Institute of Technology University of Moratuwa

1st International Research Conference

"Fostering Research through Collaboration and Innovation"

IRCITUM 2022

Proceedings of the 1st International Research Conference of ITUM

2022

Organized by

The Research Unit, ITUM

Wednesday 28th October 2022
Held online via Zoom

Institute of Technology University of Moratuwa

International Research Conference

"*Fostering Research through Collaboration and Innovation*"

Proceedings of the

9th Annual Research Session – 2022

Organized by the

Research Unit, ITUM

Friday 28th of October 2022
Held Online via Zoom

Institute of Technology University of Moratuwa
Research Symposium

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MESSAGE FROM THE DIRECTOR, ITUM
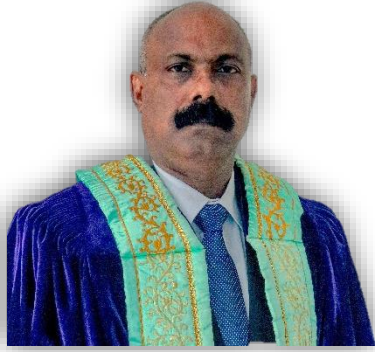
I take pleasure in sending my greetings and best wishes to the 1st International Research Conference of ITUM on the theme "Fostering Research through collaboration and innovation," thus widening the scope of the annual research symposium of ITUM held over the years to give ITUM researchers the opportunity to showcase and discuss their research findings in an open forum.

Despite the adverse health conditions prevailing in the country in 2021, the ITUM Research Unit was able to conduct this important annual event of ITUM in virtual mode, successfully. Last year for the first time, ITUM opened its research symposium to researchers from other universities and higher educational institutes in Sri Lanka and the industry. This year, I am impressed that the Research Unit has been able to extend its research forum to an international level, accomplishing another milestone in its quest for achieving excellence in research.

I am pleased that the Research Unit of ITUM, headed by Dr. (Mrs.) W. P. S. K. Perera has taken the initiative to organize the conference for the year 2022 to include international participation giving the participants the opportunity to exchange ideas with experienced researchers both from Sri Lanka and overseas and to meet potential collaborators, thus paving the way for academic staff as well as students of ITUM to undertake collaborative research.

I congratulate the ITUM Research Unit for the tremendous effort taken to conduct this event successfully and take this opportunity to thank all those who contributed in numerous ways to make this event a success.

Major General (Retd.) S. K. Thirunavukarasu RSP VSV USP,
Director,
Institute of Technology,
University of Moratuwa.

MESSAGE FROM THE HEAD OF THE RESEARCH UNIT, ITUM

On behalf of the ITUM Research Unit, I am pleased to welcome all the participants to the International Research Conference (IRCITUM2022) of the Institute of Technology, University of Moratuwa.

After eight successive research symposiums held by ITUM from the year 2013, the IRCITUM2022 has now broadened its horizons by stepping onto the international stage, for the first time. This time the conference will be a forum for oral presentations on a variety of topics related to the disciplines coming under the eight academic divisions of ITUM, as well as for presentations on other technology and engineering-related topics pertaining to researchers from other universities and higher educational institutes in Sri Lanka and overseas.

The success of the IRCITUM2022 lies in the support and contribution given by many. I appreciate with gratitude the valuable support and guidance given by the Director of ITUM, Major General (Retd.) S. K. Thirunavukarasu and also take this opportunity to thank Dr. (Ms.) Nadeeka Tissera, the Chairperson of the IRCITUM2022, for her dedication and the untiring efforts taken towards organizing IRCITUM2022.

I sincerely appreciate the invaluable assistance given by the research conference committee 2022, the editorial committee, the review committee, the panel of reviewers, and the Division of Information Technology of ITUM towards this endeavour.

I hope that the IRCITUM2022 will help in establishing new links and initiating collaborative projects between participants.

Wish you all an informative and enjoyable conference.

Dr. (Mrs.) W. P. S. K. Perera,
Head, ITUM Research Unit

MESSAGE FROM THE CONFERENCE CHAIRPERSON, IRCITUM2022

I warmly welcome you all to the first international research conference of the Institute of Technology, University of Moratuwa (IRCITUM2022), and would like to extend my sincere congratulations to all the researchers who will be presenting their work at this conference.

As in previous research symposiums, IRCITUM2022 will become an excellent forum for sharing knowledge and generating discussion on a variety of topics representing the latest technological developments and future trends.

With more than thirty experts representing different technology and engineering-related disciplines from local and international universities coming together at IRCITUM2022, we will be able to broaden our horizons by developing important networks and engaging in fruitful collaborations.

From physics to material science, or reading the lines between science and entrepreneurship, we are presenting world-renowned individuals who have achieved their targets as scientists and successful founders and cofounders of many spinoff companies, through the keynote and pre-conference speeches of IRCITUM2022.

I express my gratitude to the Director of ITUM, Major General (Retd.) S. K. Thirunavukarasu for giving leadership and support to make this conference a reality.

On behalf of the organizing committee, I am very much thankful to the Head of the research unit Dr (Mrs.) Srimala Perera, the Heads of Divisions of ITUM, and all the academic and non-academic staff of ITUM for their unstinting support extended for this event.

I am extremely happy that you have joined us to experience a very pleasant, interesting, and fruitful conference.

Dr (Ms.) Nadeeka D. Tissera
Conference chairperson – IRCITUM2022

International Research Conference

on the theme,

"*Fostering Research through Collaboration and Innovation*"

Organized by

the Research Unit, Institute of Technology University of Moratuwa (ITUM)

Friday 28th October 2022

Online via Zoom

8.55 AM – 9.00 AM	Conference Announcements
9.00 AM – 9.05 AM	Welcome Address Dr. Nadeeka Tissera, conference chairperson
9.05 AM- 9.10 AM	Address by the Director, ITUM Major General (Retd) S.K. Thirunavukarasu RSP VSV USP,
9.10 AM – 10.15 AM	Key note speech Prof. A.P De Silva, School of Chemistry and Chemical Engineering, Queen's University Belfast, United Kingdom "From Chemistry to Medical Diagnostics and Information Processing"
10.15 AM -10.25 AM	Dance performance by Ms. Lakni Kumarasiri, IDS, Lecturer in charge Aesthetic studies, ITUM & Mr. Thilina Dayananda, Visiting lecturer, ITUM.
10.25 AM -10.30 AM	Vote of thanks and announcement of session plan
10.30 PM – 12.30 PM	Technical sessions 1, 2 & 3 Presentations & QA sessions

International Research Conference ITUM, October 28th, 2022 - SESSION PLAN

	SESSION 1	SESSION 2	SESSION 3
Zoom Link	https://learn.zoom.us/j/69300910758?pwd=TkM4NFdQd1hDUWkzRjBMRmpmTldVdz09	https://learn.zoom.us/j/65059724159?pwd=MFhocWJxMVNSWVlFd3JMK1JFTTN4UT09	https://learn.zoom.us/j/67810480086?pwd=V3JNR01VcXlnd21TVFhTTkgzRnQ2dz09
Session Chairperson	*Dr. Kaushika Premarathna*	*Dr. N.P.K. Semananda*	*Dr. Sudarshana Perera*
Time	**PAPER TITLE**, author(s), **Page numbers**	**PAPER TITLE**, author(s), **Page numbers**	**PAPER TITLE**, author(s), **Page numbers**
10.30 - 10.45 am	**THE IMPACT OF 'PROBLEM-SOLVING SMALL GROUPS' METHOD ON RETENTION: A CASE STUDY OF ENGINEERING TECHNOLOGY STUDENTS AT THE INSTITUTE OF TECHNOLOGY UNIVERSITY OF MORATUWA.** K. G. A. S. Kariyawasam & B. Thoradeniya **PP 10**	**DESIGN AND DEVELOPMENT OF AN AUTONOMOUS TOOL CART (ATC)** M.M.A.P. Peiris, A.C.D. Athukorala, J.M.D.A. Jayasuriya & R.L.W. Koggalage **PP 39**	**APPLICATION OF NATURAL MORDANTS WITH PALM LIGNIN DYE FOR COTTON TEXTILES** D. Kajenthiran, N. D. Tissera, R. N. Wijesena & D. C. Manatunga **PP 68**
10.45 - 11.00 am	**IMPROVING TRANSPARENCY IN SUPPLY CHAIN FOR BETTER BRAND PERFORMANCE (APPAREL INDUSTRY): A STATISTICAL APPROACH** M. Shavini, I. Wijesiri, S. Mathugama & D.R.T. Jayasundara **PP 14**	**FORECASTING THE ALL SHARE PRICE INDEX OF THE COLOMBO STOCK EXCHANGE DURING THE COVID 19 PANDEMIC** J.A.G. Jayakody & B. Jayasinghe **PP 45**	**STUDY ON THE SLOW-RELEASE BEHAVIOUR OF FERTILIZER-LOADED HYDROGELS** Manchika Inparasa, R. N. Wijesena, N. D. Tissera & D. C. Manatunga **PP 74**
11.00 – 11.15 am	**MACRO TRANSFORMATION THROUGH MICRO CHANGES: PROMOTING ACTIVE LEARNING VIA LECTURE BREAKS** W. E. Iroshani **PP 19**	**BENEFITS OF IMPLEMENTING GREEN BUILDING PRACTICES IN HIGHER EDUCATIONAL INSTITUTES** I.E. Illeperuma & M.D.T.E. Abeynayake **PP 49**	**SUCCESSIVE IONIC LAYER ADSORPTION AND REACTION FOR THE FABRICATION OF NANOSTRUCTURED BIVO 4 FILMS WITH HIGHPH OTOELECTROCHEMICAL EFFICIENCY** S.P. Ratnayake & E. D. Gaspera **PP 79**

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11.30 - 11.45 am	**SECOND LANGUAGE LEARNING STRATEGIES EMPLOYED BY TERTIARY LEVEL STUDENTS: WITH SPECIAL REFERENCE TO STUDENTS OF THE INSTITUTE OF TECHNOLOGY, UNIVERSITY OF MORATUWA** H.A.S.L. Amarasinghe **PP 29**	**MEASUREMENT OF SHEAR STRENGTH CAPACITY OF METAMORPHIC ROCK – CONCRETE INTERFACE OF PILE SOCKETS: A LABORATORY STUDY** A.U.V.B. Bulathsinhala & U.G.A. Puswewala **PP 59**	**IDENTIFICATION OF OPTIMUM BARIUM SULPHATE FILLER LOADING FOR NATURAL RUBBER/HIGH-DENSITY POLYETHYLENE BLEND FOR ROOFING APPLICATION –A STATISTICAL APPROACH** S.A.I.M. Samaraweera, W.V.W.H. Wickramarachchi, S. Walpalage, S.M. Egodage & W.E. Iroshani **PP 89**
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12.15 – 12.30 pm			**FACILE FABRICATION OF CONDUCTIVE SILVER NETWORKS THROUGH ELECTROSPINNING** R. N. Wijesena, N. D. Tissera & K. M. Nalin de Silva **PP 100**

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Session 01

THE IMPACT OF 'PROBLEM-SOLVING SMALL GROUPS' METHOD ON RETENTION: A CASE STUDY OF ENGINEERING TECHNOLOGY STUDENTS AT THE INSTITUTE OF TECHNOLOGY UNIVERSITY OF MORATUWA

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ABSTRACT: The delivery of education in Sri Lanka is presently being converted from teacher-centered, traditional methods to student-centered active learning. As such, students who sit the GCE (A/L) examination do not experience the benefit of student-centered active learning methods and have typically formed the habit of depending on traditional teacher-centered methods. This study is therefore designed to investigate whether there is a positive impact of student-centered active learning on the level of retention. This article aims at discussing students' improved performance in a tutorial class through a changed learning method, from a traditional teacher-oriented class to a 'problem-solving small group discussion' class using a sample of 700 first-year students. The test instrument was an in-class examination which resulted in a majority of students (54%) attaining higher retention levels in the 'Learning Pyramid' by obtaining more than 90% marks. Furthermore, 90% of the students asserted the effectiveness of the "problem-solving small group discussion" method over the traditional method used in tutorial classes. The students' feedback agrees with the feedback of the two academics who functioned as observers. Hence, the small group discussion method is recommended for small group (20-25) tutorial classes for the other modules which can use the problem-solving approach.

Keywords: Learning Pyramid, Retention, Student-centered Active learning, Problem-solving Small Group Discussions

1. INTRODUCTION

The level of retention of the learned matter is an important component of critical thinking and deep learning (Pollock, Hamann, & Wilson, 2011). The 'Learning Pyramid' model (Khalifa & Brahimi, 2017) illustrates the effectiveness of different learning methods within a spectrum of 7 levels of retention, ranging from 5% retention through traditional lectures to 90% retention by teaching peers. Within this spectrum, there are numerous learning methods. The teacher is responsible for applying the most suitable method for a particular educational activity in such a way that the students are guided to engage in deep learning.

Primary, Secondary, and Tertiary education in Sri Lanka is being converted from teacher-centered, traditional methods to student-centered active learning (Kenedy & Sebarajah, 2021). However, even now, after completing the GCE (A/L) examination, a large majority of students are in the habit of being teacher dependent and they remain in their comfort zones by not experiencing the benefit of student-centered active learning methods. Therefore, any attempt to change the learning style at the earliest time possible in their higher education would positively impact the students' competence for deep learning and lifelong learning.

The case selected for this study was the first-year students who followed the 'Strength of Materials' module of the National Diploma in Technology program at the Institute of Technology University of Moratuwa in 2019, specifically due to the lethargic attitude shown by the majority of students during the tutorial class in 2018. The study was designed with three major objectives: (a) To change the method of delivery to student-centered active learning from traditional teacher-centered learning, (b) To measure the relative performance of students after the new student-centered active learning method was employed: and (c) To make recommendations for the suitability of the method of delivery for comparable modules.

2. METHODOLOGY

The module selected is commonly taken by engineering technology students from chemical, civil, electrical, electronics, mechanical, marine, polymer, and textile disciplines. Therefore, the total number of students participating in this case study was 700 first-year students who attended the tutorial classes of the module in batches of 25. Each tutorial class was of 4 hours' duration.

The flow of the case study is illustrated in Figure 1. The planning phase included the selection of a delivery method, preparation of the content for the class, and arranging the class learning environment. The "problem-solving small group discussion" method to be used as the method of delivery was selected through the literature review, as it was expected to support participants to gain logical solutions and to make responsible decisions (Brewer, 1997). A tutorial consisting of 6 questions was the content to be delivered. The questions were of a problem-solving nature based on the application of the theory the students had learnt and practiced earlier.

Planning
- Select the appropriate method for delivery
- Prepre the contents to be delivered
- Arrange the learning enviroment
- Grouping / Seating

Delivery
- Motivate students
- Introduce the tutorial
- Facilite group discussion
- Students present the answer
- Feedback by the tutor

Data collection and analysis
- Conduct in-class test
- Students' Feedback
- Comparison of marks
- Academics' Feedback

Figure 1: Methodology flowchart

The classroom arrangement covered two aspects: grouping of students and their seating arrangements. The students were divided into four groups comprising of 6 or 7 students. The class was arranged in a circle as it assisted students to carry on the group discussion instead of the traditional theater setting (Mills & Alexander, 2013; Wood, 1998).

Delivery: The students were prepared and motivated for the changed method of delivery. They were told that their enthusiastic engagement would help in minimizing additional time needed to study this lesson later on before the final examinations and also that they would be able to apply the knowledge gained immediately and effectively. Next, the students were briefed about the tutorial, and the groups were guided to discuss and solve the questions from 1 to 6, in order. The students were encouraged to discuss their quarries regarding the questions, first among the group members and then with the tutor. After about 15 minutes one student from each group was asked to write the answer to the first question on the board. The tutor provided feedback, which was also noted on the board by the student. This procedure was followed for all 6 questions.

Data Collection and Analysis: The first data collection instrument was a 30 minute in-class test for 10 marks. The test was a structured question mostly based on knowledge covered within 6 tutorial questions which had been developed and used in the previous year (2018). This facilitated measuring the relative performance of students during the two years. The data (raw marks) of the two in-class tests conducted in 2018 and 2019 were analyzed using graphical plots in which simple students' percentages were used (Figure 2) and statistics (mean and standard deviation) for the two data sets were computed.

The second instrument was a feedback form on a 5-point Likert scale (1-Strongly 2-Agree, 3-Neutral, 4- Disagree, 5-Strongly Disagree) given to a sample of students (n=190) who were asked

to respond with their experiences for the given statements (See Figure 3). The third instrument was feedback obtained from the two academics involved as the tutor and the observer.

3. RESULTS AND DISCUSSION
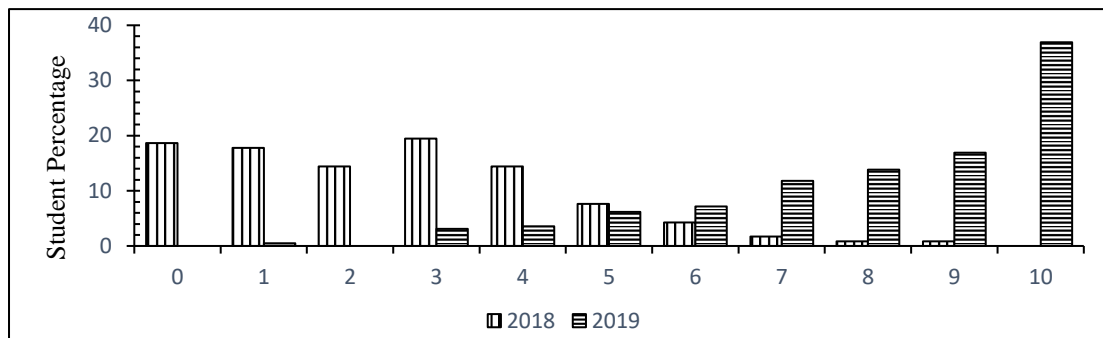
Figure 2: Students' In-class test marks in the year 2018 & the year 2019

Figure 2 illustrates significantly high student achievement in 2019 compared to that of 2018. A majority (68%) of students had obtained high marks (i.e., 8 - 10) compared to the 2% in 2018 while the low marks (i.e., 0 to 3) had declined from 70% to 4% in 2019. Further 54% of the students had achieved 9 or 10 marks, and could be assumed to have achieved 90% retention, with the assumption that 9 marks represents 90% retention.

The mean values of raw marks were 2.3 and 8 and the standard deviation was 1.95 and 2.11 respectively, in 2018 and 2019. This means that in 2018, the raw marks were low on average and were closely spread, while high retention levels due to the changed delivery method was clearly visible in the high mean value and the standard deviation of raw marks in 2019.

LEGEND
- ▨ Strongly Agree
- ☰ Agree
- ▦ Neutral
- ▨ Disagree
- ■ Strongly Disagree

Chart Statements

1 - The tutorial increases students' willingness to participate in the discussion
2 - The small group discussion of the questions improves the knowledge of the subject area
3 - I have enjoyed this small group discussion class than the traditional tutorial class.
4 - A small number of students in a group is more effective than a large number of students in a tutorial class.

Figure 3: Student feedback - Numbers responded on 5-point Likert scale

Figure 3 illustrates the responses received on the 5-point Likert scale for the given statements. Accordingly, 89% (n = 165) of the students agreed that the delivery method had helped them in improving their knowledge (Figure 3.2) and 85% (n = 158) agreed that the new method had

improved their willingness to participate in the discussion and that they had enjoyed the small group activity more than in the traditional teacher-centered tutorial class (Figure 3.1 and 3.3). 90% (n =167) of the students agreed that the small numbers in a group were more effective and 98% recommended this type of small group tutorial classes for their colleagues and the students of future batches.

On the whole, students' feedback suggest that small group discussions had improved their retention, interest in the subject, and subject knowledge. However, both academic staff members engaged in the experiment noted fatigue among the students after about 3 hours while agreeing with students on all positive outcomes.

4. CONCLUSION

'Problem-Solving Small Group Discussion' method of delivery resulted in a remarkable increase (from 2 % to 68 %,) in the high marks and a remarkable decrease (from 70% to 4%) in the low marks of students. This is a breakthrough achievement in the delivery of tutorials for large groups (n=700). A Majority (54%) of students obtained ≥ 90% marks indicating the possibility of achieving 90% retention in the Learning Pyramid, suggesting that more than half the students in a group had engaged in peer teaching. Application of the problem-solving small group discussion method (a method of student-centered active learning) is recommended for the other modules where the problem-solving type questions are discussed in order to train students to apply the theories they had learnt in their lectures. However, this method should be restricted to groups of 20-25 students and should be limited to about 3-hours' duration.

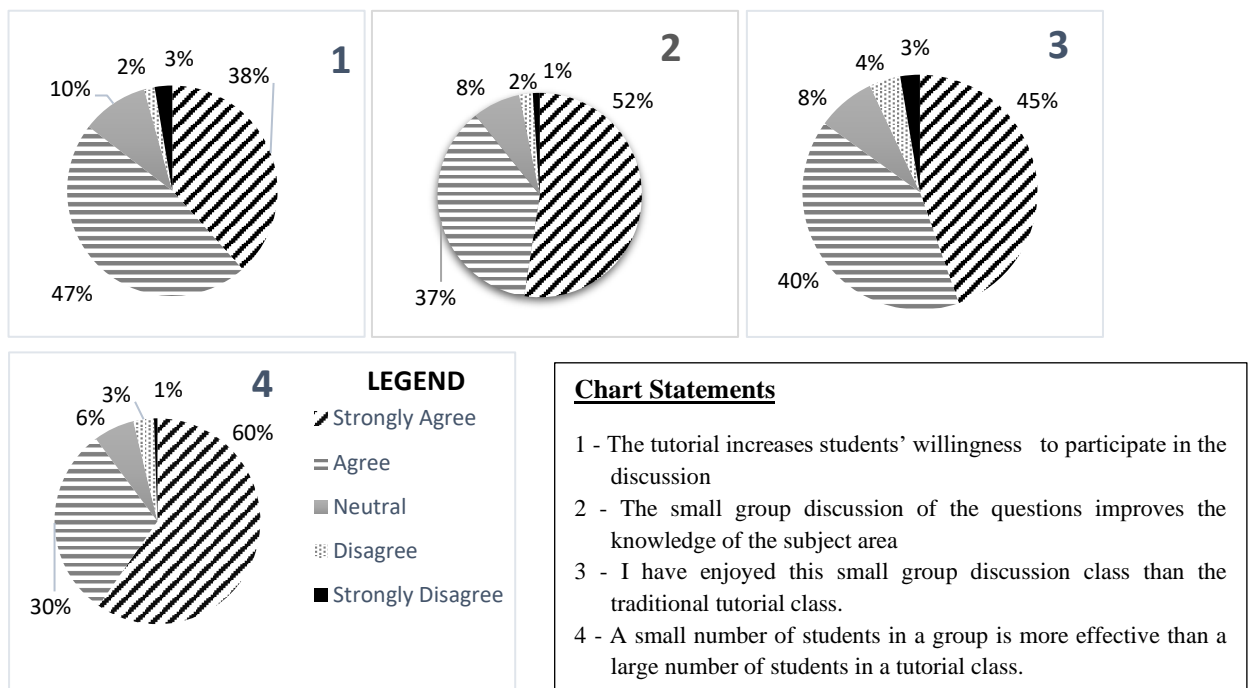The students' increased willingness to participate, their improved knowledge, and their ability to enjoy the class, etc. highly contributed towards deep learning, and such changed delivery methods will contribute towards an engineering technology professional achieving 21st century skills.

5. REFERENCES

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IMPROVING TRANSPARENCY IN SUPPLY CHAIN FOR BETTER BRAND PERFORMANCE (APPAREL INDUSTRY): A STATISTICAL APPROACH

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ABSTRACT: The competitiveness in the economic environment is increasing rapidly. Hence achieving a balance between supply and demand has become a prevailing concern for many businesses. This is further aggravated when there is a lack of transparency in the supply chain both internally and externally. The focus of this study was on improving transparency through an in-depth study of the produced and sold garments of a particular style of a global brand. The data consisted of quantities of produced and sold goods from a leading manufacturing company in Sri Lanka. The study was carried out with a time series analysis, mainly using the Autoregressive Integrated Moving Average (ARIMA) and the Vector Autoregressive (VAR) models. The VAR model fitted was statistically adequate where models were derived for the manufactured and the sold quantities. Apart from that, a mathematical model of percentage reduction was used to identify excess stocks that were stored in the warehouse. This mathematical model would facilitate the reduction of future stock amounts and thereby lead to better financial performance. The final short-term solution for stock reduction given by the stock reduction model will help in reducing stocks that will be stored in the warehouses. It can be used for more holistic queuing modelling in future.

Keywords: Supply Chain, ARIMA, VAR, Apparel

1. INTRODUCTION

The global apparel industry includes clothing textiles, footwear and luxury goods which play a major role in the global economy in terms of investment, trade, employment, and revenue. The apparel industry reached approximately US$ 596,520 million in 2021 (Sri Lanka Export Development Board, 2022). This study focused on one brand of apparel, to improve its brand performance in terms of market conditions, financial performance, and operational performance. The complexity of the fashion industry is a major concern and in the supply chain it is common to see most brands working with many factories at a given time and these factories may operate in different parts of the world. With the current trends, the fashion industry is improving rapidly and is striving for "fashion on demand". When geared towards "speed to market" it is a necessary factor to have complete transparency in the supply chain from the beginning to the end.

Many researchers identified the importance of supply chain transparency and how it could positively impact the performance of a brand internally as well as in terms of how it could positively impact the customers. In order to manage risks more effectively, companies need to take action based on the insights gained by higher data visibility and transparency. The four steps that are identified by the study for forming transparency are: Identifying and prioritizing risks, visualizing risks, using transparency levers to close information gaps and managing and monitoring (Linchi, 2014; Apple Rubber, 2017). As per statistical studies, previous research shows the use of time series models. Therefore, going ahead with hybrid models where soft computing is necessary is widely recommended (Babai, 2013). The main objective of this study is to suggest a mechanism to minimize the production that is been stocked and hence reduce the inventory cost. This will ensure carving out a better business model to achieve operational excellence and thereby reduce the financial impact using statistical model building.

2. METHODOLOGY

The study was carried out under three main sections; descriptive statistics, time series analysis, and the stock percentage reduction method. The Box-Jenkins method of systematic time series modelling was carried out to fit Autoregressive Integrated Moving Average (ARIMA) models. The Augmented Dickey Fuller (ADF) test was carried out to check the unit root nonstationary of the series. Residual plots and Ljung-Box test statistics were used to check model adequacy (NCSS, 2020).

