanism of physisorption of both pollutants in the basic superficial groups type amines of the AC studied.*

Keywords*: Chlordecone, β-hexachlorocyclohexane, activated carbon, amines, wastewater treatment*

Authors' Biographical Notes:

Kenia Melchor-Rodríguez *is assistant professor and aggregate researcher at Instituto Superior de Tecnologías y Ciencias Aplicadas (InSTEC), University of Havana, Cuba. She received her BSc in Chemistry at Chemistry Faculty of University of Havana, Cuba in 2001, and MSc in Environmental Analysis and Technologies at InSTEC in 2004. Actually she is PhD student of InSTEC and University of Antilles, Guadeloupe, France. She has published over 10 peer-reviewed papers and one book about composting process. She research has led to environmental analysis and technology; water, wastewater and solid waste analysis and treatment, and molecular modeling of complex systems.*

Chayan Carmenate-Rodríguez *is a fourth year student of the Radiochemistry career at the Higher Institute of Technology and Applied Sciences, University of Havana, Cuba. He belongs to the group of chemical systems modeling based in the institute. He works on the topic of computational quantum chemistry with environmental profile.*

Juan J. Gamboa-Carballo *is graduated of BSc in. Radiochemistry at InSTEC since 2015. Achieved the degree of Master of Radiochemical Sciences of the University of Havana in 2018. Currently pursuing his PhD degree of*

Chemistry, and working as teaching and research assistant in ETH Zürich. He has published several peer-reviewed papers regarding the molecular modeling of pesticides removal methodologies.

Nady Passe-Coutrin *is assistant-professor in chemistry at Université des Antilles (UA), pôle Guadeloupe, PhD in 2001in UA, student from Ecole Normale Supérieure of Paris, 11 publications and 3 participations in book chapters. searching domains: adsorption and desorption of pollutants initially in water using activated carbons (AC) prepared from local lignocellulosic materials. Her skills: apply mathematics to modelling transport in porous media and textural characterizations. New theme: electrochemical characterization of AC electrodes for energy storage in supercapacitor.*

Sarra Gaspard *is titular professor in Chemistry at the University des Antilles and Vice-Director of COVACHIMM2E laboratory, where she leads research projects on adsorption on activated carbons and bioremediation. She did her graduated studies at the University of Orsay, France, and got her PhD in 1993. She has been working two years as a post-doctoral researcher at the University of Pavia, Italy, and three years as a post-doctoral and a research assistant at the EAWAG/ETH, Switzerland. She has authored 50 scientific articles and communications, in biophysical chemisty, environmental microbiology, environmental chemistry and adsorption processes meanly on activated carbons.*

Ulises. J. Jáuregui-Haza *is titular professor and researcher at Instituto Tecnológico de Santo Domingo (INTEC), Dominican Republic and at Instituto Superior de Tecnologías y Ciencias Aplicadas (InSTEC), University of Havana, Cuba. He received his BSc and MSc in Chemical Engineering at Moscow Institute of Chemical Technology D. I. Mendeleyev, Russia, in 1987 and PhD at National Polytechnic Institute of Toulouse, France, in 2002. He has published over 100 peer-reviewed papers and 4 books chapters. His research has led to environmental engineering, wastewater treatment, mathematical modeling of technological processes and molecular modeling of pharmaceuticals and complex systems.*

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Depollution of Waters Contaminated with Chlordecone and β-hexachlorocyclohexane by Their Precipation with Cyclodextrins

Juan J. Gamboa-Carballo[1], A. Ferino-Pérez[2], Vijay K. Rana[3], Kenia Melchor-Rodríguez[4], Ronald Ranguin[5], Joëlle Levalois-Grützmacher[6], Sarra Gaspard[7] and Ulises J. Jáuregui-Haza[8]

[1,2,4,8] Instituto Superior de Tecnologías y Ciencias Aplicadas (InSTEC), Universidad de La Habana, La Habana, Cuba, West Indies;
[1]Email: jjgamboa@instec.cu;
[2]Email: anthuan@instec.cu
[4]Email: keniamr@instec.cu;
[8]Email: ulises.jauregui@infomed.sld.cu; ulisesjhaza@yahoo.com

[3,6] Department of Chemistry and Applied Biosciences, Laboratory of Inorganic Chemistry, ETH Zürich, Switzerland;
[3]Email: vkr23@cam.ac.uk
[6]Email: levalois@inorg.chem.ethz.ch;

[5,7] Laboratoire COVACHIM M2E, Université des Antilles, Guadeloupe, France;
[5]Email: rranguin@univ-antilles.fr; ronaldranguin@gmail.com
[7]Email: sarra.gaspard@univ-antilles.fr

[8]Instituto Tecnológico de Santo Domingo (INTEC), República Dominicana; Emails: ulises.jauregui@intec.edu.do