VAR models consisted of the linear function of its past values as well as the past values of the other variables that were carried out for the multivariate time series and the relevant diagnostics tests. Equation (1) shows the multivariate time series which follows a VAR model of order p, VAR (p).

$$z_t = \phi_0 + \sum_{i=1}^{p} \phi_i z_{t-i} + a_t \qquad \text{……………………}(1)$$

ϕ_0 is a k-dimensional constant vector and ϕ_i are $k \times k$ matrices, for $(i > 0)$, $\{a_t\}$ is a sequence of independent and identically distributed random vectors with mean zero and a positive-definite covariance matrix Σ_a (Tsay, 2013).
In the short-term mathematical model, the percentage of stock that remained each month was calculated and the percentage that could be saved was determined.

3. RESULTS AND DISCUSSION

The basic statistics in Table 1 show that there has been a positive increment in the number of products manufactured and sold during five years. It clearly shows that the average sold quantity is lower than the average volume manufactured each year.

Table 1: Average and Standard Deviation of Manufactured and Solid Volumes

Year	Annual Average Quantity		Annual Standard Deviation	
	Manufactured	Sold	Manufactured	Sold
2015	28,518	25,764	14,990	14,147
2016	30,209	26,709	15,749	15,511
2017	30,777	28,274	15,982	16,427
2018	31,256	29,169	19,608	19,035
2019	31,509	30,113	21,678	17,916
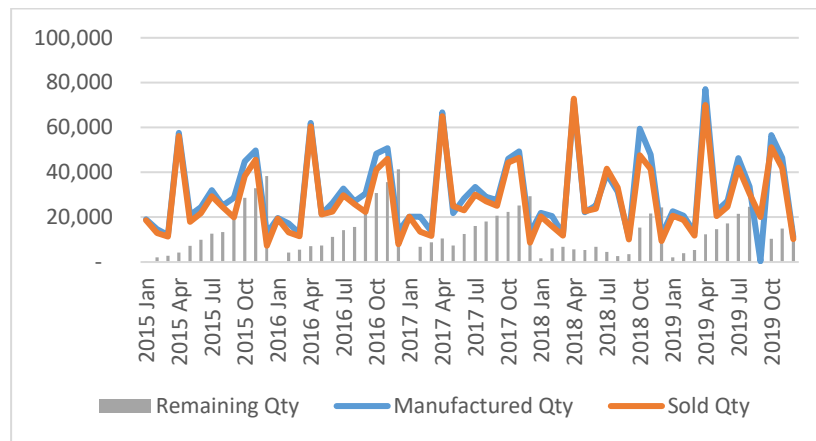
Figure 1: Manufactured, Sold and Remaining Quantities

Figure 1 shows that there is remaining unsold production each month, which is a waste. Hence it would be better if this unsold production can be reduced so that it will improve the working capital. When storage is less utilized, further production costs too can be reduced.

The statistical package R was used to fit time series models. ARIMA (0,0,1) (1,1,0)[12] was built for the produced quantity. The model seemed adequate having white noise residuals with normal distribution, however without a constant variance. For the sales volume, the ARIMA model ARIMA (0, 0, 0)(0,1,1) was developed and the residual analysis showed the same result as in the produced quantity.
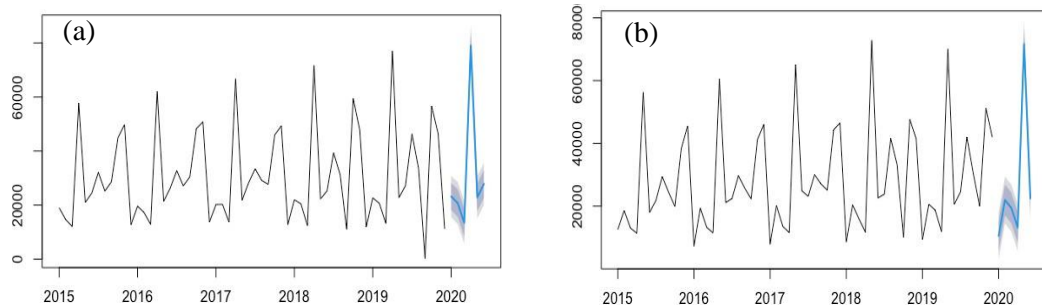
Figure 2(a): The graph for produced quantity, (b). The graph for sold quantity forecast

Figures 2(a). and 2(b). show the estimated figures for the subsequent 6 months including the upper and lower limits. It depicts that the forecast value derived from the model is near the average value of the observed data.

In ARIMA modeling the models were fitted for individual data sets. Therefore, a multivariate time series analysis was carried out combining both the produced and the sold quantity series, and a VAR model was developed. Data were checked and confirmed for stationarity, even without differencing. This creates an ideal situation to carry out the VAR model. Table 2 depicts the model adequacy statistics of the VAR (1) model fitted.

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Table 2: Model diagnostics for manufactured and sold volumes

Statistics	Manufactured volume	Sold volume
Multiple & Adjusted R^2	$R^2 = 0.1363$ Adj. $R^2 = 0.1054$	$R^2 = 0.9457$ Adj. $R^2 = 0.9438$
F-statistic, p-value	$F = 4.418$ $p = 0.0165$	$F = 487.9$ $p < 0.001$
Portmanteau Test	$\chi^2 = 55.45$ $p < 0.001$	
ARCH test	$\chi^2 = 111.81$ $p = 0.0382$	
JaJarque-Bera test	$\chi^2 = 55.45$ $p = 0.003$	

The R^2 s adjusted value for the manufactured quantity equation was very low (10%) while it was 95.16% for the sold equation. However, the F statistic is very high with p-value < alpha (0.05) indicating adequate models. Model diagnostic tests show that the residuals are auto-correlated and non-normal with no heteroscedasticity indicating further improvements. However, the use of these models is questionable for longer terms as further analysis would be required to test out these models. This led to coming up with a mathematical calculation for reducing wastage by producing lesser goods after evaluating the stock in the preceding years.

Table 3 shows that if the lowest remaining quantity was reduced from the first month of production, then the remaining capacity from each month could be reduced. This exercise was carried out for each year to understand the optimal percentage reduction that could be utilized for the forecast

Table 3: Remaining Quantity Calculation, Month-wise

Yr.-Month	Previous method (Without a Mathematical Model)			New Method (With a Mathematical Model)				
	A Manuf.	B Sold	C =A-B Rem.	D =New_ Manuf.	E=B Sold	F=D+P-E New_Re.	G=C-F Wastage	H = (G/C) ×100% Wastage Red.
2015 Dec						31955		
2016 Jan	19612	7274	28863	(19612-2677*0.7) =1218	7274	(1218-7274+31955*0.5) =9922	18941	66%
2016 Feb	17225	19382	26706	17225	19382	7765	18941	71%
2016 Mar	12835	13264	26277	12835	13264	7336	18941	72%
2016 Apr	62024	11498	76803	62024	11498	57862	18941	25%
2016 May	21390	60482	37711	21390	60482	18770	18941	50%
2016 Jun	26312	21140	42883	26312	21140	23942	18941	44%
2016 Jul	32774	22441	53216	32774	22441	34275	18941	36%
2016 Aug	27090	29712	50594	27090	29712	31653	18941	37%

P – Previous months' remaining quantity

* Please note considering material deprecation in the apparel industry to keep a buffer. When bringing forward finished goods from one year to the next, considered only 50% of the remaining goods.

** Also, note considering a buffer, for the calculation of the newly manufactured quantity. Reduced only 70% of the remaining quantity from the first month.

Table 3 shows that the reduction of wastage varies from 25% to 72%. Hence this calculation was carried out for all the years to understand the optimal reduction percentage with lower and upper bounds. This could be further improved to analyze data every quarter and thereby reduce the stock quantity in each quarter.

4. CONCLUSION

Based on the study, a short-term mathematical solution for reducing stock quantity will lead to operational and financial improvements in the company. Operations wise the wastage would be mitigated because production will be done based on the requirement only. When operations are improved, it directly impacts the financial gain. This will help to improve the working capital of the organization as well as day-to-day financial gain. For future study, data points could be further collected to come up with an adequate time series modelling. Also, for model building, there could be various other factors that may affect sales or production. Hence it would be appropriate to incorporate them into the model as well. Especially when coming up with multivariate time series, these components could be included in the time series and it would give a better model which speaks the data better. For future forecasting models, it is necessary to come up with a hybrid model with AI?? and statistical tools.

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MACRO TRANSFORMATION THROUGH MICRO CHANGES: PROMOTING ACTIVE LEARNING VIA LECTURE BREAKS

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ABSTRACT: It was observed that the allocated two-hour period for the lectures cannot be used effectively as it is difficult to retain students' attention throughout the lecture, especially in online mode. To overcome this issue, the lecture break technique was implemented during online lectures. The main objective of this study was to enhance students' active participation in lectures and their performance at assessments. To promote students' active participation, three lecture breaks were implemented in a two-hour lecture after every twenty minutes. One course module which covers both theoretical and practical applications of mathematical concepts was selected for the study. The first three weeks of the lecture series were conducted as usual at a stretch to cover up all the content as planned. This was followed by students completing an online quiz via Moodle. After receiving the marks for the first quiz, the lecture break technique was implemented, and students participated in another quiz after three weeks of implementation of lecture breaks. The paired t-test was used to check whether there is a significant difference between students' average marks before and after the implementation of lecture breaks. The study reveals that the implementation of lecture breaks results in a positive impact on students' marks and it was observed that students' active participation had improved during online lectures.

Keywords: Lecture Breaks, Online Teaching, Active Learning

1. INTRODUCTION

Improving knowledge of different online platforms such as Zoom, Microsoft Teams, Google Meetings, Moodle, and other platforms, within a very short period of time became a challenge for both students and teachers in different educational settings in the world with the outbreak of the COVID-19 pandemic. Similarly, the onsite teaching-learning process was transformed into an online mode in the education system of Sri Lankan Universities and Higher Education Institutes. Getting familiar with the features of online platforms, upgrading the knowledge of new technologies, and adapting to the virtual platform were a few quick steps initiated by academics during this period of time. Ensuring the necessity of maintaining a close intervention in the teaching and learning process, it was observed that there was less active participation on the part of the students at online lectures.

Students' attention dwindles after fifteen minutes of lecture time (Gibbs & Habeshaw, 1989). According to Gibbs and Habeshaw, after fifteen minutes, students' physiological level of arousal will lower and their note-taking will be less accurate compared to the first fifteen minutes. There is ample evidence to show that learners lose attention, especially when listening to lectures or passively reading a textbook (Gibbs & Habeshaw, 1989); (Cicekci & Sadik, 2019); (Bradbury, 2016); (Hlas, Neyers , & Molitor, 2017). Active engagement of students in their learning process enhances students' learning and their performance in evaluations (Rao & DiCarlo, 2001). Bonwell (1991) mentions that it is more convenient for both the lecturer and the students to have lecture breaks in the middle of the lecture and to assign some activities like think-pair-share, short writes, and formative ungraded quizzes. He also mentions that lecture breaks allow students to deal with the physiological and psychological responses that keep them active for a longer period resulting in increasing their effective focus. Hence, this study focuses on retaining students' attention by introducing lecture breaks approximately

every twenty minutes during a lecture to promote students' active learning during online lectures. The progress of the students was evaluated by two assessments.

2. METHODOLOGY

This study was implemented for Semester III students (N=96) who follow the module, Computational Mathematics and Advanced Statistics at the Institute of Technology University of Moratuwa in 2021.

The first three weeks of the lecture series were conducted at a stretch with PowerPoint presentations and handouts. After three weeks, the students were asked to complete a random quiz based on the content covered in the previous three weeks. The quiz was administered via online mode on the Moodle platform. The lecture breaks were introduced from the fourth week onwards. Before implementation, the students were informed about the lecture breaks and the activities to be done during the lecture breaks. Three lecture breaks were introduced for a two-hour lecture with a maximum duration of 15 minutes per break. The first lecture break was given after the first twenty minutes and the second break was given 20 minutes after the first break. During the lecture breaks, a few discussion topics and simple questions were given to the students to complete individually or via Zoom breakout rooms. After completing three weeks of lectures with lecture breaks, another random quiz was assigned to the students via Moodle platform. The marks of the quizzes, before and after giving the lecture breaks were statistically analyzed using the 'paired t-test'. Subsequently, the outcomes were observed through self-observations by the lecturer and students' feedback. The students' feedback was collected through a Google form at the end of the 6th week of the lecture series.

3. RESULTS AND DISCUSSION

It was observed that students' behavior regarding their active participation in the lesson had changed after implementing the lecture breaks. The students were previously reluctant to answer questions during lectures, but after the implementation of the lecture breaks, students seemed to be more energetic after the breaks. Also, when monitored, a change was observed in students' behavior in answering questions during lectures. The number of students who answered a particular question was recorded and the average change in students' responses over time is shown below in Figure 1.
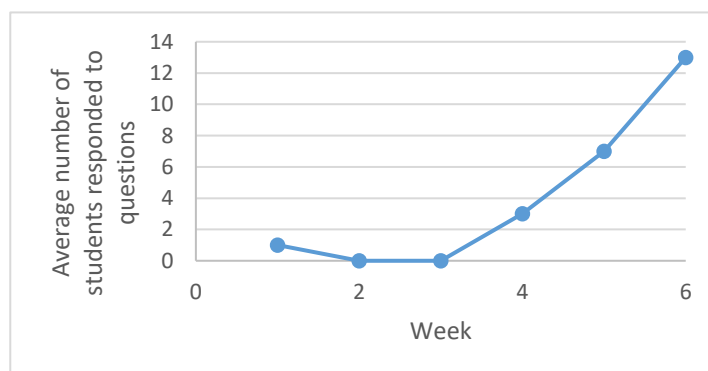

Figure 2: Change in students' participation in discussion sessions by week

According to Figure 1, it can be stated that the responses of the students increased during the discussion sessions. Furthermore, it was observed that students paid more attention to the lecture after the lecture breaks and the Zoom breakout sessions which provided them with the

opportunity to clarify their issues or doubts on the subject matter before going to the next step of the lecture.

In addition to self-observations by the lecturer, students were also asked to give their feedback by answering the questions given in Table 1. Thirty-three students gave their feedback and Table 1 below shows students' perceptions regarding the lecture breaks and their experiences during the lecture.

Table 1: Student feedback on lecture breaks

Statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Lecture breaks are useful to get rid of fatigue in online lectures	2 (6.1%)	0 (0%)	2 (6.1%)	17 (51.5%)	12 (36.4%)
I feel refreshed after the lecture breaks	2 (6.1%)	0 (0%)	3 (9.1%)	19 (57.6%)	9 (27.3%)
Activities done during the lecture breaks helped to enhance teamwork	2 (6.3%)	0 (0%)	3 (9.4%)	19 (59.4%)	8 (25%)
Activities given during lecture breaks enhanced my learning process	2 (6.1%)	0 (0%)	3 (9.1%)	20 (60.6%)	8 (24.2%)
Do you prefer to have lecture breaks in future sessions?	Yes 28 (87.5%)		No 0 (0%)		May be 4 (12.5%)

Overall, the majority of the students agreed that the lecture breaks had enhanced their learning process, and teamwork skills. Similarly, they were of the view that lecture breaks had a positive impact on lessening the fatigue caused by online learning. Approximately 88% of the students preferred to have lecture breaks in their future sessions.

To evaluate the effectiveness of lecture breaks, the marks obtained by the students for the quizzes were analyzed. Quiz 1 was given before implementing the lecture breaks and Quiz 2 was given after implementing the lecture breaks. The following chart shows the distribution of marks before and after the lecture breaks were implemented.
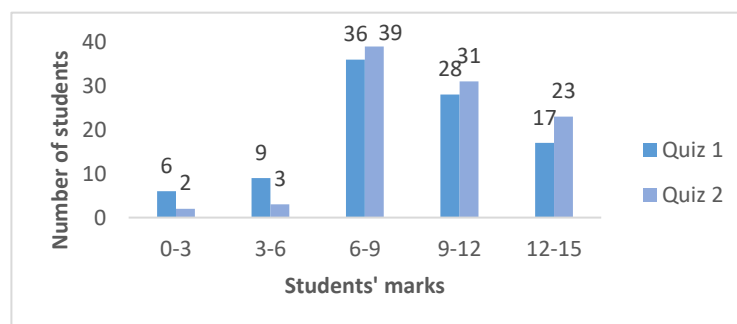

Figure 2: Students' marks distribution

It can be clearly observed that the students scored higher marks in their second quiz than in the first quiz. Also, the number of students who scored more than 9 marks out of 15 has

increased. Therefore, there is an increment in students' marks for their assessments after the implementation of lecture breaks.

Then the paired t-test was performed to test the following hypothesis

$$H_0: \mu_A = \mu_B \quad \text{vs} \quad H_0: \mu_A \geq \mu_B$$

where, μ_A indicates the average marks after the implementation of lecture breaks and μ_B the average marks before the implementation of lecture breaks.

Estimation for Paired Difference

Mean	StDev	SE Mean	95% Lower Bound for μ_difference
1.4896	0.8078	0.0824	1.3526

μ_difference: mean of (After - Before)

Test

Null hypothesis	H₀: μ_difference = 0
Alternative hypothesis	H₁: μ_difference > 0

T-Value	P-Value
18.07	0.000

Figure 3: Paired t-test to verify the difference between student marks before and after the implementation

Since the p-value (0.000) of the paired t-test is less than the significance level of 0.05, the null hypothesis is rejected under the 95% significance level. Therefore, it can be concluded that the mean marks of the students after the implementation of lecture breaks are significantly larger than the mean marks of students before the implementation of lecture breaks.

4. CONCLUSION

The results of the study indicate that lecture breaks can be utilized to enhance the effectiveness of lectures on online platforms. Statistical tests revealed that there is a significant difference between the average students' marks before and after the implementation of lecture breaks at a 0.05 level of significance. The mean difference of marks is approximately 1.5 with ± 0.8078 standard error. Therefore, it can be concluded that there is an increment in the average marks of students after the implementation of lecture breaks. Furthermore, allowing students to engage in activities during the lecture breaks enhances student active participation since there is an increment in the average number of students who actively participated in discussion sessions.

Implementation of lecture breaks was successful since the majority of the students (87.5%) preferred to have lecture breaks in their future sessions. Furthermore, it was observed that students were actively taking down lecture notes while listening to the lectures and completing the assigned activities rather than trying to depend on Zoom recordings. Hence, it is evident that this approach can be applied to other online course units to keep students' continuous attention and enhance their learning process.

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IMPACTS OF THE USE OF ONLINE METHODS ON THE TEACHING & LEARNING PROCESS OF HIGHER EDUCATION DURING THE COVID-19 PANDEMIC: A CASE STUDY IN THE FIELD OF ENGINEERING TECHNOLOGY

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ABSTRACT: The use of online methods ensured an uninterrupted teaching & learning process during the Covid-19 pandemic. Despite unequal access to online learning among Sri Lankan students in higher education, the average acceptance of online teaching and assessment methods was found to be remarkably high. This study was conducted to assess the impact of using online methods in teaching and assessment processes on student learning using a comparative study of physical classroom learning and online learning of a specific engineering technology module. The study reveals that after online learning, nearly 98% of students were successful in the final examination, which was also conducted online, despite a noticeable reduction in high performers. The study also reveals that students' mindset prefers the traditional classroom method of delivering lectures.

Keywords: Covid-19 Pandemic, Online Education, Online Assessments, Student Performance

1. INTRODUCTION

Online education has been used by educators mostly in developed countries before the Covid-19 pandemic to facilitate learning for large groups through distance education. One of the earliest online programs in tertiary education in Sri Lanka was the eBIT program which was the online version of the Bachelor of Information Technology (BIT) program. This program was conducted using a new virtual learning environment (VLE) based on Moodle LMS (Mozelius et al., 2011).

The sudden closure of education institutes with the onset of the pandemic forced educators worldwide as well as in Sri Lanka to change over from traditional physical classroom learning to online learning within a short period of time. This transition compelled educators to employ various technologies such as learning management systems (LMS), live-video communication platforms, open online courses, and mobile applications in the delivery of lectures and assessments.

As per the surveys conducted by university administrators for academics, and students in June 2020, almost all academics and nearly 90% of students in the Sri Lankan higher education system had participated in online education despite their lack of experience and training (Hayashi et al., 2020). State universities popularly used LEARN Zoom for online teaching with WhatsApp also being used increasingly for education & communication. Lecturers used PowerPoint to deliver lecture material and recorded lectures were considered a positive solution for the lack of internet coverage (Haththotuwa, Rupasinghe, 2021). Due to the poor internet coverage in rural areas and the non-availability of physical resources, the average acceptance of online learning methods was found to be 70.7% among Sri Lankan undergraduates (Subashini et al., 2022).

1.1. BACKGROUND TO THE STUDY

The Institute of Technology, University of Moratuwa (ITUM) conducts the National Diploma in Technology (NDT) program covering 06 semesters within a time period of 03 years. Civil Engineering Technology, which is one of the 10 disciplines conducted by ITUM, is the program considered in this study. The test module considered in the study, Soil Mechanics and Geology, is conducted in the third semester. This module consists of lectures, tutorials, and laboratory sessions.

In the pre-Covid-19 era, a 02-hour lecture was delivered to the whole group of 120 students every week in a classroom environment using PowerPoint slides. A printed note was given to students at the start of the lecture. This group was divided into two for a 02-hour tutorial class which was conducted every other week by two tutors. Another sub-division was done for the laboratory work and one-quarter of the group was assigned to a practical class. The laboratory classes were conducted in small groups assisted by an instructor and a printed instruction sheet. Coursework had to be written as a take-home assignment.

The onset of the Covid-19 pandemic compelled the use of online methods in different modes for the uninterrupted delivery of the module. Hence the lecture was converted into a narrated PowerPoint presentation and uploaded to the Moodle LMS platform at the scheduled time of the lecture. With the subsidence of the intensity of the Covid-19 outbreak, 200 students were allowed to participate in tutorial and laboratory classes physically for a limited time following health guidelines. The tutorial classes were conducted more as revision classes considering the time gap between the delivery of lectures and the tutorial classes. At a scheduled time, half the group participated in these classes for 03 hours and were assisted by two tutors. The laboratory classes were conducted considering both the time limitation and health guidelines. Hence a prepared video presentation was used to demonstrate the apparatus and the procedure used for each experiment. Then the experimental data was given to small groups of students, and they were asked to do the calculations assisted by an instructor. The coursework had to be submitted as an in-class assignment. Also, as per the author's proposal made after analyzing the data regarding students' performance in laboratory classes and the relevant assessment during the previous year, a marking rubric was introduced and explained to the students at the beginning of the class.

The assessments for the test module consist of continuous assessments (CAs) and a final examination (FE). The CAs carried 30% of the total marks and the FE carried 70% of the total marks. In the pre-Covid-19 period, the final examination was conducted physically as a proctored exam of 2 hours duration. During the Covid-19 pandemic, the exam was conducted as an unproctored online open book, exam.

Table 1.1: Details of the FE in Pre-Covid & Post-Covid periods

Period	Pre - Covid	Post-Covid
Time & Marks allocation	02 hours, 70% of the total	02 hours, 70% of the total
Mode of conduct	Physical, Proctored	Online, unproctored, open book

Table 1.2: Details of the CAs in Pre – Covid & Post-Covid periods

Period	Pre- Covid			Post-Covid	
CA	CA1	CA2	CA3	CA2	CA1
Marks allocation	10	10	10	20	10
Mode of conduct	Physical, Unproctored	Physical, proctored	Physical, proctored	Physical, Unproctored	Physical, proctored
Description & time allocation	Take home lab. report	In class test 0.5 hours	In class test 0.5 hours	In-class lab. report	In class test 0.5 hours

At the completion of the module in the Post-Covid period, feedback from a group of 100 students was collected using a questionnaire aiming at evaluating the quality, effectiveness, and future use of online methods to be adopted.

2. METHODOLOGY

This study was conducted to assess the impact of using online methods in the teaching and assessment processes on student learning. Online methods were used in various forms; lectures and assignments on the LMS Moodle platform, videos, online quizzes, and online examinations during the Covid-19 pandemic to maintain an uninterrupted teaching & learning process of the test module. In this study, students learning was measured by their performance at various assessments. The impact of the changeover to the online mode was measured by comparing the pre-Covid-19 pandemic teaching & learning environment (2019) with the Covid-19 pandemic environment (2020) using student performance at different assessments.

As the first step, the marks obtained by students for assessments conducted in the test module in the year 2019 were compared with marks obtained for assessments conducted during the year 2020. Secondly, the student feedback collected to determine the future use of technology to be adopted in the delivery and assessment processes was analyzed.

3. RESULTS AND DISCUSSION

The comparison of students' performance in CAs and the FE in the years 2019 and 2020 is given in Figure 3.1.
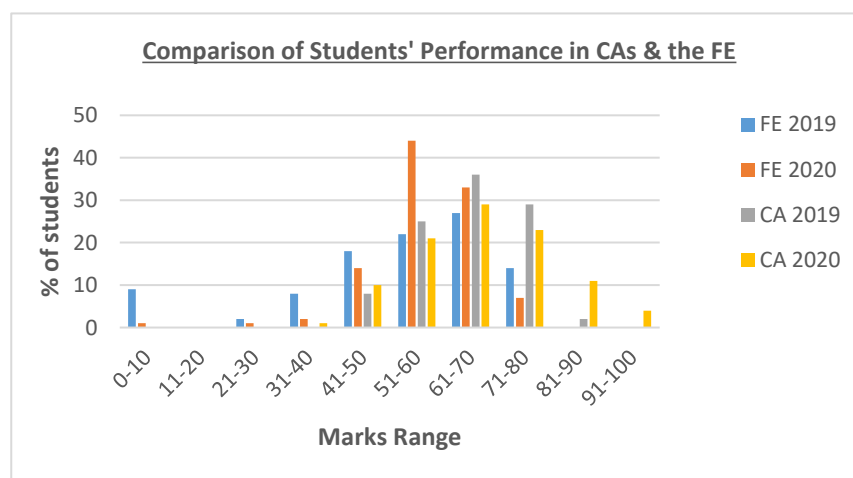

Figure. 3.1: Comparison of Student Performance in CAs & the FE – 2019 & 2020

In the year 2020, there was an unusual increase of 44% of students reaching the marks range of 51-60 in the FE. A drop in the number of high performers was indicated at the FE in the year 2020 compared to the year 2019. (Only 7% of students reached the marks range of 71-80 compared to 15% in the earlier year) In the year 2020, more than 15% of students reached the marks range of 81-100 in CAs compared to only 2% reaching the same in 2019.

The comparison of students' performance in laboratory assessments in the years 2019 and 2020 is given in Figure 3.2.

Comparison of Students' Performance in the laboratory Assessment (LA)

Legend: ■ 2019 CA1 ■ 2019 CA2 ■ 2020 CA2

X-axis: Marks Obtained (0–10)
Y-axis: % of Students
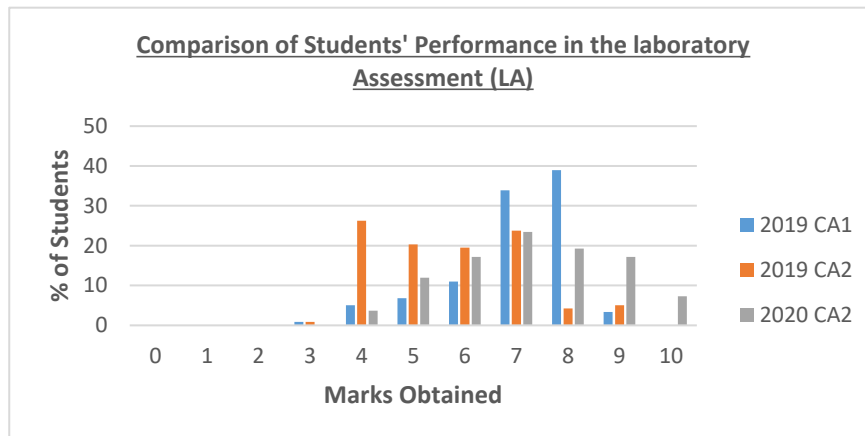
Figure. 3.2: Comparison of Students' Performance in LAs – 2019 & 2020

Student performance has improved in the year 2020 with 43% of students obtaining marks higher than 8 out of 10. In the year 2020, there was an unusual increase of 44% of students reaching the marks range of 51-60 in the FE. A drop in high performers is indicated at the FE in the year 2020 compared to the year 2019. (Only 7% of students reached the marks range of 71-80 compared to 15% in the earlier year) In the year 2020, more than 15% of students reached the marks range of 81-100 in CAs compared to only 2% reaching the same in 2019.

The student feedback collected to determine the future use of technology to be adopted in the delivery of lectures is given in Figure 3.3

Feedback on Future Use of Technology

Legend: ■ No ■ Yes

X-axis: Lecture, Lab Class
Y-axis: % of students (0%–100%)
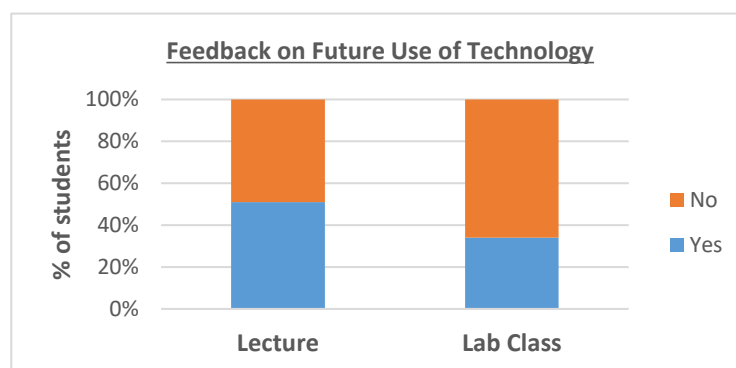
Figure. 3.3: Students' Feedback on Future Use of Technology

Results indicate that only 50% of the students prefer the continuation of online teaching and 65% of students prefer to gain hands-on skills in the laboratory.

4. CONCLUSION

A majority of students seem to prefer the traditional classroom delivery of lectures and gaining hands-on skills in the laboratory. Online learning and online unproctored open book assessments have resulted in nearly 98% of students being successful in the FE although there is a noticeable reduction in high performers in the FE. After introducing video technology and the marking rubric, 43% of students scored more than 80 marks at laboratory assessments. The reduction of high performers and the unusual increase in average performers in the online unproctored open book final examination may be due to; delivery of an offline syllabus in the online mode, the sudden transition from traditional to online teaching and the majority of students being surface learners.

5. FUTURE WORK

It is suggested to compare the performance of a student group who have learned online but assessed at a physical proctored examination.

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SECOND LANGUAGE LEARNING STRATEGIES EMPLOYED BY TERTIARY LEVEL STUDENTS: WITH SPECIAL REFERENCE TO STUDENTS OF THE INSTITUTE OF TECHNOLOGY, UNIVERSITY OF MORATUWA

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ABSTRACT: Among the extensive variety of factors that influence the process of Second Language Acquisition, Language Learning Strategies have gained a vital research interest in different contexts in the world. A wide array of Language Learning Strategies is employed by tertiary level students in the Sri Lankan context to achieve their second language goals. The present study explores the Language Learning Strategies used by students of the Institute of Technology, University of Moratuwa. Even though all the students follow the compulsory English modules in the first two semesters, there can be observed variations in their second language proficiency levels. This showcases the necessity of investigating the types of Language Learning Strategies used by them. The Strategy Inventory of Language Learning was administered among the sample (N = 68) of Semester III students to collect data. Then, the data were analyzed through descriptive statistics via Social Package for the Social Sciences. The results of the study revealed that the students are Medium strategy users as the overall mean for the frequency of Language Learning Strategies was 3.34. Also, Metacognitive strategies are the most frequently used strategy type. The students can be identified as medium strategy users of Compensation, Cognitive, Social, Memory, and Affective respectively. On the contrary Affective, strategies are reported to be the least preferred type of strategy. The results of the present study indicate that the students need to employ Language Learning Strategies more frequently to achieve their second language targets. Similarly, these findings are beneficial for language teaching as effective strategies can be introduced to the students to improve their language skills. Further research is needed to be conducted to explore whether there is a significant relationship between Language Learning Strategies and proficiency level and academic majors.

Keywords: Language Learning Strategies, Proficiency Level

1. INTRODUCTION

The process of the second language (L2) acquisition exposes the learners to a new culture by enabling them to experience the world from a new point of view. According to Lightbown and Spada (2006), this process can be viewed from different perspectives such as Behaviourism, Innatism, Cognitivism, and Social constructivism. Moreover, there are individual learner characteristics that impact the second language acquisition process: intelligence, language learning aptitude, learning styles, personality, motivation, attitudes, age, teaching methodology, and learner beliefs. The use of Language Learning Strategies (LLS) that has gained a large research interest in the field of L2 learning underpins all the above aspects in different ways. LLS refer to special techniques or strategies used by learners to achieve their language learning targets. According to Oxford (1990), LLS are specific actions, techniques, or behaviors implemented by learners to improve their language skills. The present study focused on the LLS employed by the students at ITUM. They are required to complete compulsory English modules in the first two academic semesters that include all four language skills, grammar, and vocabulary by exposing them to different types of language learning experiences. However, it is evident that some students successfully achieve language proficiency while the rest show a less achievement level during the semesters. So, it is necessary to investigate the LLS employed by the students.

2. METHODOLOGY

The mixed method design was employed in the present study as it explores both quantitative data and qualitative data. 68 students from semester III were chosen as the sample of the study under the stratified sampling method. The target population of the study was approximately 800 students and the sample included students from three Engineering Technology divisions. The Strategy Inventory for Language Learning (SILL) Oxford (1990) which is widely used by researchers was used as the major data collection instrument. It was a fifty-item Likert scale ranging from 1-5. The five responses indicated how true each statement was for the subjects of the sample. The students were given 15 minutes to complete and submit the Google form. Version 7.0 of SILL contains 50 items and is divided into six categories as follows. Table 1 briefs the content embedded in the questionnaire.

Table 1. Types of Strategies According to the SILL Questionnaire

Strategy	Definition
Memory (1-9) (Direct Strategy)	- related to mental processing of language
Cognitive (10-23) (Direct Strategy)	-related to manipulating the language material in direct ways such as summarizing, reasoning, analyzing and outlining
Compensation (24-29) (Direct Strategy)	-enable learners to use language either in speaking or in writing fluently and effectively despite knowledge gaps
Metacognitive (30-38) (Indirect Strategy)	-enable learners to control their own cognition. This includes identifying one's own learning style preferences and needs, gathering.
Affective (39-44) (Indirect Strategy)	- help the learners to manage their emotions, motivation and also attitudes which influence learning.
Social (45-50) (Indirect Strategy)	- enhance language learning through interaction with other learners

The descriptive statistics (mean, standard deviation, mode) obtained via the Statistical Package for Social Sciences (SPSS) were used to analyze the data. Then the mean values were discussed according to the following ranges as interpreted in the SILL. If the mean value of a component of SILL is more than 3.5 (3. 5 < Mean) the sample is identified as High strategy users of that particular strategy type. And also, if the mean value is between 2.4 and 3.5 (2. 4 < Mean <3. 5) the sample is identified as Medium strategy users of that strategy type. Next, the sample is identified as Low strategy users of a particular strategy type, if the mean value is less than 2.4 (Mean < 2. 4).

3. RESULTS AND DISCUSSION

Table 2 elaborates on the responses of 68 students for the strategy inventory in relation to Mean and Standard Deviation. They employ Metacognitive, Compensation, Cognitive, Social, Memory, and Affective strategies respectively. As the overall mean value is 3.34, they can be identified as Medium Memory strategy users. However, the mean value of the most frequently used strategy, Metacognitive is 3.69 which can be identified as a Highly used strategy. On the contrary, the Affective strategy type is the least frequently used strategy type which has obtained 2.47 as the mean value. This implies these learners rarely use Affective strategies to improve their second language skills. Moreover, the mean values for Cognitive, Social, and Compensation strategies used by the learners indicate a slight similarity in the frequencies by

reporting them as Medium strategy usage. Next, they employ Memory strategies with less frequency reporting a mean value of 2.74.

Table 2: Frequency of Language Learning Strategies used by Students

Strategy	Mean	SD	Rank	Strategy Use
Metacognitive	3.69	0.97	1	High
Compensation	3.31	0.99	2	Medium
Cognitive	3.28	0.96	3	Medium
Social	3.28	0.98	4	Medium
Memory	2.74	1.10	5	Medium
Affective	2.47	1.12	6	Medium
Overall Mean	3.335			Medium

Figure 1 provides a graphical representation of the results obtained which provides a comprehensible comparison regarding the use of strategies. Each column reports the average (arithmetic mean) of each item under the major strategy types.
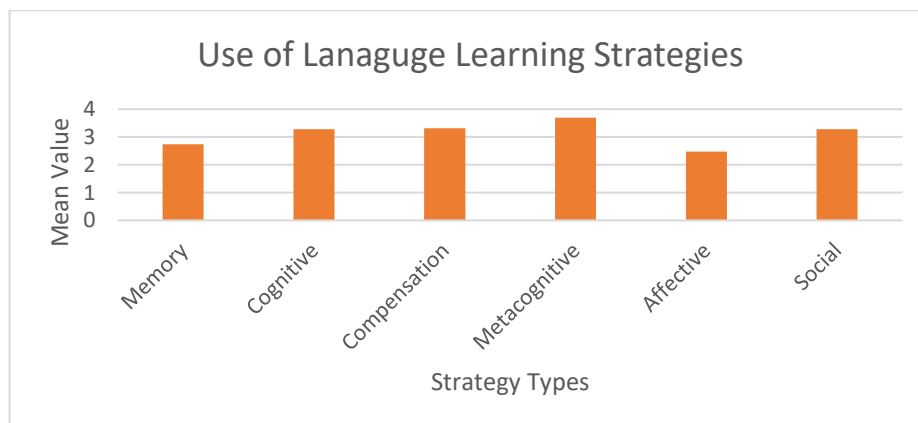
Figure 1: Graphical Representation of Strategy Usage

The results of this study can be more explained in light of the findings of some literature in the field. The results of this study are compatible with the study conducted by Kehing et.al (2021) that investigated the Metacognitive strategies as the most used strategy while the Social strategies as the least used type of Engineering Diploma students in Indonesia. Similarly, Patil and Karekatti (2012) report that Engineering students in Maharashtra, India indicate a huge likelihood to employ Metacognitive, Cognitive Compensation, and Social strategies while not employing memory and affective strategies at an average range. The research findings of Dhanapala (2007) also indicate that Sri Lankan learners are at the higher end of the medium use range while Japanese students are at the lower end of the medium use range in her study titled "Focus on Language Learning strategies of advanced learners in Japan and Sri Lanka". Also, the Metacognitive strategies have been most frequently used by Sri Lankans while the Japanese learners use Compensation strategies most frequently which is also investigated in

the present study. The research study conducted by Rathnayake (2017) on Metacognitive strategy usage of students at the University of Moratuwa revealed that the learners practiced different LLS related to Metacognitive strategies.

4. CONCLUSION

The students at ITUM employ a wide array of LLS to improve their L2 skills. Overall, they are medium strategy users while reporting high usage only for the Metacognitive strategies. This implies that the students have a high concern for planning and monitoring their L2 acquisition process as it is a required skill for them to survive in their academic as well as professional life. However, the learners need to focus on other effective LLS included in the inventory that are embedded in English course modules as well as in the immediate environment.

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A NARRATIVE REVIEW OF THE SIGNIFICANCE OF HUMANITIES MODULES FOR ENGINEERING AND TECHNOLOGICAL EDUCATION

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ABSTRACT: The main objective of this study was to identify the significance of humanities for engineering education. This research was conducted on a narrative review method. Forty research articles significant to humanities for engineering and technological education were collected and screened for the number of citations, journal indexes, etc. Out of that, 12 articles were selected and analyzed. However, the authors could not find any narrative review or systematic review on the subject from Sri Lanka. In this study, three main categories were identified for review: the significance of teaching humanities, the relevance, and importance of humanities according to students' perceptions, and the barriers to incorporating humanities in engineering and technology disciplines. The study reveals that humanities improve the communication skills, interpersonal skills, emotional intelligence, and critical thinking of students. The review of students' perceptions reveals that students believe most engineers are limited in their careers not because they lack technical knowledge, but because of their inability to reason verbally, communicate their ideas to others, and give leadership. Also, several studies emphasized the barriers to implementing humanities modules in the curricula of engineering disciplines as resistance to change, external influences on the curricula, lack of guidelines, and misconceptions about humanities. The study found that there is a considerable amount of demand for introducing the humanities modules in engineering education in order to promote the all-around development of engineering professionals.

Keywords: Humanities, Engineering, Curriculum, Education

1. INTRODUCTION

Humanities have been included as a module in different fields of study in many universities worldwide. In value-based education, this is done with a view of enhancing the personal, and professional growth of students through social skills, personality development, independent thinking, etc. However, in Sri Lanka, the inclusion of the humanities modules in different disciplines/programs and the number of students taking such modules have not increased over the years even though there has been an upward trend globally. Hence, the main objective of this study is to show the significance and relevance of humanities modules for engineering and technological education in Sri Lanka. In spite of various humanities modules being included in university courses, there is no evidence of any narrative reviews being conducted on the relevance of humanities in engineering and technology disciplines in Sri Lankan universities.

2. METHODOLOGY

This study was conducted as a narrative review, based on publications related to the importance of including Humanities modules in higher education. Initially, forty research papers were found, including one from Sri Lanka from secondary data sources such as journals, conference proceedings, and Google scholar websites. Based on the number of citations, and the journal indexes, twelve research publications were selected. According to the objectives of the selected research publications, the following three categories were identified: (i) the significance of teaching humanities (ii) the relevance and importance of humanities according to students' perceptions, and (iii) barriers to the incorporation of humanities modules in engineering and technology disciplines. This review was conducted under these three categories.

3. RESULTS AND DISCUSSION

The research papers pertaining to the three major categories that were reviewed are discussed further, along with the authors' views.

(i) The significance of teaching humanities

Chanchal Dey (2021) studied the possibilities and relevance of Humanities and Social Sciences (HSS) in the field of engineering education. His findings show that modern engineers are required to work in multifaceted environments and cross-functional teams. The researcher claimed that this requirement can be successfully fulfilled by the humanities modules. Humanities enhance the exposure of students' minds to innovative ideas from outside the scientific domain. The engineering curricula need to be updated to stay relevant to the changing scenarios and must focus on developing skills other than technical knowledge. Supporting these divergent views mentioned by Chanchal Dey, Hudson (1975) states that students with humanities backgrounds possess highly developed divergent thinking skills. Razumnikova (2013) also supports this idea by suggesting that divergent thinking helps in the generation of a large number of alternative, creative and innovative responses in the quest for finding solutions. In addition, Davis, et al., (2021) are of the view that humanities encourage the analysis and critical thinking of all aspects of human experiences, the world, and their interconnections.

Another important aspect of the humanities modules is the development of soft skills. In Canada, elective courses from the humanities and social sciences are featured in the engineering curricula to encourage students to develop their soft skills such as social competency, ethical awareness, and the ability to communicate, both orally and in writing (Donald, et al., 2017).

Moreover, as the Israeli researcher Ben'haim (1999) states, learning humanities is also beneficial, as technology development is a part of the cultural development of ideas, attitudes, and activities because engineers are influenced by the cultural and intellectual context within which they work.

The acceptance of these benefits is reflected by what is opined in Grinter's and Heitmann's ideas. Grinter (1995) proposed that humanities and social science subjects should have a share of 30% in the engineering curricula in the United States, while Heitmann (1995) was of the opinion that allotting a 20% share to HSS was sufficient in the case of European engineering education. The engineering faculties of the University of Moratuwa, the University of Ruhuna, the University of Sri Jayewardenepura, the Ocean University, and the Institute of Technology University of Moratuwa have included humanities in their engineering curricula. The authors of this paper agree with the benefits of HSS for engineering students and suggest that it should be a compulsory Grade Point Average (GPA) module in the initial stages of their engineering education.

(ii) The relevance and importance of humanities according to students' perceptions

As students' perceptions of humanities affect their selection of HSS subjects, three research studies were reviewed regarding students' perceptions of the inclusion of humanities modules. A study conducted by Bandara, et.al (2021) found that around 69% of students following engineering technology courses at the Institute of Technology University of Moratuwa preferred to follow both Aesthetic and Sports studies modules as they felt that studying

humanities modules would help them to improve their personal skills and reduce their stress levels. The present study also confirms that students perceive the humanities modules to help in creating balanced personalities who can better engage in the industry and with society.

Even though students' beliefs are such, O'Neal (1990) claims that students select humanities subjects without sound background knowledge. In this study, students claimed their selections to be sensible decisions because humanities provide the intellectual environment for them to deal with the questions, "Who am I and what should I be?", and "Who are we and what should we be?". Furthermore, O'Neal mentions that engineers are limited in their careers not by a lack of technical knowledge, but by their inability to communicate effectively and furnish leadership. These skills seem to be better developed in the humanities than in engineering courses.

A study on leadership by Howard (1986) shows that, among people of comparable intelligence, those with an education in the humanities were judged to possess stronger leadership qualities than those educated as engineers.

Based on the above-mentioned findings on students' perceptions, the authors suggest that the students who follow humanities subjects should be given the opportunity to choose from a selection of subjects in creative arts. This would give students a better opportunity to choose an area where they can easily acquire the expected competencies and enjoy learning.

(iii) Barriers to the incorporation of humanities modules in engineering disciplines.

A study by Josa and Aguado (2021) found the following barriers to the incorporation of humanities modules in engineering curricula.

1. Resistance to change

2. External influence on the curricula

3. Lack of guidelines

4. Misconceptions about humanities in relation to engineering studies.

They concluded that it is necessary to gradually incorporate both hard social skills and soft skills from the beginning of the degree courses.

The authors of the present study experienced that a low value is given by some students and industrialists in the engineering sector to humanities subjects. This can be seen as a barrier to incorporating humanities modules in engineering education. The high workload of engineering students being compressed into a smaller duration is also seen as a barrier due to the humanities being perceived as low-value subjects. As such humanities modules are given lesser time and a lesser number of credits in the curricula. There are also suggestions for them to be completely removed from the curricula.

4. CONCLUSION

Five research publications out of the 12 that were reviewed emphasized the importance of humanities in improving students' communication skills, interpersonal skills, and emotional intelligence in engineering disciplines. Two researchers mentioned that 20% - 30% of the engineering curricula should be allocated to humanities modules. Studies show that students with a humanities background possess highly developed and divergent thinking skills.

A researcher from the Israel research institute identified the bilateral interaction between technology and society. According to the author, most students perceive engineers' technical knowledge and not their inability to reason verbally, communicate their ideas to others, and furnish leadership. These skills seem to be better developed in the humanities than in engineering courses.

Research has identified that resistance to change, external influences on the curricula, lack of guidelines, and misconceptions about what humanities are in relation to engineering are seen as barriers to the incorporation of humanities modules in engineering curricula.

The authors of this study suggest that humanities modules should be compulsory GPA subjects in the initial stage of learning. Furthermore, the authors recommend that there should be electives to select humanities modules preferred by students so that they can enjoy the module while enhancing their skills according to their talents.

Finally, the authors of the study point out the barriers to conducting humanities modules in technological disciplines through their own experiences; students feel that humanities modules are a low-value subject and an extra burden on their studies due to their heavy workload, the lack of guidelines, and resistance to change are barriers to the inclusion of humanities modules in engineering education. The authors propose that as the humanities are not a time-limited and structured form of learning the modules should be conducted in a leisurely manner and in a proper environment without them being stressful for the students.

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Session 02

DESIGN AND DEVELOPMENT OF AN AUTONOMOUS TOOL CART (ATC)

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ABSTRACT: With the development of the industrial world, various tactics have been used to facilitate human work. However, industrialists working in factories face various problems. Among them, the problem of not having the correct and appropriate tools and equipment at the work site is a major hindrance. This may happen due to the worker not being able to carry all the tools together at the same time, forgetting, or not being able to guess what is required beforehand. As a result, they may have to go back to pick up the required tools or have difficulty in getting tools when working at difficult-to-reach locations such as places at higher elevations which might adversely affect the efficiency and quality of the work. The objective of this research project is to minimize such problems by introducing an Autonomous Tool Cart (ATC) that can be used by the technician to select or request the necessary tools so that the ATC can bring them to the required place. In order to minimize the problems faced by the technician, this ATC can be used not only to carry the requested tools to the required location but also to lift them to a higher elevation or a difficult-to-reach place. The ATC can play the role of the assistant.
Keywords: Autonomous Tool Cart, Automated Guided Vehicle, Global Position System, Printed Circuit Board, Radio Frequency

1. INTRODUCTION

The world's first automated guided vehicle was introduced in America in 1953, marking the beginning of automated transportation. (Ullrich, 2015) The Autonomous Tool Cart (ATC) was developed using AGV technology (Hamid *et al.*, 2009), and the world's latest technologies, human follow robots, GPS navigation, and wireless transmission (Zahir *et al.*, 2020), (Zein, Darwiche, and Mokhiamar, 2018). The main reason for developing this ATC is to reduce the problems created for the factory workers when using tools, and equipment in the workshop.

Today, the use of automated machines and tools in factories is very common. This is because automation greatly helps in reducing the cost, the time, and energy of production. Also, industrialists working in factories have various problems. For example, moving tools from one place to another, not being able to move all the tools at the same time, forgetting and having to go back to pick up forgotten tools, and having difficulty getting tools when working at higher elevations. A solution currently used by the technician is to carry out his tasks with an assistant. But this increases the labor cost of production. A possible solution to overcome these problems is to introduce an Autonomous Tool Cart. The purpose of the proposed ATC is to avoid any inconvenience to the technician during such situations by assisting in bringing the required tools from the workshop to the site automatically. We hope this project will help the technician to avoid the inconvenience of carrying tools in the midst of performing his daily work in the workshop. The tool cart will be different from a normal tool cart because it will be able to move automatically through GPS technology to the technician's work location from the workshop. (Zein, Darwiche and Mokhiamar, 2018) There are several types of robots that assist humans (Islam, Hong and Sattar, 2019), but this robot tool cart will be designed to help the technician to do technical work easily by providing the tools whenever necessary. That is, it will automatically move to the place where the technician is with the tools when requested, so

that the technician can avoid carrying all the tools required, at one time. What is special about the proposed ATC is that the tool holder height can be increased so that even a technician working at a higher place will be able to receive the tools easily (Islam *et al.*, 2014).

2. METHODOLOGY

There will be two main sections in this ATC to perform different functions. They are a remote controller and a tool cart. The main part is the tool cart. The tool cart will be used to move tools around in the workshop and the remote controller will be used to communicate between the tool cart and the technician. Here radio frequency is used as the method of wireless communication. Two 24l01 transceiver modules connected to the microcontrollers will be used in the remote control and the tool cart to communicate via radio frequency. (Sojka and Jaros, 2019), (Mansour *et al.*, 2021). Figure 1 shows the Conceptual block diagram of the ATC. The function of the remote controller is to detect the location of the technician and to transmit it to the tool cart. The tool cart will then use its own position and compare it with the position of the technician sent by the remote control to move the tool cart to the technician's location automatically.
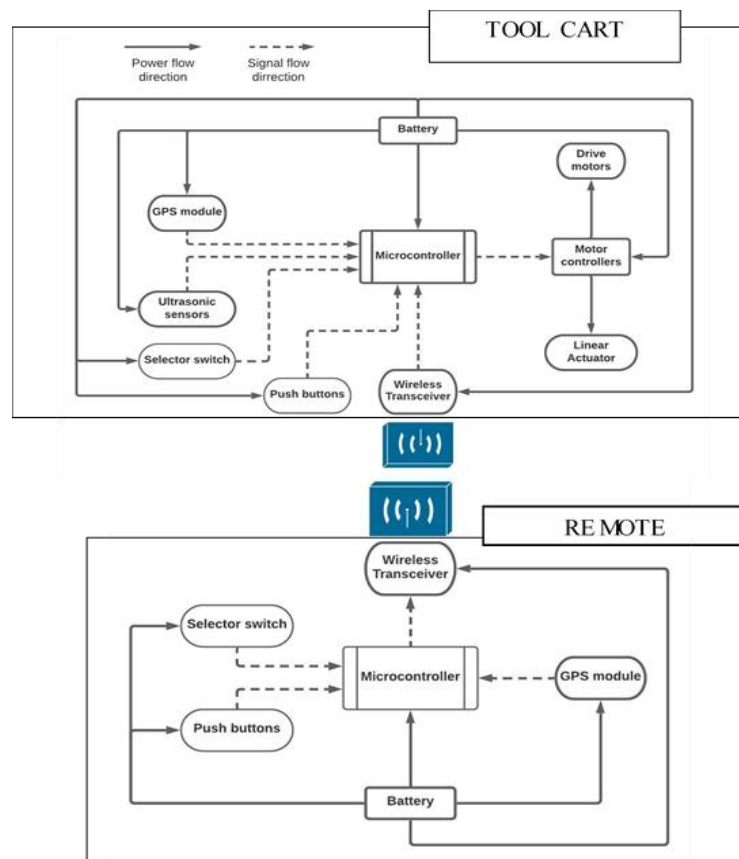
Figure 1: Conceptual block diagram of ATC

The ATC will use GPS technology (Kharisma *et al.*, 2019) for finding the technician's and the tool cart's location, a wireless communication system for communication between the tool cart and the remote controller (Sojka and Jaros, 2019), and a system to retrieve the required tool from the tool store. Also, dc geared brushed motors are used to power the tool cart. The BTS7960B H-Bridge Motor Driver Module also uses a microcontroller to control the direction and the speed of the motors (Rittenberry, 2016).