Abstract: *The present work studies the interactions between two pesticides: chlordecone (CLD) and β-hexachlorocyclohexane (β-HCH), with the cyclodextrins (CDs) and the formation of their nanoaggregates by guest-host complexation. CLD and β-HCH are persistent organic pollutants of high environmental stability that causes severe affectations to the health. Results suggest the utility of these complexes in the separation of studied pollutants and the possibility of using CDs for the management, purification and treatment of polluted waters.The Multiples Minima Hypersurface methodology coupled with PM6-D3H4X semiempirical Hamiltonian and Density Functional Theory calculations using M02-2X/6-31G(d,p) scheme with SMD implicit solvent model, were used to investigate the interaction space of the two pollutants with the symmetrical conformers of the three CDs. The description of the interactions was made through a topological study of functions related with the electron density after a refinement of the systems' wavefunctions using the M06-2X/6-311++G(2df,2pd) scheme. Finally for the β-HCH@CDs complexes a study of the charge distribution, charge transfer and Fukui's dual descriptor was employed to elucidate the forces involved in the formation of these nanoaggregates. Three types of interactions were observed: total occlusion, partial occlusion and external interaction. The more stable complexes were obtained when the γ-cyclodextrin is the host molecule, as it was confirmed experimentally by means of spectroscopic and thermodynamic results in the case of the CLD@CDs complexes. These complexes are stabilised by a great number of dispersive interactions between the pesticide and the hydrophobic interior of the CDs and as it could be seen from the studies on the β-HCH@CDs systems, this stability could be increased introducing electron with-drawing substituents. Experimental results confirmed the expected theoretical results. The formed complexes were characterised, confirming the formation of nanoagregates pesticide-CD. These results suggest the utility of these complexes in the separation of studied pollutants and the possibility of using CDs for the management, purification and treatment of polluted waters*

Keywords*: Chlordecone, β-hexachlorocyclohexane, cyclodextrins, nanoagregates, wastewater treatment*

Authors' Biographical Notes:

Juan J. Gamboa-Carballo *is graduated of BSc in. Radiochemistry at InSTEC since 2015. Achieved the degree of Master of Radiochemical Sciences of the University of Havana in 2018. Currently pursuing his PhD degree of Chemistry, and working as teaching and research assistant in ETH Zürich. He has published several peer-reviewed papers regarding the molecular modeling of pesticides removal methodologies.*

A. Ferino-Pérez *is a student coursing the 5th year of Bachelor in Radiochemical Sciences at Instituto Superior de Tecnologías y Ciencias Aplicadas, University of Havana, Cuba. He has been coauthor of two papers and had participated in more than 5 international events as the 6th Green Process Engineering Congress at Toulouse, France. His current research interest is the use of computational chemistry tools to explain and predict chemical phenomena.*

Vijay K. Rana *is a Marie-Curie Postdoc Research Fellow at the Department of Chemistry, University of Cambridge, UK. He pursued his PhD at ETH Zurich and worked on the synthesis and modification of activated carbon for the adsorption of chlordecone from water. His current research interest is to develop new supramolecular structures, liquid colloidal crystals for biological, photocatalysis and photonic applications, respectively.*

Kenia Melchor-Rodríguez *is assistant professor and aggregate researcher at Instituto Superior de Tecnologías y Ciencias Aplicadas (InSTEC), University of Havana, Cuba. She received her BSc in Chemistry at Chemistry Faculty of University of Havana, Cuba in 2001, and MSc in Environmental Analysis and Technologies at InSTEC in 2004. Actually she is PhD student of InSTEC and University of Antilles, Guadeloupe, France. She has published over 10 peer-reviewed papers and one book about composting process. She research has led to environmental analysis and technology; water, wastewater and solid waste analysis and treatment, and molecular modeling of complex systems.*

Ronald Ranguin *is an engineer at COVACHIM M2E (Connaissance et Valorisation : Chimie des Matériaux, Environnement, Energie) Research Group at the Université des Antilles, in Guadeloupe, France. He received his BSc in Physical and Chemical Sciences from the University of Aix-Marseille (II), and an MSc in Physical Science in 2011 and a PhD at the Université des Antilles in 2015, in Guadeloupe, France. His work can be summarised as covering the following subjects: wastewater treatment, analytical chemistry, preparation of activated carbons, green chemistry, characterisation techniques, and adsorption.*

Joëlle Levalois-Grützmacher *is titular professor and researcher at the Université des Antilles (Guadeloupe, FWI) and associate researcher ETH-Zürich (Swiss Federal Institute of Polytechnic). She received her BSc and MSc, as well as her PhD in 1994, at the Université Paul Sabatier de Toulouse, France. She has published over 40 peer-reviewed papers and 1 book chapter. Her research is orientated on the surface modification of various materials by means of low pressure plasma treatments. A particular focus is made on flame retardant materials and on charcoal activation for water depollution.*

Sarra Gaspard *is titular professor in Chemistry at the University des Antilles and Vice-Director of COVACHIMM2E laboratory, where she leads research projects on adsorption on activated carbons and bioremediation. She did her graduated studies at the University of Orsay, France, and got her PhD in 1993. She has been working two years as a post-doctoral researcher at the University of Pavia, Italy, and three years as a post-doctoral and a research assistant at the EAWAG/ETH, Switzerland. She has authored 50 scientific articles and communications, in biophysical chemisty, environmental microbiology, environmental chemistry and adsorption processes meanly on activated carbons.*

Ulises. J. Jáuregui-Haza *is titular professor and researcher at Instituto Tecnológico de Santo Domingo (INTEC), Dominican Republic and at Instituto Superior de Tecnologías y Ciencias Aplicadas (InSTEC), University of Havana, Cuba. He received his BSc and MSc in Chemical Engineering at Moscow Institute of Chemical Technology D. I. Mendeleyev, Russia, in 1987 and PhD at National Polytechnic Institute of Toulouse, France, in 2002. He has published over 100 peer-reviewed papers and 4 books chapters. His research has led to environmental engineering, wastewater treatment, mathematical modeling of technological processes and molecular modeling of pharmaceuticals and complex systems.*

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