3. RESULTS AND DISCUSSION

The ATC contains many mechanical parts as well as electrical and electronic parts. Considering the performance of the ATC, the tool cart automatically moves to the location of the remote controller after the technician's signal is given to the tool cart through the remote controller. It uses nrf24l01 transceivers (Sojka and Jaros, 2019) to communicate between the tool cart and the technician's remote controller, as well as the neo-6m GPS modules for finding the locations of the remote controller and the tool cart. (Kharisma *et al.*, 2019). It also includes DC geared brushed motors to move the tool cart and also ultrasonic sensors to avoid obstacles encountered while traveling. (Engemann *et al.*, 2020) Another special feature of the proposed tool cart is its ability to lift the tool holder upwards. This is done by using a scissor lifter attached to the tool holder of the tool cart and a linear actuator attached to the scissor lifter. (Islam *et al.*, 2014) The tool cart has two modes, auto and manual. In the auto mode, it moves according to the GPS location received by the tool cart. The manual mode tool cart handling facility is also provided by remote control as required. Two remote controls are used, one by the technician and the other attached to the tool cart. A handheld remote control is installed here to control the tool cart in case of any issue in the remote controller.

Figure 2 : Final product of the ATC

3.1 COMMUNICATION & LOCATION FINDING SYSTEM

Communication is mainly between the tool cart and the remote control. Here radio frequency (RF) is used as the method of wireless communication. The reason for using RF is due to it having different penetrations for communicating through walls of buildings or houses based on the frequency, for being able to transmit more and for being able to communicate more easily. Two transceiver modules connected to the microcontrollers are used on the remote control and the tool cart to perform RF communication. Here, nrf 24l01 transceivers are used to communicate between the tool cart and the technician's remote control.

The GPS module used is a complete GPS module based on Ublox NEO-6M. This unit uses the latest technology from Ublox to give the best possible positioning information. Another feature of the GPS module used is its Anti-jamming technology. Anti-jamming technology enables operation by avoiding interference from radio or other waves. Figure 3 shows how the data of the GPS module changes when the tool cart moves to the location given by the remote controller.

Figure 3: GPS: Location finding result

3.2 OBSTACLE AVOIDANCE SYSTEM

In avoiding obstacles, the first step is to measure the distance between the tool cart and the obstacles encountered when the tool cart is being moved. The reason for choosing ultrasonic sensors, is to reduce the cost and the ease of use when using several sensors. Here, the ultrasonic sensor is connected to a microcontroller to measure the distance between the ultrasonic sensor and the barrier. The reason for giving the tool cart this particular shape is to make the obstacle avoidance system work properly. Figure 4 shows the readings given by the obstacle avoidance system when avoiding the obstacle encountered while traveling to the given location.
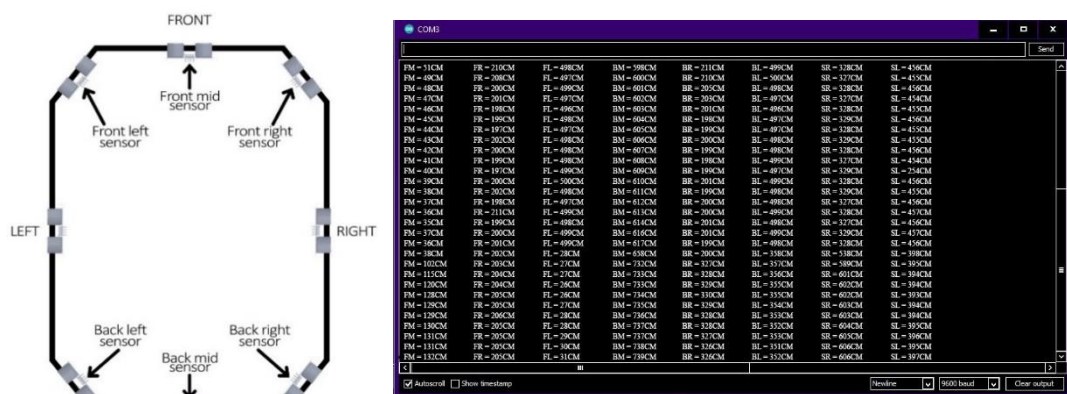

Figure 4: Sensors mounting positions & Obstacles avoiding system

3.3 MECHANICAL SYSTEM

A scissor mechanism is used to raise and lower the tool holder. The linear actuator is used to support the activation of the scissor lifter mechanism. The reason for using a linear actuator here is its ability to deliver more power. Also, the screw thread on the linear actuator can stop the scissor lifter at any point. A 750N linear actuator is used for the scissor lifter mechanism. The maximum lifting height of the tool holder is 2m.

Figure 5: Scissor lifter of the ATC

4. CONCLUSION

The ATC was designed and successfully implemented to help the technician to avoid the hassle of carrying tools in his daily work at the workshop. This tool cart is different from a normal tool cart as the technician can avoid the hassle of carrying all the tools required at one time from the workshop stores during his daily work. This ATC can also automatically move to the technician's location with the requested tools as and when required. It can even be used to send back unnecessary tools and waste back to the workshop.

Another feature added to the ATC is that the tool holder height can be increased so that the technician working at a different height can get the tools easily. Another notable advantage of this ATC is that since it's a fully electrically operated tool cart, it is environmentally friendly with zero-emission to the environment.

The tool cart is expected to be developed beyond its current state to be able to move on any surface and the working efficiency and running time of the tool cart can also be further developed. Also, improvements can be made to the mobile application, the charging system, the obstacle avoidance system, and the tool selecting system. An automatic tool selecting, and loading and unloading system without manual handling can be developed for the ATC. Further, if the ATC can be developed to be shared by many workers it can be highly recommended for many sites where different tools are shared by the workers. We hope that the ATC will be the next revolution in tool-carrying systems for future industries to increase their efficiency and quality.

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FORECASTING THE ALL SHARE PRICE INDEX OF THE COLOMBO STOCK EXCHANGE DURING THE COVID-19 PANDEMIC

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ABSTRACT: This research was carried out to forecast the direction of the Colombo Stock Exchange (CSE) during the Covid-19 pandemic using daily stock indices of the All Share Price Index. The conventional ARIMA, SARIMA, and Dynamic Harmonic Regression (DHR) models were employed as the forecast techniques in this study. All the models were carefully crafted and compared to identify the most suitable approach for forecasting. The results indicate that the DHR model was superior to the others with the lowest Corrected Akaike's Information Criterion (AIC) value. The Portmanteau test indicated that the residuals were white noise, and all the models were appropriate for forecasting. Both the ARIMA and DHR models were capable of capturing the downward movement of the CSE but, the DHR model provided significant outcomes. Moreover, the results signified that the DHR model was ideal for forecasting daily share indices with unconventional seasonal effects compared to the SARIMA model in terms of forecast accuracy. This enabled stakeholders to make investment decisions precisely during the pandemic.

Keywords: All Share Price Index, ARIMA, SARIMA, Dynamic Harmonic Regression (DHR)

1. INTRODUCTION

This study was conducted with the view of precisely forecasting the All Share Price Index of the Colombo Stock Exchange during the COVID -19 pandemic. As suggested in the literature (Konarasinghe *et al*., 2015), predicting share indices is a comprehensive task due to the highly volatile nature of the data. The daily share indices used in this study consisted of conventional and unconventional seasonal patterns.

According to Vishvakarma *et al*., (2020) SARIMA models are capable of capturing only regular seasonal effects of the data. Since the primary objective of this study was to predict the direction of the CSE during the pandemic, the ARIMA (Autoregressive Integrated Moving Average), the SARIMA (Seasonal Autoregressive Integrated Moving Average), and the Dynamic Harmonic Regression models were used so that the investors could make correct investment decisions.

2. METHODOLOGY

In this context, the ARIMA, the SARIMA, and the Dynamic Harmonic Regression (DHR) models were compared using the daily data obtained from February 2019 to April 2020. The following steps discuss the general approach.

ARIMA and SARIMA models

Initially, the data was plotted and searched for any unusual patterns in the data. If necessary, transformations were used to stabilize the variance. Then the first difference was obtained to make the data stationary. After that ACF/PCFs (Autocorrelation Function/Partial Auto Correlation Function) were examined to check whether $ARIMA(p, d, 0)$ or $ARIMA(0, d, q)$ was appropriate for the study. Consequently, ACF/PCF were further examined for the presence of seasonal lags to obtain the $ARIMA(p, d, q)(P, D, Q)_m$, SARIMA model where m represented the seasonal period.

Thereafter, the chosen models were tested on training data, and the AICc criteria was used to select the best out of the rest. Finally, the model adequacy checking was done and if residuals

were found to portray a white noise, the model was perceived to be adequate and ready for forecasting.

Dynamic Harmonic Regression (DHR) Model

A harmonic regression approach is preferred when the seasonal pattern is modeled with Fourier terms and dynamics handled by ARIMA model error (Ponziani, 2022). Dynamic harmonic regression is based on the concept that a composition of sine and cosine functions can approximate any periodic function (Hyndman and Athanasopoulos, 2021).

$$y_t = \beta_0 + \sum_{k=1}^{K}[\alpha_k s_k(t) + \gamma_k c_k(t)] + \varepsilon_t \tag{1}$$

Where $s_k(t) = sin\left(\frac{2\pi kt}{m}\right)$, and $c_k(t) = cos\left(\frac{2\pi kt}{m}\right)$, and m is the seasonal period while α_k and γ_k are regression coefficients, and ε_t is white noise. K is altered accordingly for weekly, monthly, and yearly variations.

3. RESULTS AND DISCUSSION

Figure 1 illustrates the overall share price movement of the CSE during the pandemic.
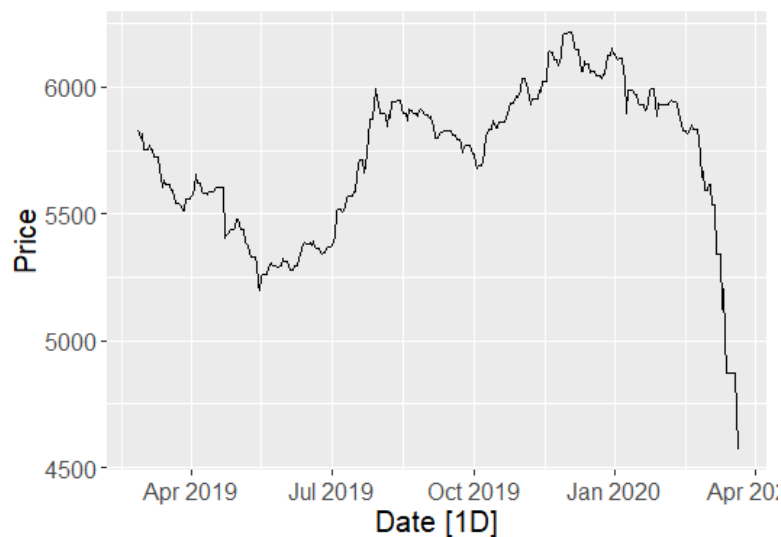
Figure 1: Time series plot of ASPI

As the graph indicates, the overall movement is a mixture of both upward and downward trends. It is immediately apparent that, as the pandemic started to spread across the country, the share market had to face a huge downfall over time.

The unit root test was conducted to determine the required order of differencing which is 2. Subsequently, the KPSS (Kwiatkowski-Phillips-Schmidt-Shin) test was implemented on the differenced data and the results suggested that the data was stationary. The following graph indicates the ACF/PACF functions of stationary data.

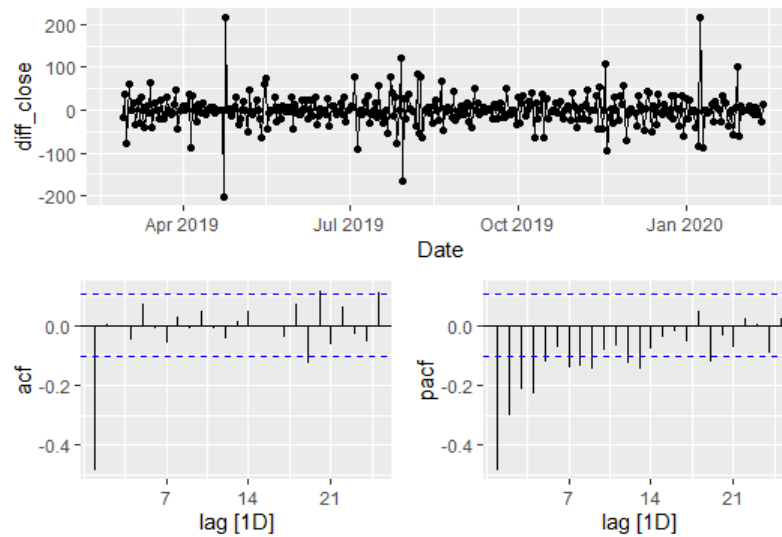*Figure 2: ACF and PACF plot.*

The negative autocorrelation suggests that the positive return for one observation increases the probability of having a negative impact on the previous observation due to the downward movement of the share indices. In addition, the PACF function dies out over time while the ACF function cuts off at lag 1. The following table ensures that the best models are selected from the process.

Table 1: AICs of ARIMA, SARIMA and DHR models.

	Model	AIC	Portmanteau Test (P-value)	RMSE
ARIMA	ARIMA (0,2,1)	3325.88	0.447	466
SARIMA	SARIMA (0,1,0) (0,0,2)	3327.52	0.620	577
DHR	ARIMA (Fourier (week, K=3) + Fourier (month, K = 1) + Fourier (year, K = 3)	3316.60	0.871	431

The training data was obtained from February 2019 to February 2020 while the test data was obtained from February 2020 to April 2020. The Portmanteau Test results suggest that all three models are adequate and ideal for forecasting. The forecast was calculated 37 days ahead and the results are presented in figure 3 below. Larger RMSE values were obtained due to the high discrepancy with the actual data. In addition, ACF plots of residuals indicate that the mean values of the residuals were close to zero and there were no significant correlations in the residual series.
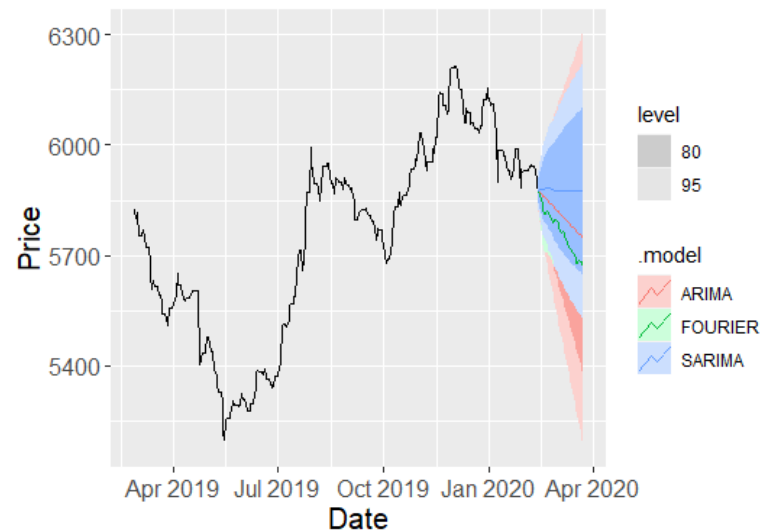
Figure 3: Forecast for the CSE during Covid-19.

4. CONCLUSION

In conclusion, as the results indicate the Dynamic Harmonic Regression model provided the optimal results compared to the other two models with a minimum AIC value and a minimum RMSE (Root Mean Squared Error) value for forecast accuracy. Moreover, it was noticed that the SARIMA model was incapable of capturing irregular seasonal patterns of daily data as it runs out of memory whenever the seasonal period is more than 200.

Overall, the downward movement of the CSE during the pandemic was captured precisely by the DHR model and it is concluded that the model is ideal for handling data with complex seasonal patterns.

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BENEFITS OF IMPLEMENTING GREEN BUILDING PRACTICES IN HIGHER EDUCATIONAL INSTITUTES

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ABSTRACT: The Talloires Declaration initiated environmental sustainability in higher educational institutes by assimilating sustainability and environmental literacy practices in teaching, research, and institutional operations. Green building has been globally recognized as a means of incorporating sustainability into the built environment. However, higher educational institutes across the world are several steps ahead of Sri Lanka in implementing green building practices. Hence, this research aimed at studying how implementing green building practices benefits the higher educational institutes in Sri Lanka. The research aim was approached through a qualitative case study. The findings reveal that low life cycle costs, increased reputation, increased knowledge sharing opportunities, and improved indoor environmental quality to be the key benefits of implementing green building practices in higher educational institutes. The study concludes that implementing green building practices in higher educational institutes is beneficial for both the institutes and society. Further, the management of the institutes should be aware of how to convert the opportunities created by the implemented green building practices into benefits.

Keywords: Benefits, Green Building, Higher Educational Institutes

1. INTRODUCTION

The World Green Building Council (2022) defined a Green Building (GB) as "a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment". Incorporating sustainable features into Higher Educational Institutes (HEIs) was emphasized during the United Nations decade of education for Sustainable Development (SD) (2005-2014) (Qdais, Saadeh, Al-Widyan, Al-tal, & Abu-Dalo, 2019). As per Universities Act no. 16 of 1978, and the Universities (amended) Act no 7 of 1985 an HEI means a university, campus, open university, university college, institute or centre for higher learning, or any degree awarding institute.

Atici, Yasayacak, Yildiz, and Ulucan (2021) effectively concluded that GB practices reinforce students' satisfaction, productivity, and academic performance. The study proved that GB practices effectively explained approximately 45% - 50% of HEI's excellent performances. Researchers have statistically proved a positive relationship between the physical conditions of classroom infrastructure and students' academic performance (Edwards, 2006). On the other hand, Li, Strezov, and Amati (2011) contended that GBs can create more opportunities for national and international knowledge sharing by offering a creative and attractive working environment. Multi-functional GBs are versatile as they serve as collaborative platforms in academia (Li et al., 2011). Li et al., (2011) claimed that adopting green practices opens doors to research on advanced green technologies and noted that GBs immensely enhance the reputation and the publicity of HEIs, and offer competitive advantages to being a leader within the arena. According to Waidyasekara & Fernando (2012) GBs cause low annual electricity, water, fuel, wastewater, and waste disposal costs compared to conventional buildings.

Hoque, Clarke, and Sultana (2016) highlighted the importance of studying the sustainability of HEIs in the South Asian context. Despite increased studies in sustainability in HEIs, only a few related studies have been conducted in the Sri Lankan context. For instance, Thennakoon (2017) proposed an agenda for transforming Sri Lankan state universities into green

universities by reviewing studies on foreign green HEIs. On the other hand, developed a green rating system for new state university buildings in Sri Lanka. However, as highlighted by Fissi, Romolini, Gori, and Contri (2020), there is a research gap in empirical studies regarding the on-field realization of green HEIs. Hence, the objective of this research was to study how the implementation of GB practices benefits HEIs in Sri Lanka.

2. METHODOLOGY

The qualitative approach allows collecting data from a comparatively lesser number of participants and analyzing them in-depth (Creswell, 2012). This approach was adopted for this study considering the inability to obtain a large sample of data due to a lack of implemented GB practices in HEIs in Sri Lanka. The study investigated the contemporary phenomenon of GB practices, within real-life contexts of the HEIs, where the researcher had no opportunity to control their behaviour. Hence, the case study was selected as the research strategy. Cases were selected through judgemental sampling based on HEIs having either rated GBs or those pending GB rating. Profiles of the selected cases are presented in Table 1.

Table 2: Case Profiles

Case	Description
C1	• Green Building Council of Sri Lanka (GBCSL) gold rated building premises • Constructed when the institute was relocating • Institute established under the purview of the University Grants Commission (UGC) • Established under Ordinance No. 3 of 2000
C2	• Green Mark gold certified building premises • Degree awarding institute recognised by the UGC • Established under the State Ministry of Skills Development, Vocational Education, Research & Innovations • Corporate entity incorporated under the Companies Act No. 07 of 2007 • Sri Lanka's first HEI with rated GBs
C3	• Pending GBCSL platinum rated premises and non-rated premises • University established under the purview of the UGC • Established under the Universities Act No. 16 of 1978

Data were collected through semi-structured interviews. Interviewees were selected based on their involvement and specialization in implementing GB practices. Accordingly, two academic staff members and one administrative staff member were interviewed in each case. Interviewees were questioned under four major sections: awards and recognitions received for the green implementations, benefits of implemented GB practices for academics, the way the implemented GB practices economically benefit the institute, and other associated benefits of implemented GB practices. In addition, situational questions were raised to clarify and explore the details further. Interviews were conducted online via the Zoom platform. The data was analyzed through cross-case synthesis and the NVivo 11 software was used to code the data.

3. RESULTS AND DISCUSSION

In Case 1 the prestige of being the first GREENSL gold rated higher educational building in Sri Lanka increased the institute's reputation. It experienced significant growth in institutional performance as well. Interviewees revealed that compared to the conventional buildings, the environment with implemented GB practices was calm, quiet, easy to concentrate on, and

offered good indoor environmental quality (IEQ). All the lecture halls were located on the top floors to minimize disturbance, and related facilities were provided in a way that avoided unnecessary circulation. However, conducting academic programs through online platforms due to the COVID-19 pandemic prevented gaining true benefits of the implemented GB practices. Additionally, reduction in water consumption was a key benefit of implementing GB practices.

Case 2 was the first HEI in the country to hold a rated GB. It immensely enhanced the reputation of the HEI and provided competitive advantages such as improved marketability. It was found that IEQ offered by the GBs inspired imagination and creativity which were essential for effective teaching, learning, and research. Additionally, the energy cost reduction was a significant long-term benefit.

Case 3 was nominated for the UNESCO-Japan Prize for education in Student Development in 2016 for the institute's efforts in being an example for enhancing students' engagement through greening. The United Nations SD Solutions Network approved the Institute's membership and would collaborate in research, solutions initiatives, and policy work. The institute secured 259th place in GreenMetric World University Rankings in 2017 and 253rd place in 2016 while securing first place among Sri Lankan universities. In 2021 the institute held the 247th position. The founder director of the Centre of Sustainability Solutions of Case 3 was awarded the Vice Chancellor's award in appreciation of the outstanding service rendered in executing sustainability initiatives at the Institute. In Case 3, the main intended benefit of pending GBCSL platinum rated GB premises was to reduce the life cycle cost. The expected Building Energy Index of the premises was 100 whereas that of a typical higher education building was around 200. Providing better IEQ for students was also an intention of the Institute. Table 2 summarizes the analysis of the research findings.

Table 3: Summary of the Analysis

Benefit	Case 1	Case 2	Case 3
Green rating	√	√	√
Awards and recognitions			√
Improved IEQ	√	√	√
Increase in academic and research performance	√	√	√
Reduction in water consumption	√	√	√
Reduction in energy consumption	√	√	√

In all three (03) cases low life cycle cost was a key benefit. However, neither Case 1 nor Case 2 quantified for cost savings. Nonetheless, Case 3 had set a target in terms of building energy index which may be explained by the fact that in Case 3 energy audits had been conducted for existing conventional buildings. The findings of Case 3 broadly supported the findings of previous research on GBs' ability to create knowledge sharing opportunities for HEIs and to expand research on fields related to SD. Findings of all three cases substantiated the findings of previous researches about the associated reputation. However, none had evaluated value addition to the brand name. Results of the case study evidenced the findings of previous researches about the impact of IEQ on academic activities. Evaluation of the case study findings indicated that Case 3 had gained more benefits compared to Case 1 and Case 2. The

researcher identified the level of awareness of the stakeholders in Case 3, and the institutional policy which institutionalized the green concept as reasons for the difference.

4. CONCLUSION

Implementing GB practices in HEIs is beneficial for both the institutes and the society. Benefits to the institutes can be broadly identified as an increase in institutional performance, reputation, and economic benefits. IEQ offered by GBs had a significant impact on the key functions of the HEIs such as learning, teaching, and research. Low operational and maintenance cost is the most significant economic benefit in the Sri Lankan context. Importantly, the authorities of the HEIs should be aware of the benefits of implementing GB practices and the opportunities created therein. The benefits indirectly act as a driving force for implementing GB practices. However, when collecting data for this study, only the members of the academic and administrative staff were interviewed and the number of interviews conducted for each case had to be limited to three. Outcomes of the research will influence the authorities of HEIs to implement GB practices in their respective institutes. It is recommended for future researchers to conduct comparative case studies (theoretical replication) of HEIs with rated GBs and HEIs without rated GBs to study the impact of GB practices and to quantify the environmental and economic benefits.

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A MODEL TO ASSESS OFF-CAMPUS WALKABILITY OF UNIVERSITY STUDENTS IN URBAN TROPICAL CONTEXTS

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ABSTRACT: The identification and mainstreaming of walkability encouraging factors in micro-environments such as university surroundings are equally important as macro environments, in the pathway of sustainable urban development. This research investigated the influence of the neighborhood environment on off-campus walkability of university students. A framework was developed based on neighborhood environmental attributes (4); functionality of the road, traffic safety, aesthetic beauty of the road, & crime safety, and elements (18), under each attribute. Attributes and elements were identified through a comprehensive literature review and adopted to compete in the tropical, developing context. The Qualitative and quantitative data were collected through field observations and a structured questionnaire survey (n = 372) which was conducted at the University of Sri Jayewardenepura, Sri Lanka. A regression model was developed based on the framework.

Keywords*:* Neighborhood Environment, Regression Model, University Surrounding, Walking Preference

1. INTRODUCTION

The transportation sector is a major contributor to greenhouse gas emissions in the cities, which encourages transportation and urban planners to motivate people to use non-motorized modes of travel like walking (Keyvanfar et al., 2018). Walkability is defined as the quality of a neighborhood that supports and encourages people to access their destinations on foot. (Alkheder et al., 2019; Wang et al., 2013). Walking is associated with numerous health benefits like enhancing social cohesion and economic prosperity of the neighborhood (Dove, & Pafka, 2018). Promoting walkability in a city is one of the priority actions in the new urban agenda and Sustainable Development Goals (SDG 11) (Tsiomprasa, & Photis, 2016; Okraszewska et al., 2013). These researches indicate that staying physically active during college may increase students' chances of being active throughout their lifetime. Also, there is consistent evidence to prove that youth who walk or cycle report significantly higher levels of physical activity than those who travel by motorized vehicles (Lu et al., 2019). However, it is evident that more than 80% of the world's adolescent population is insufficiently active physically (WHO, 2018).

The walkability of micro-environments like university campuses is equally important as macro environments, as they represent a large part of an urban area (Eboli et al., 2013; Ramakreshnan et al., 2020). Among the handful of studies conducted on the walkability of university students, most of them have considered walkability inside the university premises (Ranasinghe et al., 2015) while the walkability of university surroundings is far less inclusive (Chiang et al., 2017). In light of this, the current study was designed to identify the main neighborhood environment attributes that encourage off-campus walkability of university students and to investigate their correlation with walkability. To this end, the aim of the research study is to develop a mathematical model to pinpoint the correlation between neighborhood environmental attributes of university surroundings and the walking preferences of university students in an urban tropical context, which can be utilized in urban policy planning.

2. MATERIALS AND METHODS

Framework Development

The neighborhood environment attributes that affect the walkability of university students were identified through a comprehensive literature review. The Delphi technique was adopted to find out the relatively most significant attributes and elements to develop the framework. The framework is presented in Figure 1.
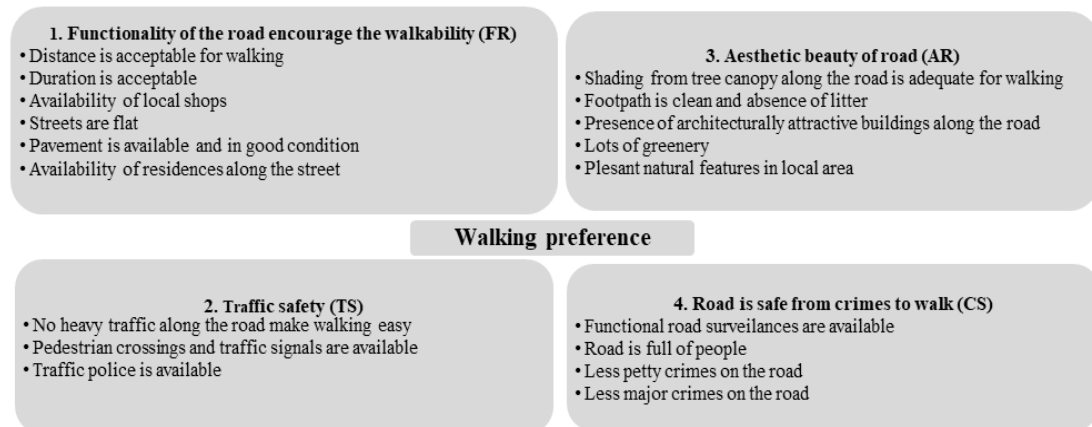
1. Functionality of the road encourage the walkability (FR)
- Distance is acceptable for walking
- Duration is acceptable
- Availability of local shops
- Streets are flat
- Pavement is available and in good condition
- Availability of residences along the street

3. Aesthetic beauty of road (AR)
- Shading from tree canopy along the road is adequate for walking
- Footpath is clean and absence of litter
- Presence of architecturally attractive buildings along the road
- Lots of greenery
- Plesant natural features in local area

Walking preference

2. Traffic safety (TS)
- No heavy traffic along the road make walking easy
- Pedestrian crossings and traffic signals are available
- Traffic police is available

4. Road is safe from crimes to walk (CS)
- Functional road surveilances are available
- Road is full of people
- Less petty crimes on the road
- Less major crimes on the road

Figure 1: Walkability Framework

Description of Study Area, Survey Design and Data collection

University of Sri Jayewardenepura (USJ) is located to the southwest of Colombo district (6.9271° N, 79.8612° E), which is the capital economic center of Sri Lanka. The land use pattern is urban. The climate is tropical with an average annual temperature of 26.9 °C, and an average annual rainfall of 2516 mm. The terrain is generally flat. There are about 13,000 undergraduate and postgraduate students attached to the USJ (USJ Official website, 2018). There are many travel mode options available for university students to reach the university from Wijerama junction including; walking, biking, driving, and taking a bus. The sample size of this study was determined by using the standard technique for determining the sample size of a finite population (Krejcie & Morgan, 1970). This study employed a structured questionnaire survey, after conducting a content validation by the experts and a pilot survey. The walking preferences (1 = I do not prefer walking, 2 = I avoid walking on many occasions, 3 = I sometimes prefer walking, 4 = I prefer to walk on many occasions, 5 = I always prefer walking) related to the sociodemographic features were included in the questionnaire. Also, the responses to the environmental attributes were surveyed using a five-point Likert scale (1 strongly disagree to 5 strongly agree), with higher scores indicating a more favorable value for the environmental characteristic. The students who walk were randomly selected at the university entrance for the interview. All the responses were managed and analyzed using Minitab version 20.2. The correlation analysis was used to identify the degree of the relationship between walkability, each independent attribute, and the strength of the relationship between each attribute, and element. Also, a Multiple regression model was developed to assess the walkability of the university students.

3. RESULTS AND DISCUSSION

As per the standard technique for determining sample size for a finite population, the sample size was estimated to be at least 372 participants to provide a representative analysis of the campus community. The sample size estimation was done at a 95% of confidence level and a 5% margin of error. The majority of the respondents for the questionnaire survey were females (69.4%) and aged between 20-25 years (66.7%). Most of the respondents were undergraduates (91.9%). Of the total respondents, about 3% owned personal vehicles. Considering the walking preferences of university students, 75.54% of the participants preferred to walk (rate either 4 or 5), and 6.99% of the participants did not prefer to walk or avoided walking on many occasions (rate 1 or 2). 17.47% of the respondents answered that they sometimes preferred to walk. Regarding the neighborhood environment, a majority of the students strongly agreed that the FR, and CS attributes encouraged walkability. Considering the elements under attribute AR; the students agreed that shading from the tree canopy is adequate for walking and there is a lot of greenery along the road that encourages walkability, however, they disagreed on the point that the presence of architecturally attractive buildings influenced walkability. Under attribute FR; the students agreed that the elements, availability of local shops, the distance, and the availability of residences encouraged walkability. The respondents strongly agreed with the element; the road is full of people. Table 1 presents the correlation between attributes and elements.

Table 1: Correlation of Attributes and Elements (N=372)

Attributes	Elements	Pearson correlation	P-value
1.FR	Distance is acceptable for walking	0.769	0.000
	Duration to reach the university by walking is acceptable	0.675	0.000
	Availability of local shops	0.704	0.000
	Streets are flat	0.542	0.000
	Pavement is available and in good condition	0.575	0.000
	Availability of residences along the road	0.146	0.005
2.TS	No heavy traffic along the street makes walking easy	0.672	0.000
	Availability of pedestrian crossings and traffic signals	0.769	0.000
	Traffic police are available	0.579	0.000
3.AR	Shade from the tree canopy on road is adequate for walking	0.478	0.000
	The footpath is clean and absent of litter	0.554	0.000
	Presence of architecturally attractive buildings	0.045	0.389
	Lots of greenery along the road	0.218	0.000
	Pleasant natural features in the local area	0.144	0.005
4.CS	Functional road surveillances are available on the road	0.067	0.198
	The road is full of people	0.731	0.000
	Less petty crimes on the road	0.151	0.004
	Less major crimes on the road	0.405	0.000

Regression model for walkability

By using the identified factors, a model for assessing walkability was developed based on the value of independent variables to be used in future urban planning around universities. According to the analysis of variance under multiple regression, the relationship between walkability and attributes, FR, TS, AR, & CS, of the road are statistically significant hence the p-values for these terms are less than the significance level of 0.05.

Regression Equation

$$Walkability = -0.620 + 0.0701\,AR + 0.0704\,TS + 0.1791\,CS + 0.8306\,FR$$

Where; FR – Functionality of the road, TS – Traffic Safety, CS - Crime Safety, AR - Aesthetic beauty of the road

Table 2: Model Summary

S	R^2	R^2(adj)	R^2(pred)
0.519074	70.37%	70.04%	69.52%

4. CONCLUSION

The study identified four main attributes that determine the walkability of university students. Furthermore, the study identified the significant and insignificant elements under each attribute. The findings of the study show that it is vital to consider neighborhood environment attributes when planning sustainable universities. Although traffic safety is a significant attribute that determines the walkability of university students in most developed countries, this study revealed that the attribute, functionality of the road is the most significant factor which affects the walkability of university students, over the attribute, safe from crime. The findings of the study further revealed that the presence of architecturally attractive buildings along the footpath, pleasant natural features in the local area, and functional road surveillances available on the road could be treated as contributive factors, but not significant enough to affect the walkability of university students. This walkability model can be used to assess the level of walkability in off-campus surroundings in Sri Lanka. However, we believe that this model needs to be applied in similar micro-environments in Sri Lanka to confirm its validity.

5. ACKNOWLEDGMENTS

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MEASUREMENT OF SHEAR STRENGTH CAPACITY OF METAMORPHIC ROCK – CONCRETE INTERFACE OF PILE SOCKETS: A LABORATORY STUDY

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ABSTRACT: Quantifying the shear strength of the rock-concrete interface of the socketed region is vital for the design process of pile foundations. In the design of cast in-situ bored piling in Sri Lanka, highly conservative skin friction capacity values are used for socketed regions of piles based on overseas studies that had been done for bedrock conditions such as Sandstones and Mudstones. Nevertheless, in Sri Lanka, most of the bedrock consists of Crystalline Metamorphic rocks which have favorable strength parameters compared to Sandstones and Mudstones. Though some local researchers have quantified the mobilized skin friction capacity of socketed regions of the piles by back calculating the readings obtained during pile load tests, no experiments have been carried out so far to quantify the actual strength when the piles are sheared. Numerous studies conducted overseas have found that Bentonite filter cake which forms over the rock surfaces during the pile drilling operation, reduces the skin friction capacity of the rock-concrete interface. However, there is no evidence of such reduction of skin friction capacity caused by Bentonite filter cake recorded in the Sri Lankan piling industry. Therefore, this study focuses on developing a direct shear apparatus to quantify the skin friction capacity of metamorphic rock-concrete interfaces, which can operate under Constant Normal Loading (CNL) and Constant Normal Stiffness (CNS) conditions. This paper presents the results of direct shear tests carried out to quantify the skin friction capacity for Metamorphic rock-concrete interfaces under CNL boundary conditions with and without the presence of bentonite filter cake.

Keywords: Direct Shear Apparatus, Bentonite Filter Cake, Constant Normal Loading, Metamorphic Rocks, Skin Friction.

1. INTRODUCTION

Cast in-situ bored (CIB) piles are widely used in Sri Lanka for high-rise buildings, expressways, and bridges (Wijayasinghe and Samarawickrama, 2013). The rock concrete interface of CIB piles transfers significant load to the rock through skin friction. In Sri Lanka, conservative design practices are used for pile designs that generally suit weaker rock environments, even though the bedrock conditions are more favourable strength-wise due to their crystalline nature. Ultimately it leads to large overhead costs, which clients have to bear (Thilakasiri et al., 2015). Pile load test results of a 1200 mm diameter pile having a depth of 13.4 m driven in Colombo, Sri Lanka, have shown a mobilized skin friction capacity value of 710 kPa in the socketed region, which was almost more than 3 times its designed capacity for the skin friction when compared with the designed value of 200 kPa obtained for the particular pile from the ICTAD guidelines (Thilakasiri et al., 2015). Though the skin friction of local rocks possesses such good capacity, there is a possibility of its reduction owing to the Bentonite filter cake, which is formed in the socketed region by the infiltration of Bentonite drilling mud into the rock surface. Several global studies have confirmed the reduction of skin friction capacity of the rock-concrete interface in the presence of Bentonite filter cake (Scott, 1978; Williams, 1980; Farmer and Goldberger, 1969; Holden, 1984). Nevertheless, the skin

friction capacity reduction due to the Bentonite filter cake, which forms over metamorphic rock surfaces, is unnoticeable in Sri Lankan bedrock conditions when compared with the available load test results so far. Also, the highly crystalline nature of the local bedrock does not support the Bentonite filter cake formation (Thilakasiri et al., 2015). However, the current study, in its initial stage, found that a Bentonite filter cake of about 2 mm in average thickness can be formed over fresh metamorphic rocks under high slurry pressure of about 3 bars. This finding posed the requirement of finding the reduction of skin friction capacity of the rock sockets caused by the formation of Bentonite filter cake. This study aims to quantify the skin friction capacity of the metamorphic rock-concrete interface using a locally developed direct shear apparatus,

     I.   with the presence of Bentonite filter cake (unbonded rock-concrete interface)

and

    11. without the presence of Bentonite filter cake (bonded rock- concrete interface).

2. METHODOLOGY
1.1 Development of a CNS direct shear apparatus

Modern CNS direct shear apparatus was developed based on the extensive research work done by Williams (1980), Johnston et. al., (1987), and Indraratna et.al. (1997). The first construction of the CNS direct shear apparatus was done by Monash University, Australia, in 1983. It consisted of a large reaction frame made out of a hollow steel section, which was strong enough to provide 150 kN in both horizontal and vertical loading. The Normal load was applied by a screw jack on the upper shear box which was supported by a steel spring that had the same stiffness as the rock mass to simulate CNS conditions. The CNS direct shear apparatus of the University of Monash has both a length and a height of 4 m and can test the specimens having a length of 600 mm and a width of 200 mm (Johnston et.al., 1987).

The CNS direct shear apparatus developed for the current study at the University of Moratuwa, Sri Lanka is somewhat similar to earlier versions of the University of Monash apparatus with a length of 2100 mm and a height of 1100 mm, as shown in Figure 1.
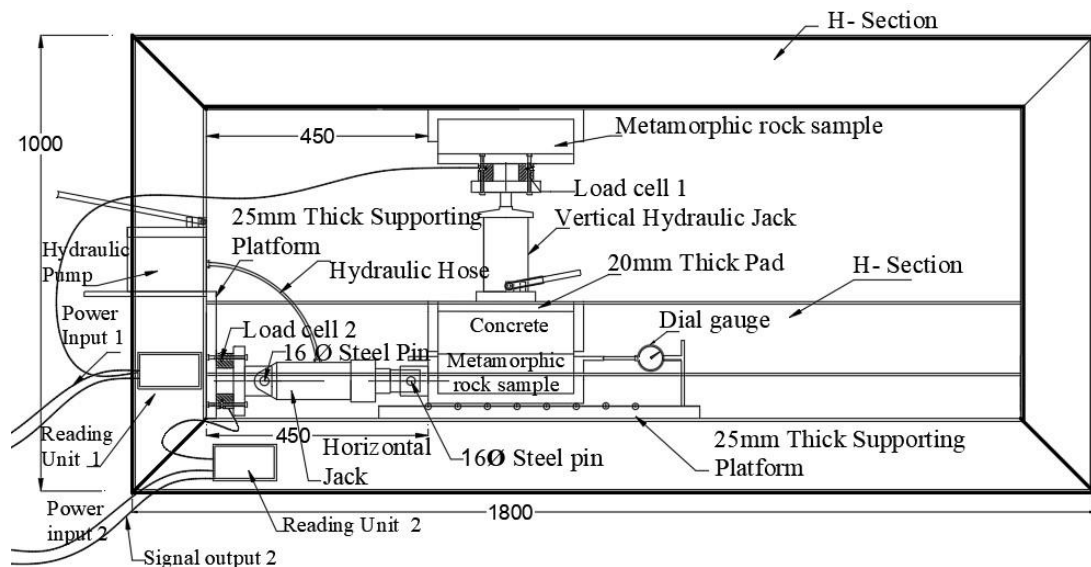

Figure 1: CNS Direct shear apparatus developed at the University of Moratuwa, Sri Lanka

The apparatus consists of two shear boxes having a maximum length of 275 mm and a width of 175 mm. The lower box is 65 mm high and accommodates rock samples, while the upper box, which is 55 mm high, accommodates concrete samples. Shear force is given by a manual hydraulic jack which operates horizontally and has a capacity of 15 tonnes. Normal loading is applied by means of a hydraulic jack which is placed over the concrete sample. Both load cells are capable of measuring loads up to 100 kN. CNS conditions are given by a rock sample of the same type and size placed at the top of the apparatus, which supports the hydraulic jack during normal loading. The outer frame is made using 175x50x6 mm steel I section and jointed by welding in such a way that strains of the frame are negligible.

2.2 Carrying out direct shear tests

A fresh rock sample of Garnet Granulite Gneiss was shaped to be accommodated in the lower box of the apparatus. For the initial testing program, the rock surface was made smooth (JRC value 0-2), and hence the samples may shear under Constant Normal Loading (CNL) conditions unless undulations in the surface cause dilation of the sample. Grade 30 piling concrete having a slump of 200 ± 25 mm was placed over the rock sample in such a way that the upper half of the shear box was accommodated by the concrete. The concrete poured into the upper shear box was cured for 7 days. After checking the compressive strength of the cubes made from the same concrete poured into the shear box, the rock and concrete samples were sheared, and readings were obtained from the 1st version of the already developed computer application FDC1. To compare with the readings obtained by Thilakasiri et.al. (2015) for mobilized skin friction, normal stress of 317 kPa was applied over the samples, which simulates the lockdown pressure exerted on the rock wall surface due to the wet concrete column of 13.3 m. The test was repeated for the same samples in the presence of 2 mm thick Bentonite paste in the rock-concrete interface.

3. RESULTS AND DISCUSSION

A skin friction value of 923 kPa was recorded as the maximum value for the unbonded rock-concrete interface during the CNS direct shear tests. Shearing the rock and concrete samples with Bentonite paste of an initial average thickness of 2 mm showed an unbonded behavior as the maximum recorded skin friction value was 474.5 kPa. The variation of skin friction with the displacement for bonded rock-concrete interface and the rock-concrete interface filled with bentonite paste is shown in Figure 2.
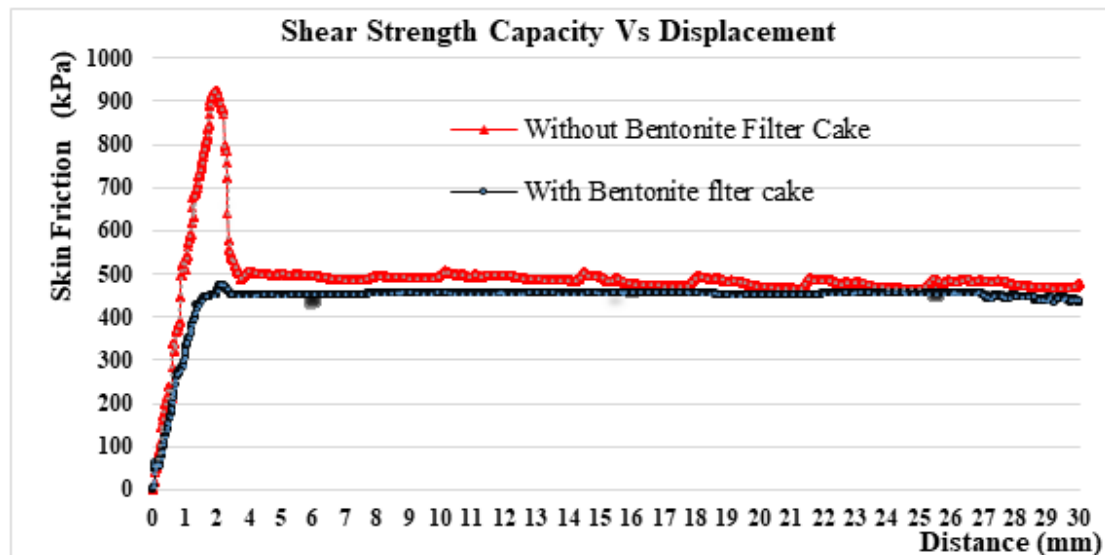
Figure 2: Skin friction Vs. displacement curve for both bonded and unbonded rock concrete interface

As shown in Figure 2, bonded rock-concrete interface behaved elastically for about 2 mm, and at the maximum skin friction value of 923 kPa, the rock-concrete bond was destroyed, and it showed a sudden drop of shear strength with almost no displacement. Then the skin friction showed almost a flat behavior with minor fluctuations which may have been caused by small undulations on the surface. Further, Figure 2 shows that the shear behavior had been governed by CNL conditions, as this graph does not indicate continuous spikes after achieving the maximum skin friction value as in the typical graphs sheared under CNS conditions. Though the test was carried out for a smooth rock surface, the highest skin friction value observed (923 kPa) was greater than the value (710 kPa) obtained from the reported back calculation of load test data. After the bond between the rock and concrete was destroyed, the skin friction varied within the range of 450 kPa to 500 kPa. This was more than twice the design value of 200 kPa, which had been previously calculated according to ICTAD guidelines by Thilakasiri et.al. (2015). When the bentonite paste is between a rock and concrete interface, shear behavior is governed by both the bentonite and the rock-concrete interface. Though the initial average thickness was 2 mm, when the normal load was applied, it was compressed to more than half of its original thickness. Nevertheless, the shear behavior was entirely different from the bonded interface as the shear strength did not drop considerably after reaching the peak. Thereafter the shearing continued with the skin friction variation almost flat, with only minor fluctuations within the range of 440 kPa -460 kPa. Further, when the two curves were compared, it clearly showed that the bentonite paste had reduced the skin friction capacity by a small margin varying up to 50 kPa for the paste thickness used for this experiment.

4. CONCLUSIONS

The laboratory experiment shows that even for the weakest surface roughness condition of smooth rock surfaces, which is not usually encountered in rock sockets, the skin friction capacity is much greater than the design values. Therefore, there is a requirement to incorporate the skin friction capacities of metamorphic rocks for the design equations to save large extra costs incurred annually in the Sri Lankan construction industry. Further, this experiment has indicated the reduction of shear strength capacity in the rock-concrete interface in the presence of Bentonite filter cake, as experienced in previous global studies. Therefore,

it should be quantified for different thicknesses of Bentonite paste and different rock surface roughness.

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PREVALENCE OF REPETITIVE STRAIN INJURY (UPPER EXTREMITY)

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ABSTRACT: People use muscles, bones, tendons, and joints of body regions to perform manual tasks. These manual tasks may be performed intermittently or repeatedly depending on the requirements of the job. Over-Repetitive movement of muscles creates Repetitive Strain Injury (RSI). The literature reveals that those who suffer from RSI tend to ignore the mild symptoms so that the symptoms get worse and later become critical illnesses. People who perform manual tasks repeatedly in occupations may be the victims who frequently suffer from RSI. Thus, the aim of this study is to identify work-related causes that result in the prevalence of RSI. The scope of this study is limited to RSIs of the upper extremity of the human body. The objectives of the research were to discover the features, characteristics, and other relevant information on RSI, based on the reviewed literature, and to propose remedial solutions to manage RSI by providing suitable applications through postural analysis in the areas of industrial engineering, method study practices, ergonomics or human factors engineering, occupational health, and safety practices. The outcome of the study will benefit the manual worker population and society in general.

Keywords: Repetitive Strain Injury, Occupational Risk Factors, Range of Motion, Posture, Work Place Analysis

1. INTRODUCTION

To perform manual tasks in the upper extremity, people use muscles, bones, tendons, and joints of fingers, wrists, elbows, and shoulders. These manual tasks are sometimes performed intermittently or otherwise repeatedly. However, over-repetitive movement of muscles creates Repetitive Strain Injury (RSI) (McConnell, 1996 & Hall and Morrow, 1988) which is a cumulative trauma disorder (Tyrer, 1994) that occurs in several upper-extremity body regions (Freitas et al., 2018). Initially, those who suffer from RSI, tend to ignore the symptoms so that they become worse. Furthermore, several occupations in which people perform manual tasks repeatedly, suffer badly (Hall and Morrow, 1988).

When maintaining posture, the proper employment of good practices such as industrial engineering and method study practices, ergonomics / human factors engineering, and occupational health and safety practices will play a major role in managing RSI. Therefore, it is the responsibility of the researchers to make people aware of the proper application of these practices. Reduction in the risk of injury increases the productivity and the well-being of the workers and has strong relevance to the sustainability of their performance in any industry and in their day-to-day life.

2. AIM AND OBJECTIVES

Further research is vital to identify possible work-related causes of RSI and to make recommendations to overcome or manage RSI. It is essential to identify the symptoms of RSI by reviewing literature and categorizing them according to persistent hand grip motions and to suggest applications through ergonomics to reduce or support solving them. Therefore, this review tries to understand the prevalence of RSI (upper extremity) as an initial step.

3. METHODOLOGY

The keywords used to carry out the initial reviews were 'repetitive strain injury, 'upper extremity strain injury', 'musculoskeletal disorders', 'contributing factors for RSI', 'hand injuries', 'neck injuries', 'carpel tunnel syndrome, 'work-related upper arm symptoms', 'awkward wrist postures' and 'awkward elbow postures. Only online sources of information published in English were searched. Through a title-based search, 23 journal and conference articles were accessed, and by reading the abstracts of these articles eight (08) articles were chosen for review.

4. RESULTS AND DISCUSSION

Researchers have recognized several symptoms of RSI and some of them are painful joints (wrists, elbows, and shoulders, etc.) and body regions (arms and forearms, etc.) (Tyrer, 1994), tingling or numbness in hands; swelling (Kattel et al., 1996); numbness (McConnell, 1996); pinching (Kattel et al., 1996); tingling sensation (Kattel et al., 1996); weakness or clumsiness in hands; dropping things (McConnell, 1996); long- term deformity (McConnell, 1996) and decreased strength (Kattel et al., 1996) (Hall and Morrow, 1988; Tyrer, 1994; Kattel et al., 1996; McConnell, 1996). Work-related upper arm symptoms such as numbness in the fingers, cold feelings, and fatigue in the affected arm are also common reasons for RSI (Tyrer, 1994).

Numerous causes have been identified for RSI: those who perform a high rate of manual tasks repeatedly with over execution of certain hand movements causing the excessive use of muscles or joints, face RSI (Hall and Morrow, 1988 & Freitas et al., 2018); jobs which have a basic cycle time of 30 seconds or less (i.e., the production rate of two or more parts per minute or more) were found to have increased rates of upper-extremity disorders (Kattel et al., 1996).

The commonest types of RSI are identified as hand-related injuries such as Carpel Tunnel Syndrome (CTS), tendonitis and tenosynovitis (DeQuervain disease) (Freitas et al, 2018), and tennis elbow (McConnell, 1996). CTS is caused by the tendons, blood vessels, and the median nerve passing through a narrow area in the wrist, and the swelling around may pinch that nerve again causing pain.

Causes for upper extremity musculoskeletal disorders are mainly due to extensive movement of the Range of Motion (ROM) in the upper arm and wrist (McConnell, 1996, Kattel et al.,1996) resulting in deviated postures such as excessive flexion, extension, radial deviation and/or ulnar deviation of the wrists (Kattel et al., 1996) which may ultimately lead to injuries. ROM is the movement of any joint.

The predominant factor of RSI is the repetition of awkward postures of the human body regions for longer time durations leading to occupational risk factors. Some of them have been identified as 'fixed screens on desks which could not be adjusted and modesty panels among computer operators', 'workers not stretching their legs forward while sitting', 'failure to provide suitable chairs with proper height appropriate to the job' (McConnell, 1996), 'repetitive motion at work especially if the cycle time of the job is less than 30 seconds', 'forceful exertions of body regions with limited opportunity for recovery', 'poor and awkward postures, hand/arm vibration, and exposure to cold' (Kattel et al., 1996).

Results of awkward wrist postures are difficult to manage due to various reasons which are not easily recoverable such as improper workplace design, uncomfortable workplace layout, and the shape and orientation of hand tool handles (Kattel et al., 1996). Extreme pronation

(palm downwards) and /or supination (palm upwards) of the forearm can result due to awkward elbow postures, principally when performing highly repetitive motions.

To manage RSI, numerous remedial solutions have been identified as useful and practical by Kattel et al. (1996). Ergonomically designed hand tools and workstations will reduce the bad effects of awkward hand and wrist movements while performing a task since the proper design of hand tools reduces the pressure exerted on the median and other nerves. It is suggested that stretching exercises should be done at the beginning and the end of daily functions.

Severe RSI has been reported among workers employed in several occupations. For example, typing on a computer keyboard with an awkward posture may develop unbearable pain in the hands and the employee may wake up with arms and hands hurting and burning and find it difficult to perform activities of daily living such as cleaning, carrying heavy objects, gardening, and driving resulting in the need for medical advice. Process workers and machinists too suffer from RSI (Hall and Morrow, 1988).

5. CONCLUSION

As several factors affect the prevalence of RSI, further study is vital to manage RSI among people for comfortable living. If an individual has to exert more than his/her ROM leading to maximum voluntary strength, there is a potential risk involved in the work which may ultimately lead to RSI. However, it is difficult to manage RSI since new employees do not understand the risk of RSI at the early stages of their employment nor are they encouraged to report aches and pains at the outset.

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Session 03

APPLICATION OF NATURAL MORDANTS WITH PALM LIGNIN DYE FOR COTTON TEXTILES

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ABSTRACT: The global environment is changing day by day and now it has become a challenge to life forms as a result of nations trying to develop their countries without considering the environmental impact of degradation and pollution. Dyes currently used in the textile field for dyeing textile material are commonly synthetic compounds, which are not environmentally friendly as their degradation does not take place naturally. As a result, using synthetic dyes is becoming an increasingly major problem for living organisms. The industry, therefore, has to design expensive protocols to remove these harmful compounds from the environment. In this study, strengthening the use of natural dyes and natural mordants was an economically viable option for dyeing fabrics with less or no harmful effects. To develop affinity between the fabric and the natural dye molecules, most natural dyes require mordanting. Here, the mordants are auxiliary dyeing agents capable of forming linkages between the textile substrate and the dye molecules. In most cases, mordanting has resulted in the proper fixation of natural colors on any type of textile fabric. Moreover, the natural mordanting method during the dyeing process has made it possible to reuse wastewater by significantly lowering the toxic effect. This is a turning point for the environment's long-term sustainability. This study has focused on improving the palm lignin dye fixation on cotton by using the two natural mordants, turmeric, and sepalika extracts. Numerous mordanting processes, including pre-mordant, simultaneous mordant, and post-mordant approaches were used for this study. When the two mordants were compared, the sepalika mordant with palm lignin-dyed cotton fabric expressed a strong color shade. In most instances, washing, light, and rubbing fastness capabilities were determined to be good or excellent.

Keywords: Color Strength, Cotton Fabric, Fastness, Natural Mordanting, Palm lignin dye

1. INTRODUCTION

Textile production is one of the biggest industries in Sri Lanka and plays a key role in advancing the country's economy. The coloring of textiles is one of the most important practices in the textile manufacturing process. Dyes that are used by the textile industry are now mostly synthetic. They are inexpensive, offer a huge range of the latest colors, and add value to the dyed fabric. The use of synthetic dyes and chemical fixers produces hazardous and toxic waste, 95% from the coloring process and 5% from the rinsing process (Rather *et al.,* 2019). The use of chemicals in the textile coloration process will produce waste leading to an increased BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), TSS (Total Suspended Solid), and pH changes (Rather *et al.,* 2019).

Natural dyes and mordents are simply dye substances extracted from natural sources. For the development of natural dyes, coloring materials are obtained from natural resources such as roots, barks, flowers, leaves, stems, berries, lichens, mushrooms, vegetables, animals, and minerals (Bechtold *et al.,* 2006).

Synthetic dyes are preferred over natural dyes mainly because they possess very distinct advantages over natural dyes for their color range and availability (Rani and Bar, 2020). Furthermore, natural dyes are associated with some technical issues such as limited coloring

capacity, poor color fastness properties, limited applicability (mostly for natural fibers), and the requirement of large concentrations of dye. In addition, they lack standard color recipes and methods required for the colorization process. However, the following properties are often considered to be the advantages of natural dyes. They are: being renewable, practically having no or mild chemical reactions involved in their preparation, and no disposal problems. They are unsophisticated and harmonize with nature (Anandhan and Prabaharan, 2018). The aim of the present research is to provide a solution to improve the color shade of cotton textiles via the use of palm lignin dye and the fixation of natural mordanting agents.

There are three types of mordanting processes which may include post-mordanting, simultaneous mordanting, and pre-mordanting. Out of different mordants, turmeric and sepalika are considered natural mordants. The natural mordants of turmeric and sepalika extracts with natural dyes have been widely studied and reported in the literature. Worku, A. (2018) reported that turmeric can be used in color and mordant textiles based on the main coloring component, curcumin of turmeric, which results in a yellowish color on the products. When dyed in different ways, pure curcumin produces a wide range of colors on textiles. The findings of this study clearly indicate that turmeric is an environmentally friendly dye for stylish leather products (Worku, 2018).

Avani Agrawal, A. A. G., (2019) reported on *Bauhinia racemosa* the dyeing of cotton fabric with sepalika flower mordants. She had carried out the pre-mordanting procedure while dyeing textiles. According to her research, sepalika mordanting produced the deepest colors on the fabric. Furthermore, washing and light fastness tests were compared. Following washing and light exposure, sepalika mordanted samples showed minimal color change (Avani Agrawal, 2019). A study by Wijayapala (2020) investigated Floral dye extracts as dyeing material and concluded that waste floral extracts mordanted with sepalika (*Nyctanthes arbor-tristis*) flowers are highly suited for textile dyeing and a bio-mordant such as sepalika can be applied to improve fastness properties of dyed fabrics. However, no studies have investigated turmeric and sepalika mordants with palm lignin dye for cotton textiles. Therefore, this study mainly focused on these two natural extracts as mordants.

2. EXPERIMENTAL SECTION / MATERIALS AND METHODS

Materials

Materials used in this study included scoured and bleached 100% plain knitted cotton fabric, palm oil industry waste; palm lignin dye (manually extracted in the laboratory)**,** and laboratory reagents, such as NaOH pellets (98% purity), sepalika flowers (*Nyctanthes arbor-tristis*)**,** turmeric (*Curcuma longa* L.) powder, distilled water, and pH paper. All the chemicals were used without further purification.

Description of Experimental Design and Dyeing Recipes

The palm lignin dye was dissolved in water while increasing the temperature up to 30°C. Into this dye dispersion, bleached 100% plain knitted cotton fabric was added. The temperature was maintained at 80 °C with continuous stirring for about 45 minutes. Then the fabric was removed from the dye bath and subjected to washing for 1 – 2 minutes. Finally, the dyed fabric was dried and stretched. During the dyeing process, the fabric samples were prepared as the pre-mordanting sample, simultaneous mordanting sample, and post-mordanting sample.

Pre-Mordanting Process

During the pre-mordanting process; the pretreated cotton fabrics were soaked in a solution containing 10% of over weight of fabrics (o.w.f) of a mordant, at 60 ^{o}C for 60 minutes with a material to liquor solution ratio of 1:20. The fabric samples that were soaked with mordant solutions were then dyed. This process was carried out separately using each of the selected mordants.

Simultaneous Mordanting Process

In the simultaneous mordanting process, the mordants and palm lignin dye were added to the same dye bath; where dyeing and mordanting took place simultaneously. It was done by placing the pretreated cotton fabric in a beaker containing 10% of the weight of the fabric of the mordant. This was separately carried out using each of the selected mordants.

Post Mordanting Process

In post mordanting treatment, the pretreated cotton fabric was dipped in the dye bath for 60 minutes at 80°-90°C with intermittent stirring. The dyed samples were removed from the dye bath and squeezed to remove excess dye. The dyed fabric was then washed for 1 minute. Then the dyed fabric was soaked in a mordant solution containing 10% of the weight of the fabric.

Cotton fabrics were dyed with each of these mordanting methods separately using different natural extracts; sepalika flower (*Nyctanthes arbor-tristis*) and Turmeric (*Curcuma longa* L.) as mordants. The optimum mordant as well as the method of applying the mordant were identified and used to mordant the fabric.

Evaluation of Colorfastness

Colorfastness to washing, lighting, and rubbing tests were performed using ISO standard test methods; colorfastness to washing according to AATCC 61 – 2A, colorfastness to light according to AATCC 135, and colorfastness to rubbing according to AATCC 8-1995 and ISO 103-X12 were tested to determine their effect on the dyed cotton. Color shade, fastness to washing, light, and rubbing effect of mordanted dyed samples were also evaluated under UV light using the grey scale.

The UV–vis spectroscopy analysis of the lignin-treated cotton fabric was performed using UV-3600 Shimadzu UV–Vis-NIR spectrophotometer and the color strength of these dyed cotton fabrics was measured. Fabric samples were placed on a microscope glass surface using double scotch tape. The absorbance measurement was used in the 200–800 nm light range for the sample analysis. As a baseline, the measurements were done on untreated normal cotton fabric.

3. RESULTS AND DISCUSSION

Cotton fabric usually accounts for a neutral or negative charge when soaked in water. Palm lignin dyes used for colorization also account for a negative charge. Therefore, it can be clearly shown that the dye was not fixed well during the visual observation of the dyed fabric.

Mordants are auxiliary dyeing agents capable of forming linkages between the textile substrate and the dye molecules. For numerous mordanting processes, including pre-mordant, simultaneous mordant, and post-mordant approaches visual observations are given in Table 1.

Table 1: Visual observation of Color intensity on different mordanting optimization

Sample No	Mordant	Pre – mordanting	Simultaneous mordanting	Post- mordanting
01	Turmeric			
02	Sepalika			

This may be explained by the affinity of the dye component through H-bonding and van der Waals forces which resulted in good light fastness for the samples dyed with both mordants. The dry rubbing fastness grade of 4/5 for sepalika mordanted fabric was the highest. Also, the washing fastness results of both mordanted fabrics showed a low and moderate grade of 2 to 3.

Table 2 shows the gray-scale results of the washing, lighting and dry rubbing fastness of the dyed fabrics.

Table 2: Gray scale reading of Color intensity on different mordanting optimization

Nature of mordanting method	Gray scale evaluation					
	Turmeric			Sepalika		
	Washing fastness	Light fastness	Rubbing Fastness	Washing fastness	Light fastness	Rubbing Fastness (Dry)
Pre mordant	1 – 2	3	3	2-3	4-5	3-4
Simultaneous mordant	2 – 3	3-4	3-4	2-3	4	4-5
Post mordant	2	3-4	3-4	3-4	4	4-5

Figure 1 shows the absorption spectra of palm lignin dye with the turmeric mordant which showed bands in the UV and visible ranges. The palm lignin dye absorption was quite low in the post-mordanting process of turmeric mordant-dyed cotton fabric, mainly in the UV spectrum. However, the peaks of the palm lignin dye using the simultaneous mordant process of turmeric mordant dyed cotton fabric were noticeably ordinary in the UV area. A larger UV region was seen in the turmeric-mordant-dyed cotton fabric using a pre-mordant process. As seen in Figure 2, the absorption spectra of palm lignin dye with the sepalika mordant displayed bands in the UV and visible ranges for a variety of mordanting techniques, including pre-mordant, simultaneous mordant, and post-mordant approaches. The absorptions of palm lignin dye on simultaneous mordanting of sepalika-mordant-dyed cotton fibers were relatively poor, especially in the UV range.

However, the peaks of the palm lignin dye with post mordant method of sepalika mordant dyed cotton fabric were significantly average in the UV area. The pre-mordant method of sepalika mordant dyed cotton fabrics exhibited a stronger UV area. Furthermore, when turmeric and sepalika mordanting were compared, the sepalika mordanting with palm lignin-dyed cotton fabric expressed a stronger color shade.
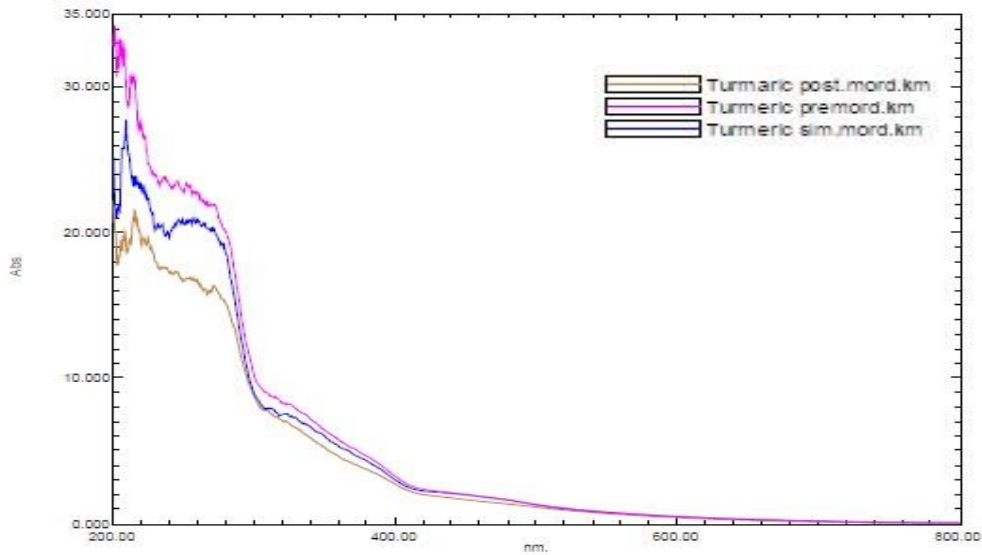

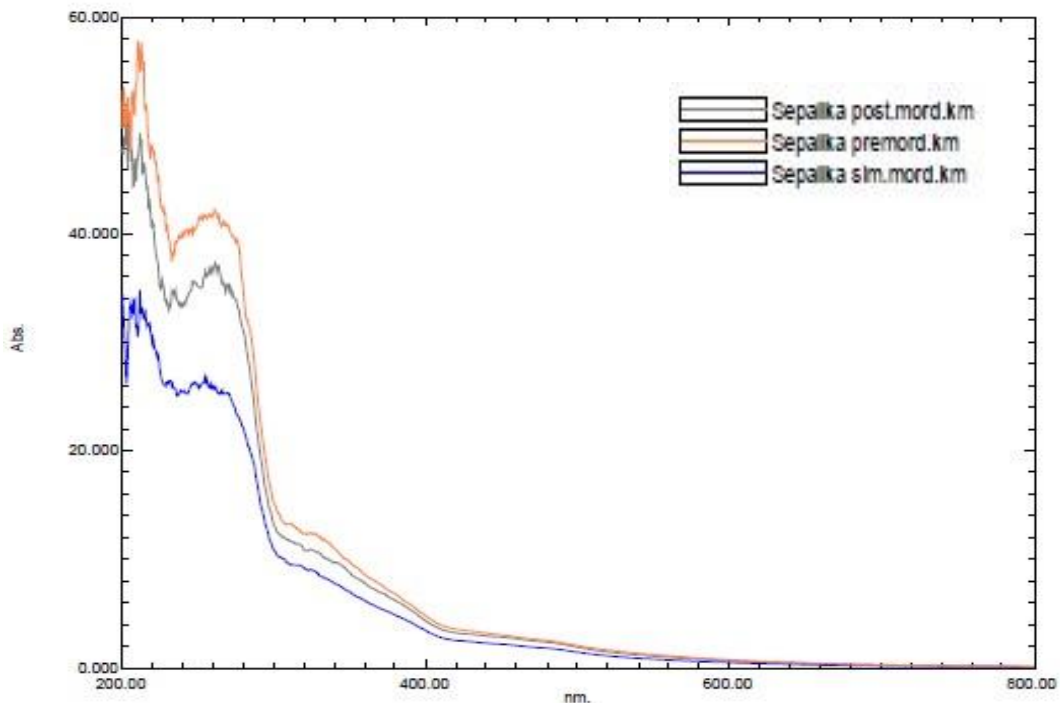
Figure 1: UV Spectroscopy Analysis of Mordanting Method of Turmeric Mordant

Figure 2: UV Spectroscopy Analysis of Mordanting Method of Sepalika Mordant

4. CONCLUSION

The results of the study revealed that using natural mordants and different mordanting methods, various shades of colors can be achieved on cotton fabric using dye palm lignin powder. Here, natural turmeric and sepalika mordants were auxiliary dyeing agents capable of forming linkages between the textile substrate and the dye molecules. In most cases, the washing, light, and rubbing fastness capabilities were determined to be good to excellent.

The above outcome demonstrates that dyeing the fabric with palm lignin dye, and natural sepalika mordant was a great achievement. As a result of these findings, it can be concluded that palm lignin natural dye with natural mordants has greater potential to be used as a colorant in cotton textiles.

5. ACKNOWLEDGEMENTS

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STUDY ON THE SLOW-RELEASE BEHAVIOUR OF FERTILIZER-LOADED HYDROGELS

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ABSTRACT: To sustain the growing world population, more food production is required. Fertilizers and water are important factors that limit the production of food. However, some of the applied fertilizers leach into water systems and contribute to environmental pollution. Therefore, it is extremely important to improve the utilization of water resources and fertilizer to reduce water and fertilizer consumption. Nowadays, the application of slow-release fertilizer hydrogel (SRFH) is used as a trend in reducing water and fertilizer consumption. In the present study, a slow-release formulation of phosphorus fertilizer was synthesized by a combination of polyvinyl alcohol (PVA), and carboxymethyl cellulose (CMC) polymer hydrogel by using chemical crosslinking via in-situ and two-step methods. Potassium dihydrogen phosphate was used as a phosphorus fertilizer for this study. The percentage of swelling and moisture evaporation was evaluated for both methods. The swelling and moisture evaporation study revealed that the hydrogel prepared via the two-step method showed a higher percentage of swelling and moisture evaporation. The chemical and morphological structures were analyzed using Fourier transform infrared spectroscope (FTIR) and the scanning electron microscope (SEM) respectively. The morphological analysis revealed that the hydrogel prepared via the in-situ method displayed a dense structure while the two-step method exhibited a loose structure. The phosphorus release behavior of the PVA/CMC hydrogel prepared via the in-situ and two-step method was investigated. The experimental data indicated that phosphorus release from the hydrogel prepared via the in-situ method was slower and lower than the two-step method.

Keywords: Carboxymethyl Cellulose, Fourier Transform Infrared Spectroscope, Polyvinyl Alcohol Scanning Electron Microscope, Slow-release Fertilizer Hydrogel

1. INTRODUCTION

The quantity of water and fertilizer are the main factors that increase food production to sustain the growing world population. Even though water and fertilizer play a key role in crop production nowadays, an insufficient supply of both becomes a global issue. However, some fraction of applied fertilizer leaches into water systems and causes environmental problems. Therefore, it is important to improve the utilization of water and fertilizer to reduce environmental pollution. Hydrogels are hydrophilic polymeric materials having network structures, and a cross-linking agent. A hydrogel can absorb an enormous volume of water in a short period of time and hold it even under pressure (Wu and Liu, 2007). Presently, slow-release fertilizer hydrogel (SRFH) is being developed to improve water resources and fertilizer utilization. SRFH releases nutrients to plants gradually when the plants need them. It leads to a reduction in fertilizer loss, water scarcity, and environmental problems (Ding *et al.,* 2016). Plants need to be fertilized with phosphorus fertilizer because of the lack of adequate phosphorus in the soil. Carboxymethyl cellulose is the most abundant natural polymer which is biodegradable but has poor mechanical strength (Ponco and Helmiyati, 2020). Polyvinyl alcohol is a synthetic polymer with good mechanical properties, hydrophilicity, and biodegradability. It is therefore added to the natural polymer to prepare hybrid hydrogels for agricultural purposes (Nayan et al., 2018). Citric acid is a non-toxic

and natural material used as a cross-linker for hydrogel preparation. Fertilizers can be incorporated into the hydrogel matrix via the in-situ and two-step methods. In the in-situ approach, all components, including the fertilizer, are added to the reaction mixture, whereas, in the two-step method, the dried hydrogel absorbs the fertilizer solution when immersed in liquid fertilizer (Rabat et al., 2016). The aim of the present work is to reveal the phosphorus release behavior of KH2PO4-loaded PVA/CMC hydrogel prepared via the in-situ and two-step methods.

2. METHODOLOGY

Materials

Polyvinyl alcohol (89 % hydrolyzed), Carboxymethyl cellulose (80 % purity), Citric acid (99 % purity), Potassium dihydrogen phosphate (99.5 % purity), Sulfuric acid (96 % purity), Ammonium molybdate (MW 1235.86), Ascorbic acid (99.7 % purity, MW 176.13)

Methodology

The KH2PO4-loaded PVA/CMC hydrogel was synthesized via an *in-situ* and a two-step method using a 1:3 polymer ratio. In the *in-situ* method, PVA, CMC, KH_2PO_4, and 7 % CA were mixed together and dried in the microwave oven whereas, in the two-step method, a potassium dihydrogen phosphate solution was prepared separately. The dried PVA/CMC hydrogel was submerged in a KH_2PO_4 solution, and then the swollen hydrogel was dried again. A concentration of 5.0 ppm and 8.0 ppm fertilizer solutions were used for this study. The percentage of swelling and moisture evaporation for both methods was evaluated after 24 hours. The presence of the functional groups and morphology were identified using the Fourier transform infrared spectroscope and the scanning electron microscope respectively. Then the prepared hydrogels were put into a dialysis bag and hung into the beaker containing 250.00 mL distilled water and placed in a mechanical shaker. A volume of 2.0 mL fertilizer-leached water sample was taken from the sample beaker and 2.0 mL of fresh distilled water was added to the container. The phosphorus release behavior was then determined for the *in-situ* and the two-step method hydrogels in distilled water at specific time intervals (After 1, 3, 5, 7, 9, 11, 13, 15, 17, and 19 days) using the standard curve of the KH_2PO_4 solution.

Data analysis

Data were analyzed by one-way analysis of variance (ANOVA) and the difference between the means was scored using the Tukey test on the statistical package of Minitab (Minitab for Windows, Version 21.0).

3. RESULTS AND DISCUSSION

According to the results, the percentage of swelling and moisture evaporation of KH_2PO_4 loaded PVA/CMC hydrogel prepared via the two-step method was found to be higher than that prepared via the *in-situ* method. Although the two-time swelling process had destroyed some cross-linked structures inside the hydrogel, it had a better swelling capacity than the hydrogel produced via the *in-situ* method. The *in-situ* method had only one swelling process and therefore had a densely cross-linked structure and lower swelling. The SEM micrograph of the hydrogel prepared via the *in-situ* method showed a denser and tougher structure whereas, the two-step method exhibited a loose highly porous structure because of the two

steps of the drying process. The hydrogels prepared via the *in-situ* method showed a better ability of slow-release than the two-step method because of the less porous, tight, and stronger structure, and as the crosslink density inside the hydrogel structure was very high, it controlled the release of phosphorus. In contrast, the hydrogel prepared via the two-step method showed a higher porous structure and facilitated the fast release of phosphorus. The fertilizer in the hydrogel with a higher concentration was released faster than in the lower concentration and the total fertilizer release amount of the higher concentration was also higher than that of the lower ones due to the higher amount of phosphate trapped inside the hydrogel, leading to a burst release.
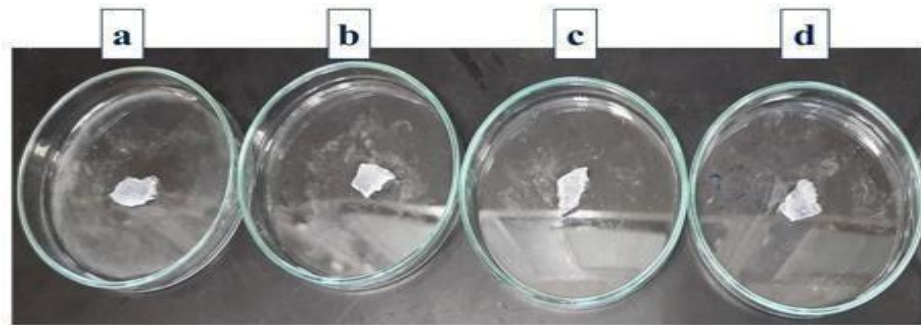
Figure 1: Dried PVA/CMC hydrogels prepared via the two-step (a and b) and the in-situ (c and d) methods

Figure 2: Swollen PVA/CMC hydrogels prepared via the two-step (a and b) and the in-situ (c and d) methods
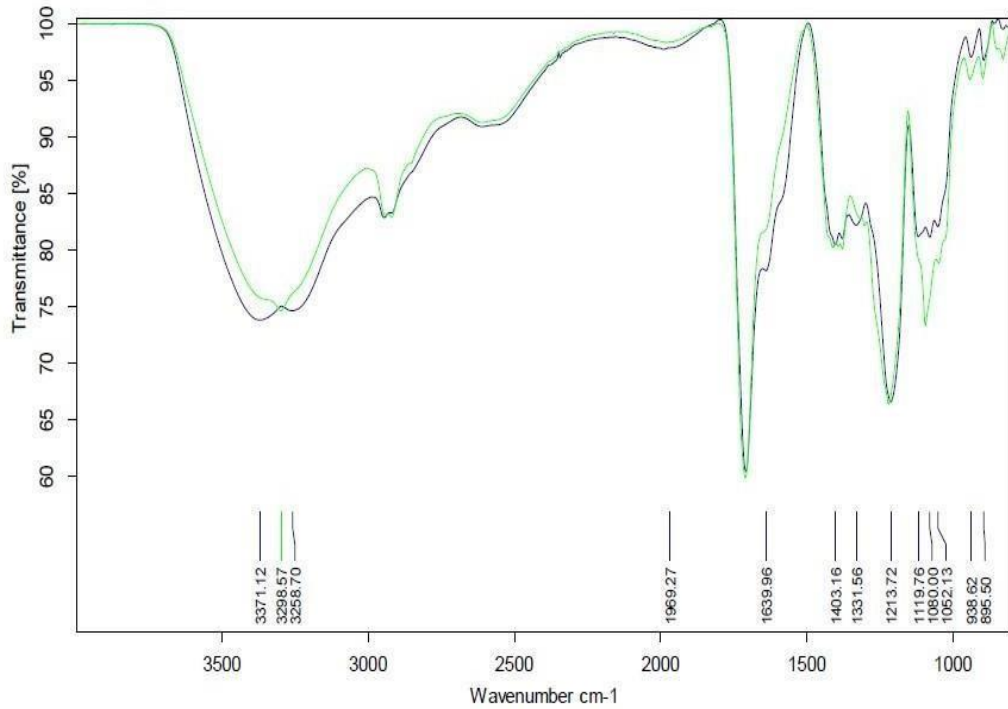
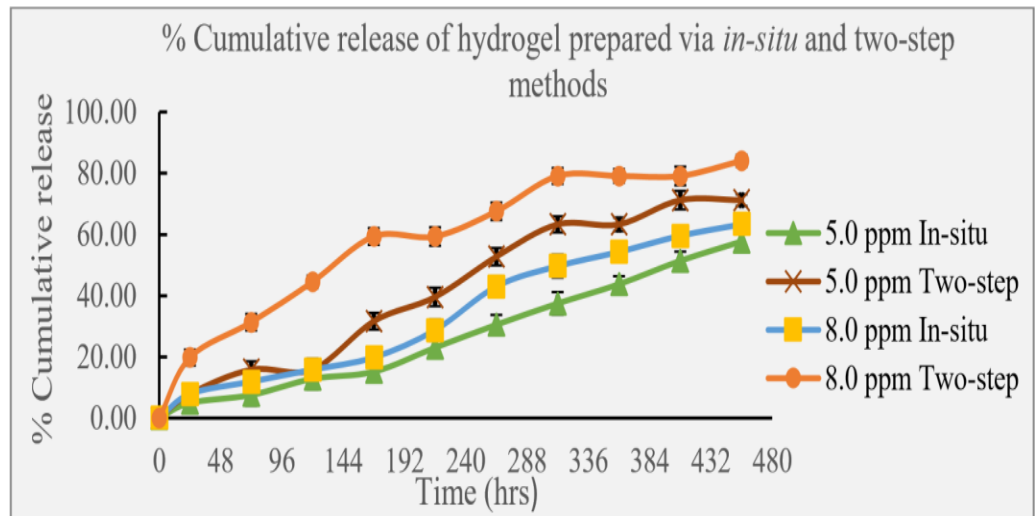*Figure 3: FTIR spectrum of hydrogel prepared via the in-situ (green) and the two-step (blue) methods*

Figure 4: Cumulative phosphorus release of hydrogels prepared via the in-situ and the two-step methods

4. CONCLUSION

In this study, slow-release fertilizer hydrogel with potassium dihydrogen phosphate was successfully synthesized via the *in-situ* and two-step methods. The hydrogel release study concludes that phosphorus released from the hydrogel prepared via the two-step method was higher and faster than that released from the *in-situ* method. These results suggest that KH_2PO_4 loaded PVA/CMC hybrid hydrogel prepared via the *in-situ* method has a better

slow-release ability than that prepared by the two-step method thus improving the utilization of fertilizer and water conservation in agricultural applications.

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SUCCESSIVE IONIC LAYER ADSORPTION AND REACTION FOR THE FABRICATION OF NANOSTRUCTURED BIVO4 FILMS WITH HIGH PHOTOELECTROCHEMICAL EFFICIENCY

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ABSTRACT: Herein we demonstrate the fabrication of bismuth vanadate (BiVO4) thin films using a convenient and scalable method based on a series of repetitive immersions in different precursor solutions called successive ionic layer adsorption and reaction (SILAR). We present a detailed investigation of the deposition of BiVO4 layers, evaluating the effect of the deposition parameters on the structural, morphological, optical, and electronic properties. Phase-pure BiVO4 films obtained, had a band gap ranging between 2.8 and 2.4 eV and showed excellent crystallinity and tuneability in terms of absorption properties. Fabricated films when tested as photoanodes for photoelectrochemical water oxidation, demonstrated the effects of the synthesis parameters on the water splitting performance. The best samples exhibited photocurrents as high as 4 mA/cm2. Our BiVO4 films are amongst the best performing solution-deposited photoanodes, and the current study further validates the capabilities of the SILAR deposition technique in fabricating high-performing BiVO4-type photoanodes for water splitting applications.

Keywords: SILAR, Bismuth Vanadate, Photoelectrochemistry

1. INTRODUCTION

Fossil fuel-induced CO_2 and other greenhouse gas emissions have become the principal cause of global warming today. Harnessing solar radiation for H_2 generation by photoelectrochemical (PEC) devices has emerged as an alternative environmentally benign process in recent years. Metal oxides have gained popularity in PEC devices and notable ternary oxide materials include $BiVO_4$ (Berglund, Flaherty et al. 2011, He et al. 2014, Guo, Tang et al. 2017, Han, Shin et al. 2018), $AgVO_4$ (Chemelewski, Mabayoje et al. 2015), $CuWO_4$ (Pyper, Yourey et al. 2013, Yourey, Pyper et al. 2013), $Fe_2V_4O_{13}$ (Tang, Rettie et al. 2016) and $Cu_2V_2O_7$(Guo, Chemelewski et al. 2015). Among these, $BiVO_4$ has recently emerged as a visible light-active, cost-efficient, stable material for PEC applications. Successive Ionic Layer Adsorption and Reaction (SILAR) is a relatively new technique that has been widely utilized in the preparation of conformal thin films of materials (Pathan and Lokhande 2004, Tolstoy 2006). SILAR stands out in terms of cost, scalability, and convenience and renders better control and tenability (Kanniainen 2001, Odling and Robertson 2016). Deposition of $BiVO_4$ via the SILAR approach is a relatively less-explored area and this work attempted to combine the exceptional photo absorptive properties of $BiVO_4$ with the superior thin film fabrication capability of the SILAR technique. The effect of deposition parameters: precursor concentration and dip cycle count on the photoelectrochemical efficiency of $BiVO_4$ (BV) was studied.

2. METHODOLOGY

Fluorine doped tin oxide coated glass (FTO) templates were ultrasonically cleaned sequentially in baths of acetone, distilled water and ethanol. 0.05 mol/dm^3 bismuth nitrate (BN) and $(NH_4)_3VO_4$ (AV) solutions were prepared in water. FTO templates were dip coated by Nadetech ND-R 11/2 coater with 10 ml aliquots of each solution in the following order: BN, H_2O, H_2O, AV, H_2O.5,10,25, 40 and 50 mM precursor solutions and dip counts: 2, 5, 10,

25, 50 and 100 were used for the fabrication of films. Afterwards, films were annealed at 500 ℃ for 2 hours in air. BV films were photoelectrochemically tested in 1 M H_3BO_3 /KOH buffer (pH ~9.5) with 0.2 M Na_2SO_3. An Ag/AgCl electrode was employed as the reference electrode while having a Pt wire as the counter electrode. 455nm and AM1.5G light was used in the testing.

3. RESULTS AND DISCUSSION

Upon examination of films by XRD, all samples exhibited diffraction patterns assignable to the monoclinic scheelite phase of the bismuth vanadate (ICDD No. 14-0688). At low dip counts, the peak intensity was lower allowing the underlying FTO peaks to become dominant (Figure 1a). The increasing presence of BV with the dip count was evident in both XRD and visual observation (Figure 1b). The optical absorption edge of BV films was detected around 500nm (Figure 1c) and the optical band gap of films fabricated with different dip counts were observed to decrease with the increasing dip count (Figure 1d).
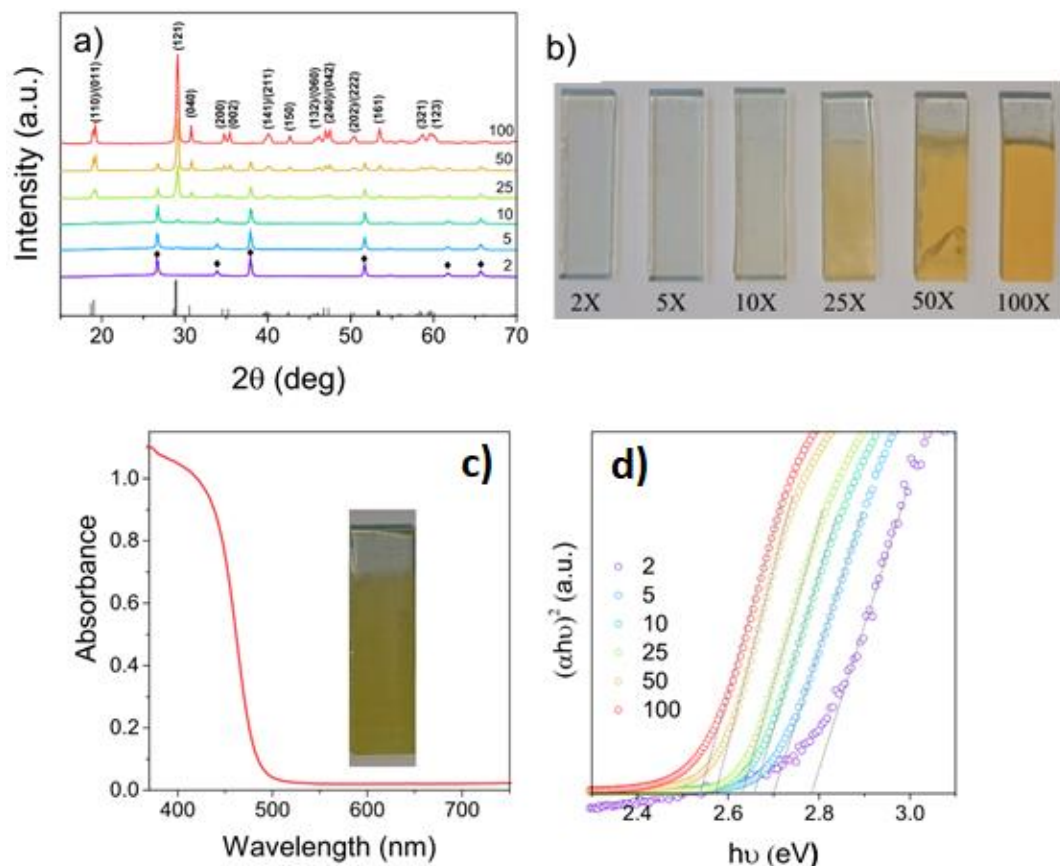

Figure 1: a) XRD patterns for BV films deposited from 50 mM precursor solutions vs number of SILAR cycles. b) Appearance of films fabricated by varying dip counts. c) Optical absorption of a typical BV film with a photograph of the sample. d) Tauc plots as a function of the SILAR dip count.

The surface morphology was examined by electron microscopy (SEM) and the increasing presence of BV with the dip count was corroborated. The particle size in films fabricated with 2 and 5 dip counts were minute such that they were not visible under magnifications utilised in the examinations. The surface features observed mostly in Figure 2a belong to the underlying FTO substrate. However, as the dip count increased, the presence of BV increased along with the particle size. This trend is clearly observed in the film series (Figure 2a-f).
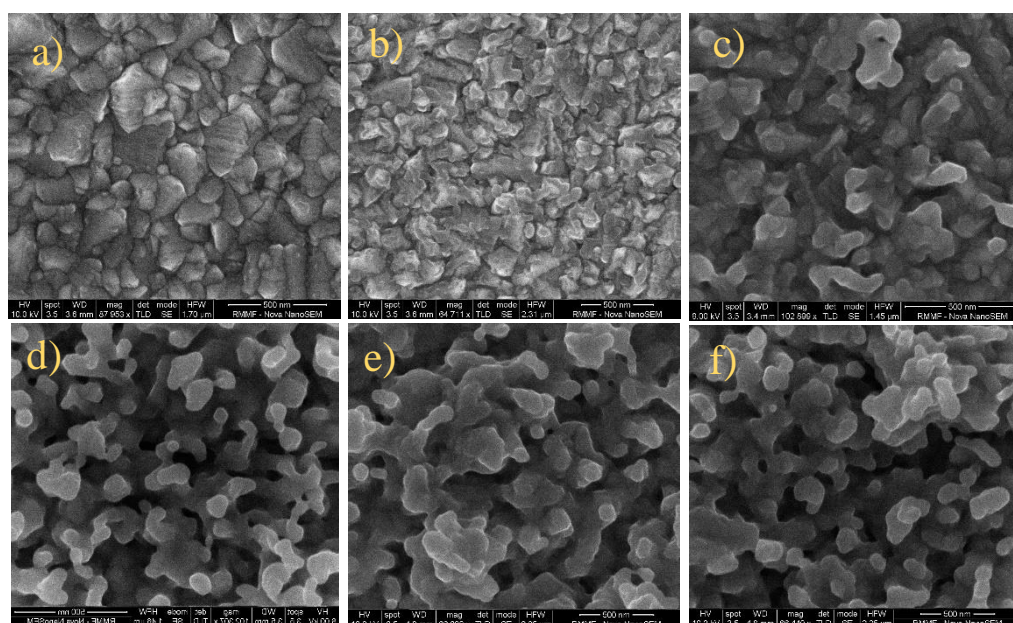
Figure 2: BV films fabricated with different dip counts: a) 2, b) 5, c) 10, d) 25, e) 50, f) 100
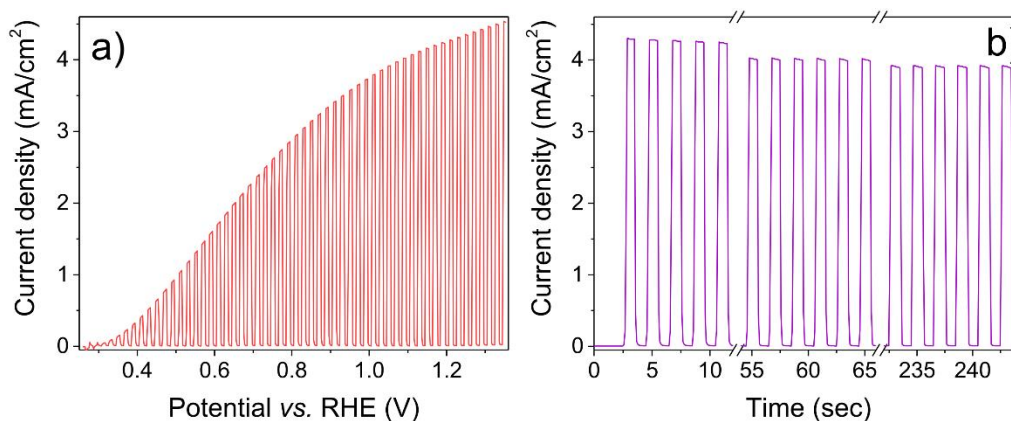

Figure 3. Photoelectrochemical characterization. a) Current-Voltage scan for one of the best BV photoanodes in the presence of sulfite buffer under blue LED chopped irradiation.
b) Chronoamperometry under chopped light at 1.23 V vs. RHE.

PEC tests were performed under chopped blue radiation (455 nm) with a power of 25 mW/cm^2. The light absorption in this scenario seems to be analogous to simulated sunlight in terms of photocurrent produced in $BiVO_4$ (Ratnayake, Ren et al. 2021). Figure 3a shows the photocurrent under blue light for one of the best performing samples. The voltage is scaled against the Reference Hydrogen Electrode (RHE). The respective current onset potential was observed at around 0.3 V *vs.* RHE, followed by a steep upshift in the photocurrent as the voltage increased. The photocurrent density of interest (1.23 V *vs.* RHE) for this specific sample was amongst the highest belonging to solution deposited BV films of this sort (4.3 mA/cm^2). Chronoamperometric measurements at a fixed voltage (1.23 V *vs.* RHE) exhibited highly reproducible photocurrents with fast on/off switching under chopped light. Although, during the first few seconds of light exposure, there was a minor decrease in current density, the photocurrent stabilized with time and retained around 4 mA/cm^2 (Figure 3b).

Photocurrent densities of other samples in this study were observed to be stable under the employed test settings.

4. CONCLUSION

The optimal conditions for SILAR-deposition of BV photoanodes for solar water splitting were identified as 25-50 mM precursor concentration and 50-100 SILAR dip cycles. Record photocurrents of ~4 mA/cm^2 were produced in optimized films. With respect to the obtained results, the simpler SILAR deposition of BV can be claimed as a competent technique in comparison to cost intensive and cumbersome chemical bath and vapor deposition methods. Further studies are warranted on the usage of this technique on additional photoactive material that can be used as efficient photoanodes for solar water splitting.

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ENGAGING DOMESTIC OCCUPANTS IN SOLID WASTE MANAGEMENT

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ABSTRACT: Domestic solid waste management (DSWM) is a global problem, and Sri Lanka is no exception. Over the last few decades, DSWM has led to several human and environmental issues in the island nation. Waste management is a two-way process that requires a considerable amount of user effort and is underpinned by a willingness to act responsibly, the availability of infrastructure, and governance arrangements over time and space. Understanding the needs, and the barriers to waste management from the perspective of the waste generators and the waste managers are essential to bridge the gap and transit into a more sustainable management system. In this study, we report on the social awareness and perceptions of solid waste management and its consequences, the key constraints affecting domestic occupants' engagement with waste management, and how they can be engaged in DSWM in the future. Data were collected using a self-administered survey and analysed using various qualitative and quantitative statistical techniques. The survey respondents were primarily adults aged 40 or over, with secondary education and living in rented houses for more than ten years, mainly due to easy access to work and schools. Overall, the respondents indicated a higher awareness of various types of waste generated at home but lacked an understanding of hazardous waste and its disposal options. The garden disposal method is still widespread among the participants, regardless of its negative consequences on human health and the health of the receiving environment. Respondents were willing to engage in waste management if given more information, time to adapt, and improved infrastructure. To better engage domestic occupants in waste management we recommend a place-based, multidisciplinary awareness strategy involving multiple agencies and targeting people with different social, cultural, and economic statuses.

Keywords: Sri Lanka, Waste-management, Perceptions, Community-engagement

1. INTRODUCTION

Domestic Solid Waste Management (DSWM) is a global problem that has considerable management implications for developed and developing nations. Sri Lanka too is facing multiple socio-environmental issues related to managing its waste and waste from other nations (Hemantha, 2020). The country generates approximately 7000 MT of waste per day, primarily biodegradable waste, but only half is collected through council disposal processes (Abeynayaka & Werellagama, 2007). In 2019, a garbage pile collapse in the capital city of Colombo claimed 19 lives and caused considerable property damage (Arachchige et al., 2019). The poor management of waste has also led to microplastic and e-waste contamination of the local environment, and the receiving waters in Sri Lanka (Ranasinghe & Athapattu, 2020). Managing domestic waste in the backyard has been a common practice, however, reduced land allocation for housing and increased use of non-compostable products have made self-management of waste difficult. Although various waste management approaches have come into effect over the last few decades, when targeting different waste types, most cities lack the capacity to manage the increased demand for waste services (Vidanaarachchi, Yuen, & Pilapitiya, 2006).

The efforts by local authorities to manage solid waste generated within their jurisdictions can be enhanced through effective community engagement, awareness, and active participation in solid waste management. Educational programs could influence the mindset of people to make

behavioral changes and appreciate their contribution to sustainable development through proper waste management (Bernardes & Günther, 2014). Hence understanding community perceptions is important to improve the efficiency of DSWM processes and find suitable strategies to engage the unengaged. This paper aims to determine (1) the level of social awareness and perceptions of solid waste management and its consequences, (2) the key barriers to domestic occupants' engagement in solid waste management, and (3) the pathways through which domestic occupants can become involved in waste management processes.

2. METHODOLOGY

A detailed self-administered questionnaire was developed following a literature review on issues associated with domestic waste management worldwide, and in Sri Lanka. Responses were a mix of predetermined categorical answers and Likert scales. The questions included user behavior patterns related to DSWM and their perceptions of active engagement. The questionnaire was administered by university students and supervised by two staff members. After data collection, the survey responses from the paper versions were transcribed into electronic form and analyzed using Excel and R statistical programs.

3. RESULTS AND DISCUSSION

The respondents were primarily adults aged 40 or over with secondary education and a medium monthly income of Rs. 35,000-300,000. Of the respondents, 91% were living in rented houses for more than ten years, mainly due to easy access to work and schools. Most houses (62%) had up to four occupants at the time of the survey.

The social awareness of the respondents and options available for the management of DSWM were assessed using multiple indirect questions. Overall, 97% of the respondents were aware of the various types of waste and often collected them in bags and emptied them daily (68%). When asked why they were bagging the waste, 45% believed that they do so because they care about the environment, 27% said it was due to awareness programs, and 15% said the council would not collect the waste unless bagged.

The most frequently spoken three words of the respondents when describing solid waste management, in general, were *plastics* (polythene and plastic) and *recycling* (compost and recycle) followed by *Local councils*. A follow-up question about their awareness of common waste disposal options revealed that they were primarily aware of composting, separating waste, recycling, burning, and handing it over to the council for disposal. But they were less aware of reuse as a method of waste management. Interestingly, about half the respondents knew about three major types of waste collection in other countries. In particular, over 80% of the respondents were aware of the roadside collection method, due to its current application in Sri Lankan cities.

Preferred disposal options for various types of waste show considerable heterogeneity (Figure 1). For example, there is a clear trend that hazardous waste such as chemicals, solvent-based paints, and asbestos products are disposed of using more than one method. While council collection was popular for all waste types in general and for pharmaceuticals and plastics in particular, building, organic waste, paper, and oils were disposed of in the garden. The garden disposal method is common for all types of domestic waste, which raise concerns as the leachate could contaminate nearby groundwater and surface water sources. In response to the

fate of the waste, respondents strongly felt that waste collected by the councils and collectors was either burned or dumped into a pit, with 14% of the respondents being unaware of its fate. Further, the respondents lacked knowledge of the consequences of the disposal of hazardous waste, the benefits of recycling, and locations for recycling. However, the participants had a good understanding of the consequences of burning waste at home.

The key barriers to better DSWM were assessed using 13 predetermined statements. Two out of the top five statements to which the respondents agreed strongly were related to their understanding viz., *'I do not believe DSWM is important'*, *'I don't know how to manage my waste'*. In similar proportions, respondents agreed on funds for infrastructure and time as significant constraints. This interesting result highlights the need to have more targeted
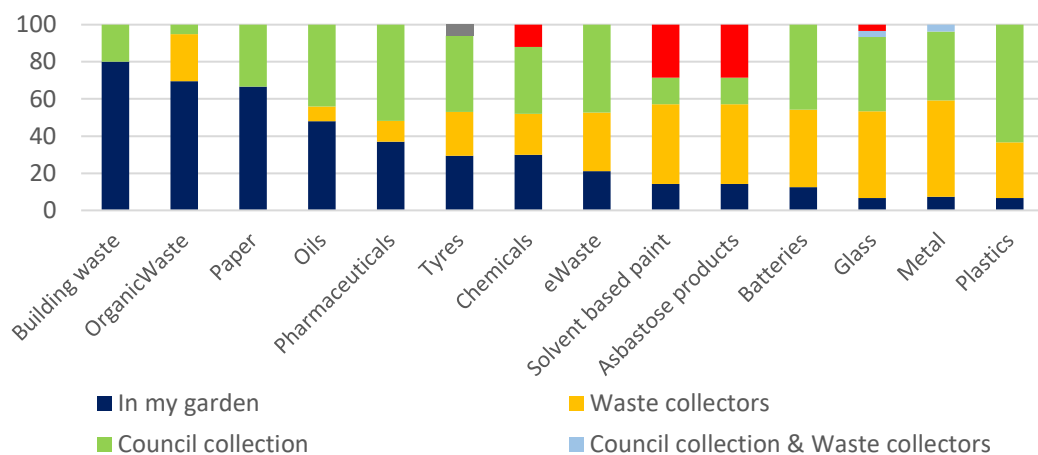

Figure 1: Preferred waste management methods among respondents

awareness programs to better engage domestic occupants in DSWM with suitable infrastructure. Respondents were also given six statements to better understand their preference for engaging in DSWM. Interestingly, over 80% of the respondents were happy to take action to minimize waste generation. This was followed by about 79% agreeing that they need to be more knowledgeable about DSWM. Paying an extra tax was the least preferred way to engage.

Similar to the study by Warunasinghe and Yapa (2016), our results agree that the occupants generally have a higher awareness of major waste types generated within their households. However, they showed a lack of understanding of hazardous wastes and the entire lifecycle of domestic solid waste. For example, the garden disposal method is still popular among the participants meaning they may continue this practice unless its flow-on effects on the receiving environment are clearly explained. Overall, the respondents indicated their willingness to take action to minimize waste generation if given more information, improved infrastructure, and time to adapt. Abeynayaka and Werellagama (2007) also reported similar results of the users' willingness to engage in a suitable domestic system of waste separation if made available to them. For domestic occupants to be more engaged, we recommend a place-based, multidisciplinary awareness strategy involving multiple agencies targeting people with different social, cultural, and economic statuses.

4. CONCLUSIONS

Issues related to DSWM are often exacerbated by the attitudes of citizens, lack of open space for landfills, poor infrastructure, and management options used for the collection and processing of waste. We believe that social perceptions and awareness of DSWM are central to creating more sustainable, resilient, and locally relevant waste management systems.

The participants indicated a higher awareness of various types of waste generated at home. Our sample agreed on the importance of separating their waste at source; however, this pattern may vary in other local government areas of the country. Also, the respondents were less knowledgeable about the fate of waste. In particular, they indicated a lack of awareness of hazardous waste management and its life cycle. Had they known the entire life cycle, they would have become more responsible for its generation and safe handling.

Although local government authorities' collection systems were available, the participants still practiced backyard disposal methods, including dumping and burning, without knowing their long-term negative impacts on the receiving environment. Respondents agreed that they need more information, improved infrastructure and time to better engage with the DSWM. Further, they believed that their current level of engagement could be enhanced by taking action to reduce waste, by being more knowledgeable about different types of waste and by engaging in government programs. This engagement can be further enhanced through a place-based, multidisciplinary awareness strategy involving multiple agencies and targeting people with different social, cultural and economic statuses. The results of this study can be further strengthened by increasing the sample size and expanding the spatial coverage to include perceptions of different socio-economic profiles.

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IDENTIFICATION OF OPTIMUM BARIUM SULPHATE FILLER LOADING FOR NATURAL RUBBER/HIGH-DENSITY POLYETHYLENE BLEND FOR ROOFING APPLICATION –A STATISTICAL APPROACH

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ABSTRACT: Although having scientifically proven health risks, asbestos is a widely used roofing material in Sri Lanka due to its low cost and installation easiness. Developing a new roofing material, which is safer and cost-competitive, will reduce the importation of this type of roofing sheets. Therefore, a natural rubber (NR)/high-density polyethylene (HDPE) blend with a 20/80 composition was used in this study to develop a new roofing material. Cost-competitive roofing material could be produced only if low-cost fillers are incorporated. Barium sulphate (BaO4) was used as the filler not only for cost reduction but also to improve the properties of the roofing material. This analysis was carried out to investigate the optimum BaSO4 loading for the newly found NR/HDPE (20/80) blend. Prepared NR/HDPE blends by varying the BaSO4 loading from 25 phr, 50 -350 phr at 50 intervals were used to investigate the mechanical properties such as tensile strength, impact strength, tear strength, hardness, and elongation at break. The experiment was laid out in a complete randomized design (CRD) with five replicates for tensile strength and four replicates for the other tested properties. Design of experiments; Analysis of variance (ANOVA) and Tukey's multiple comparisons were used to investigate the experimental data. The result of the statistical analysis identified 50 phr as the optimum BaSO4 loading for the NR/HDPE (20/80) blend for roofing application.

Keywords: ANOVA, Tukey, Natural Rubber, High-Density Polyethylene, Filler

1. INTRODUCTION

Asbestos is the most commonly used roofing material when compared to other roofing materials like clay, metal, plastic, etc. However, long-term use and exposure to asbestos will become a threat to the health and well-being of human beings (Stayner et al., 2013; Visonà et al., 2018). Therefore, the development of a health hazard-free and cost-effective material with appropriate properties for producing a safe roofing material will fulfill the needs of society. Much research has been carried out to develop new roofing materials and to improve the existing materials (Aremo & Adeoye, 2008; Darsana et al., 2016; Kizito et al., 2021). A natural rubber/ high-density polyethylene blend with a composition of 20/80 has been identified as the best blend for roofing material (Wickramaarachchi et al., 2019). A cost-competitive, property improved and modified roofing material could result, only if low-cost fillers are incorporated (Ji et al., 2021; Zhu et al., 2021). Among six functional fillers, $BaSO_4$ has been identified as the best filler for the NR/HDPE (20/80) blend for roofing material (Wickramarachchi et al., 2020). Although fillers are added for cost reduction, an optimum filler loading should be used for a blend as their properties vary according to the filler loading (Zhu et al., 2021). Therefore, this analysis is focused on investigating the optimum $BaSO_4$ filler loading for the NR/HDPE (20/80) blend using tested data records related to the five mechanical properties of the blends.

The computations associated with the design of an experiment are referred to as an analysis of variance (ANOVA) (Shalmany & Shivazad, n.d.; Sparks, 1963). In this study, to compare the means of five mechanical properties, the ANOVA was more appropriate. When there was a significant difference among means of five mechanical properties, Tukey's multiple comparison test was used to find the optimum $BaSO_4$ filler loadings (Conagin et al., 2008; Shenoy et al., 2021).

2. METHODOLOGY

Eight levels of $BaSO_4$ were applied for the NR/HDPE blend. Then five mechanical properties such as tensile strength, impact strength, tear strength, hardness and elongation at the break were measured. The mean values of the tensile strength was measured by five replicates and the mean values of other mechanical properties were measured by four replicates under eight levels of $BaSO_4$.

The statistical software of Minitab 18 was used to analyze the experimental data. First, the data grid was prepared to apply ANOVA and the following hypotheses were tested at 5% level of significance.

H_0 : There is no significant difference among means of eight BaSO4 levels of ith
      mechanical property

H_1 : There is significant difference among means of eight BaSO4 levels of ith
      mechanical property

When significant differences exist among means of eight $BaSO_4$ levels of ith mechanical property, Tukey's test was performed to identify the optimum $BaSO_4$ filler loading for each mechanical property. Finally, the optimum $BaSO_4$ filler loading for the NR/HDPE (20/80) blend which showed the highest mean values for the most number of mechanical properties was identified.

3. RESULTS AND DISCUSSION

First, the data distributions of each mechanical property using different levels of $BaSO_4$ filler loadings were observed visually as follows:
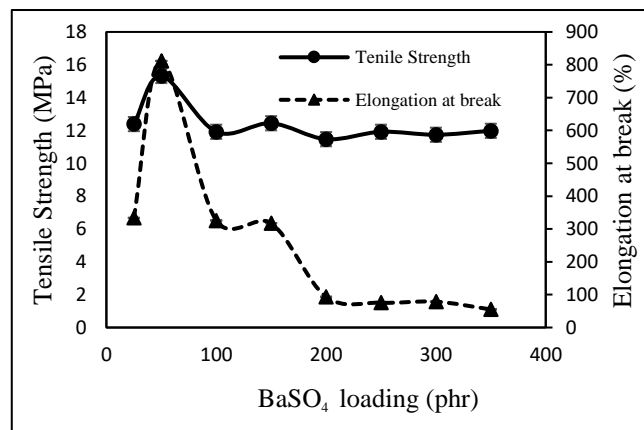

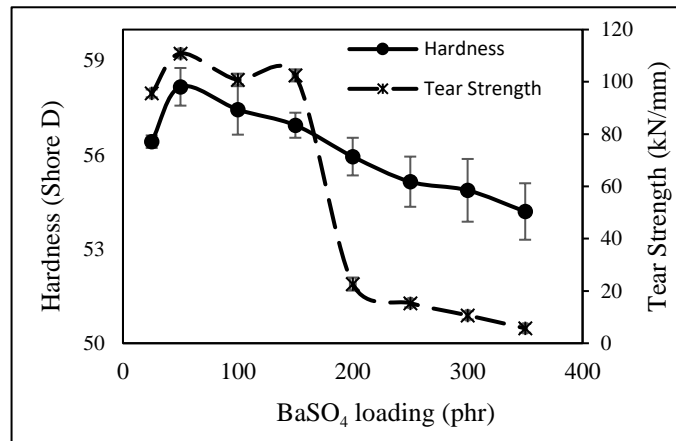*Figure 1: Variation of Tensile strength and Elongation at break with $BaSO_4$ loadings*

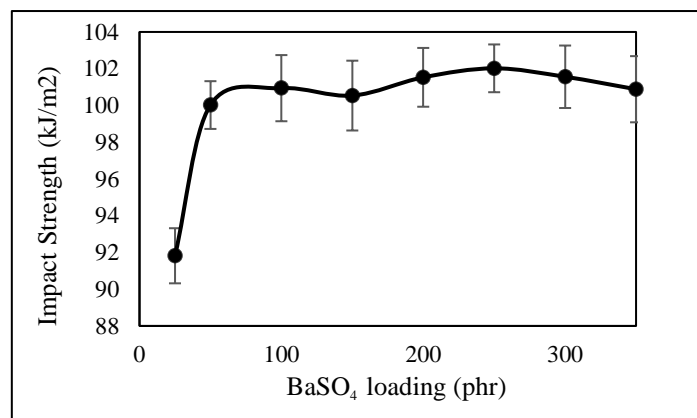*Figure 2: Variation of Tensile hardness and Tear strength with BaSO$_4$ loadings*

Figure 3: Variation of Impact Strength with BaSO$_4$ loadings

According to Figures 1-3, all the mechanical properties except impact strength offer the highest values for 50 phr of BaSO$_4$ loading. 250 phr of BaSO$_4$ loading show the highest impact strength for the NR/HDPE blends. However, the variation of the impact strength between 50 - 350 phr of the blends is very low. Values for other properties dropped drastically after the 50 phr of BaSO$_4$ loading.

A High amount of filler loadings results in difficulties when mixing. Therefore, a blend with 50 phr of BaSO$_4$ gives the optimum properties for roofing material.

Then ANOVA tests were performed to identify whether there is a significant difference among the mean values for the five mechanical properties. The test results are given in Table 1.

Table 1: ANOVA test results for mechanical properties

Mechanical Property	P-value	Decision
		(Reject Null Hypothesis: P-value < α=0.05)
Tensile Strength	0.000	Reject Null Hypothesis
Impact Strength	0.000	Reject Null Hypothesis
Tear Strength	0.000	Reject Null Hypothesis
Hardness	0.000	Reject Null Hypothesis
Elongation at break	0.000	Reject Null Hypothesis

Since the p-values of all five mechanical properties were zero (P-value = 0.000), the null hypothesis was rejected. Therefore, it can be concluded that there is a significant difference in the eight levels of $BaSO_4$ for each mechanical property. Tukey's multiple comparison tests were therefore performed to identify the $BaSO_4$ level which gives the highest mean values for each mechanical property. The obtained results from Tukey's multiple comparison are given in Table 2.

Table 2: Mean difference

$BaSO_4$ level which gives the maximum mean difference	Mechanical Property	Highest mean value
50 phr -25 phr	Tensile strength	Mean at 50 phr : 15.322
350 phr -50phr	Tear strength,	Mean at 50 phr : 110.870
	Hardness	Mean at 50 phr : 58.175
	Elongation at break	Mean at 50 phr : 812.000
250 phr -25 phr	Impact strength	Mean at 250 phr : 102.020

According to Table 2, the highest mean values in Tensile strength, Tear Strength, Hardness and Elongation at break are given at 50 phr level of $BaSO_4$ and the highest mean impact strength is given at 250 phr $BaSO_4$ level. Since four mechanical properties out of the five gave the highest mean values at 50 phr $BaSO_4$ level it was decided to select the 50 phr level of $BaSO_4$ as the optimum level for the NR/HDPE (20/80) blend.

According to the visual illustration of the graphs, the 50 phr is the highest mean value for the tensile strength, the tear strength, hardness and elongation at break. 250 phr was identified as the highest mean value for the impact strength. The ANOVA tests were used to test the significant differences among the mean values of the five mechanical properties by using eight levels of $BaSO_4$. It was concluded that there is a significant difference among the mean values of the five mechanical properties at each $BaSO_4$ level. Thereafter Tukey's multiple comparison tests were performed.

According to Table 2, the highest mean values in Tensile strength, Tear Strength, Hardness and Elongation at break are given at 50 phr level of $BaSO_4$ and the highest mean impact strength is given at 250 phr $BaSO_4$ level. Since four mechanical properties out of the five gave the highest mean values at 50 phr $BaSO_4$ level it was decided to select the 50 phr level of $BaSO_4$ as the optimum level for the NR/HDPE (20/80) blend.

4. CONCLUSION

According to the visual illustration of the graphs, the 50 phr is the highest mean value for the tensile strength, the tear strength, hardness and elongation at break. 250 phr was identified as the highest mean value for the impact strength. The ANOVA tests were used to test the significant differences among the mean values of the five mechanical properties by using eight levels of $BaSO_4$. It was concluded that there is a significant difference among the mean values of the five mechanical properties at each $BaSO_4$ level. Thereafter Tukey's multiple comparison tests were performed.

It was noticed that the means values for the Tensile strength, the Tear Strength, Hardness and Elongation at break were given at 50 phr level of $BaSO_4$ and the highest mean value for the Impact Strength was given at 250 phr $BaSO_4$ level. Also, from the pairwise comparison it was observed that the 50 phr level of $BaSO_4$ resulted in the highest mean difference from other phr levels of $BaSO_4$, except the mean values for the impact strength. Finally, it is concluded that the 50 phr level of $BaSO_4$ is the optimum level for the NR/HDPE (20/80) blend since four mechanical properties out of five give the highest mean values at 50 phr $BaSO_4$ level.

5. ACKNOWLEDGMENT

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COMPARISON OF DRYING CHARACTERISTICS OF SRI LANKAN CLOVES DRIED IN A FLUIDIZED BED DRYER AND A CONVECTION TRAY DRYER

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ABSTRACT: Drying characteristics of clove buds were studied in a laboratory-scale fluidized bed dryer, and a laboratory scale convection tray dryer. Freshly harvested clove flower buds were dried at 55º C and 65º C hot air temperatures at constant air flow rates. The drying kinetics of cloves were analyzed by analyzing the variation of the moisture content of cloves with drying time. The highest drying rate was achieved when drying at a 65º C temperature in the fluidized bed dryer under investigation. The drying operation of cloves in the fluidized bed dryer and the convection tray dryer underwent falling rate drying periods.

Keywords: Cloves, Drying, Fluidized Bed, Convection Tray Dryer, Moisture Content

1. INTRODUCTION

Cloves botanically known as *Syzygium aromaticum* is a commonly used spice in Sri Lanka. The unopened flower bud is the main harvestable part of the tree, and the dried clove bud or the extracted oil is used to improve the flavor and the aroma of cuisines and to make medicines (Uddin et al., 2017). The quality of dried cloves strongly depends on their moisture content, the drying technique, and the drying temperature. Although Sri Lanka is one of the top exporters of cloves to the global market and fulfills nearly 8.5% of the global demand for cloves, the use of low-cost industrial dryers for drying cloves is significantly lower than that of the other countries that grow cloves commercially. Sri Lankan farmers use open sun drying as their drying method. However, sun drying of cloves has some remarkable disadvantages such as having no control over drying, contamination from foreign materials, requiring a large amount of space, being subject to insect infestation, etc. Therefore; low-cost artificial dryers can be recommended to improve the quality of the harvest (Jayatunga & Amarasinghe, 2015).

Convection tray dryers are widely used to dehydrate some crops while fluidized bed dryers are rarely used for drying crops. Fluidized bed drying has been considered an economical method of drying because of its rapid heat and mass transfer rates, ease of handling, and uniform drying due to fluidization. Many research works have been reported on fluidized bed drying of agricultural products (Abesekara et al., 2020). Low-cost convection tray dryers also have great potential for drying the harvest of small-scale farms in batch drying operations. When selecting a dryer for small-scale farms, some critical factors must be considered such as initial capital cost, maintenance cost, energy consumption, etc. (Maduwanthi et al., 2021). In this research, the drying kinetics of cloves dried in a fluidized bed and a convection tray dryer are analyzed.

2. METHODOLOGY

Freshly harvested clove flower buds were obtained from a local farmer in Warakapola, Sri Lanka. The initial moisture content of the raw cloves was 0.701 kg/kg on a wet basis. They were stored at a normal room temperature after harvesting.

Cloves were dried using two different laboratory scale dryers; a fluidized bed dryer and a convection tray dryer at two hot air temperatures; 55˚C and 65˚C at a constant air velocity. Since some aromatic components can vaporize at high air temperatures and lower air temperatures can result in longer drying times, 55˚C and 65˚C were selected as the air temperatures (Jayatunga & Amarasinghe, 2019). The dimension of the fluidized bed dryer chamber was 100 mm×100 mm×200 mm and air velocity in the fluidized bed dryer was kept at 3.0 ± 0.5 m/s. The initial height of the static bed in the fluidized bed was 4 ± 0.5 cm. Cloves were spread evenly on two trays of the convection tray dryer which had dimensions of $400 \times 300 \times 15$ mm. Air velocity inside the tray dryer was maintained at 2.5 ± 0.3 m/s. Temperature fluctuations were controlled within ± 0.5 ˚C in all the experiments. The initial mass of every batch was around 250 g. The average volumetric air flow rates were controlled as 0.03 m^3/s in the fluidized bed dryer and 0.31 m^3/s in the convection dryer. Figure 01 and Figure 02 show the schematic diagram of the fluidized bed drying and the convection tray drying experiment set ups.
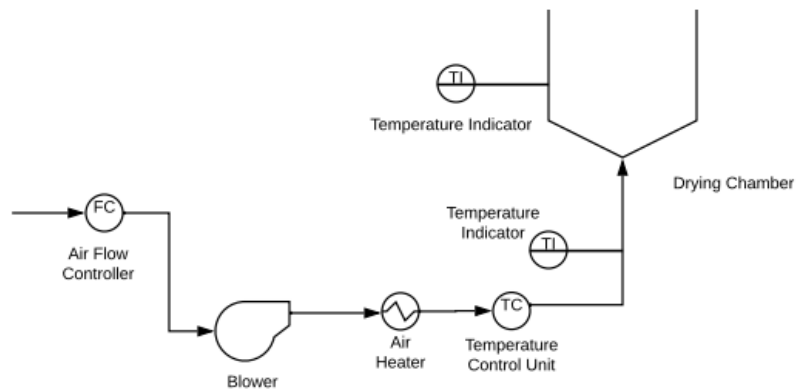

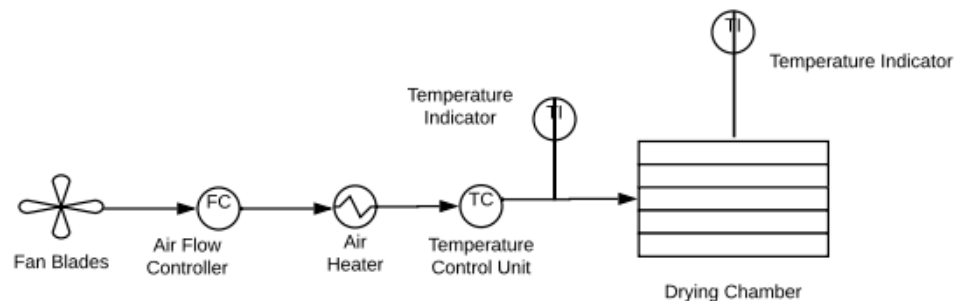*Figure 1: Schematic Diagram of the fluidized bed dryer*

Figure 2: Schematic Diagram of the convection tray dryer

The moisture content-dry basis, X (%) and moisture ratio (MR) of clove samples were calculated as per Equation (1) and (2). However, Moisture ratio was simplified to (X_i/X_o) due to variation in the relative humidity of drying air leading to a change in the equilibrium moisture content of the particle being dried (Midilli & Kucuk, 2003).

$$X = \frac{W_w - W_d}{W_d} \times 100 \qquad (1)$$

$$MR = \frac{X_i - X_e}{X_0 - X_e} \times 100 \qquad (2)$$

Where
X - Moisture content
X_e- equilibrium moisture content
X_i - i^{th} experimental moisture content and
X_o - initial moisture content
W_d- weight of sample after being dried in the oven
W_w- weight of sample before being dried in the oven

3. RESULTS AND DISCUSSION

Figure 03 and figure 04 represent the drying kinetics of cloves when dried in both the fluidized bed dryer and the convection tray dryer at 55°C and 65°C. Accordingly, an increase in the temperature from 55°C to 65°C caused a significant reduction in the drying time and an increase in the drying rate. When drying at 55°C in the fluidized bed dryer, cloves reached the moisture ratio of 0.4 within 250 minutes. However, more than 400 minutes were taken in the convection dryer to attain a moisture ratio of 0.4. When increasing the hot air temperature to 65°C, both dryers achieved a significant drying time reduction. To reach a 0.4 moisture ratio, 90 minutes and 240 minutes were spent respectively in the fluidized bed dryer and the convection dryer.

The moisture removal rate or the drying rate of fluidized bed drying of cloves is higher than that of the convection tray drying of cloves, although the air flow rate of the spouted bed dryer is almost ten times lower than that of the convection dryer. This indicates the higher performance of the fluidized bed dryer considering heat and mass transfer, compared to that of the convection tray dryer. Random fluctuation of material or fluidization behavior of cloves will enhance the heat transfer from the air stream to the drying material and moisture transfer from the drying material to the hot air stream (Jayatunga & Amarasinghe, 2014). Even though an increased hot air temperature reduces the drying time and raises the drying rate, the quality of the final dried cloves can be affected. Therefore, the quality of the dried product such as flavor profiles and essential oil yields will be analyzed in future works.
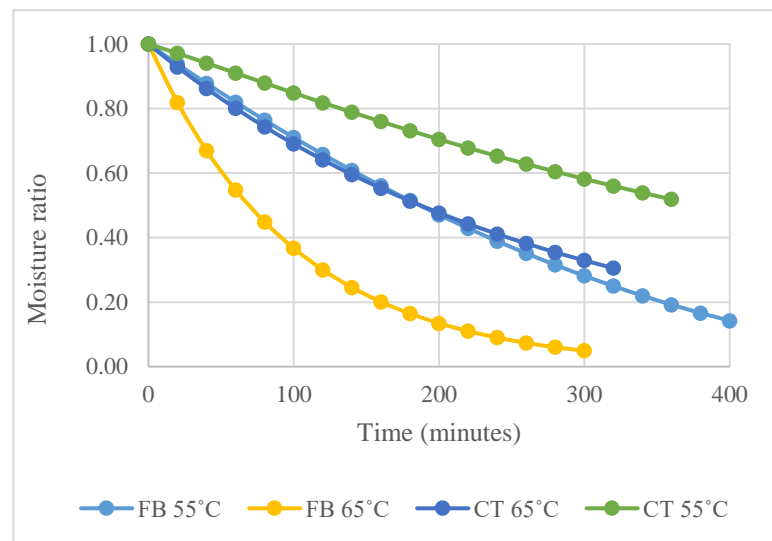
Figure 3. Moisture content vs time of cloves dried in fluidized bed dryer (FB) and convection tray dryer (CT) at 55 ˚C and 65 ˚C hot air temperatures
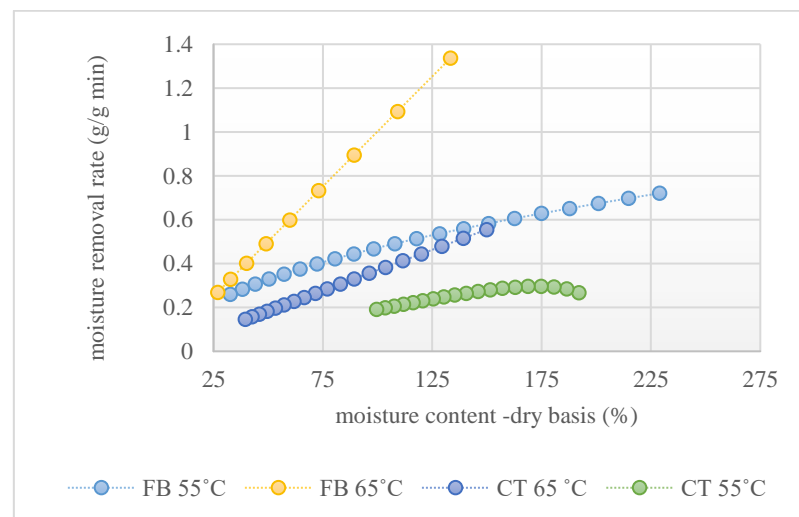

Figure 4: Moisture removal rate vs moisture content of cloves dried in fluidized bed dryer (FB) and convection tray dryer (CT) at 55 ˚C and 65 ˚C hot air temperatures

The drying kinetics of cloves in both the fluidized bed and the convection dryer lies in the falling rate period as in Figure 04. Similar trends were reported for various agricultural crops such as paddy, black pepper, etc.(Anuththara et al., 2019).

4. CONCLUSION

Fluidized bed dryers and convection tray dryers can be used for clove drying due to their simple design and good performance. According to the experimental results obtained at both hot air temperatures, drying cloves in the fluidized bed dryer at 65˚C is efficient and cost effective under investigations. The Fluidized bed achieves a faster drying rate at a moderately hot air temperature than the convection tray dryer.

5. ACKNOWLEDGEMENTS

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FACILE FABRICATION OF CONDUCTIVE SILVER NETWORKS THROUGH ELECTROSPINNING

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ABSTRACT: Transparent conductive surfaces have seen a rapid growth over the past few decades due to their widespread use in smart devices, wearables, optics, and environmental management applications. However, the conventional approach to making transparent conductive surfaces employ cost and energy-intensive methodologies including physical vapor deposition, chemical vapor deposition, and other thin film technologies. As a facile alternative for such processes, a thin film of conductive metal network can be assembled on a glass target by an electrospinning method. The setup required only a general electrospinning apparatus with no special conditions in the spinning chamber. The prepared conductive networks showed low sheet resistance of 12.0 ± 5.3 $\Omega/\square$ at optimized conditions. The prepared materials were subjected to microscopic analysis. It was observed that the conductive network is created through fused micro and nanoparticles of metallic silver. The proposed method may open up an interesting pathway to preparing conductive thin films to overcome the limitations found in traditional methodologies.

Keywords: Conductive, Thin films, Electrospinning

1. INTRODUCTION

Inefficient light extraction and transmittance through the top metal electrodes in devices that employ a transparent conductive interface is a major factor that adversely affects optical performance. In recent years, metallic grids and networks have attracted considerable attention as they not only make light extraction efficient (Hecht *et al.*, 2011) but also improve the charge transport and collection more efficient (Liu *et al.*, 2015).

Conventionally, transparent conductive surfaces are fabricated through chemical/physical vapor deposition techniques. However, these require relatively sophisticated equipment and processes carried out in specialized atmospheres. This inevitably reduces the application scope of the transparent conductive surfaces due to the increased cost of production, particularly in large area applications. Therefore, facile application procedures employing conductive nanomaterials are increasingly attracting interest among researchers and metallic grids have seen rapid growth as a potential avenue to address the above challenges.

Metallic grids are typically fabricated through the arrangement of conductive nanowires on surfaces (Hecht *et al.*, 2011), for which a number of elaborate processes such as nanowire preparation, preparation of printable paste, surface printing, drying and sintering are required. In this work we introduce, electrospinning as a direct deposition method of precursor Ag rich microfibers which can be transformed into a low resistance conductive electrode through a facile sintering process at atmospheric conditions.

2. METHODOLOGY

In a typical experiment, 0.2 g of polyvinylpyrrolidone (PVP) having a molecular weight of 1,300,000 was dissolved in acetonitrile. Then 1.0 g of silver nitrate was added and dissolved to form 2.0 ml of solution that was transparent and free of any solids. The solution was then charged onto a 10 ml syringe with a needle and electro-spun onto a glass target situated 15 cm away from the syringe tip inside an electrospinning unit operating at 20 kV. The rate of injection was 10 µl/min and the collection time was 30 s. Obtained fibers on the glass target were calcinated at 300° C inside a preheated oven for a predetermined time period (studied in this work) to obtain the conductive network.

3. RESULT AND DISCUSSION

Electrospun Silver & PVP (AgPVP) structures and their fate at various stages of the conductive network preparation process were microscopically analyzed using SEM. Fig. 1(a) and Fig. 1(b) show SEM micrographs of the resulting electrospun AgPVP structure. It could be observed that the majority of the fibers exhibited diameters in the range of 2.5 – 3.5 µm. The fiber surface was characterized by occasional ridges and elevations. Approximately 5% of the fibers exhibited beaded formations as depicted in the micrographs. These fibers showed intermittent sparse regions along the length which led to a bead at the end. Fig. 1(c) shows the AgPVP deposited glass surface after sintering at 300° C temperature under atmospheric conditions. The Micrograph clearly showed that electrospun AgPVP microfibers were no longer present on the glass collector. Instead, a material resembling an interconnected network had deposited. A magnified image of the deposit (Fig. 1(d)) indicated the presence of a fused particulate with a dense coverage.

The atomic composition map of the deposit and the surrounding area shown in Fig.1(c) was investigated using the EDX technique. The Ag Lα and Si Kα maps for the investigated region are shown in the Fig. 1(e) and Fig. 1(f) respectively. It could be clearly seen that the Ag Lα was heavily localized to the deposit area suggesting that a main composition of the deposition was silver based. Further, it's also evident that the presence of silver atoms in the places where the deposit is present is relatively low. In addition, the presence of O Kα and Na Kα (Fig. 1(g)) similar to the distribution map of Si Kα strongly suggest that these signals were coming from the glass collector. Other atoms such Carbon and Nitrogen, which were present on the electrospun AgPVP fibers were also not detected. Therefore, the SEM and EDX analysis suggests a formation of silver rich deposit after the sintering process.
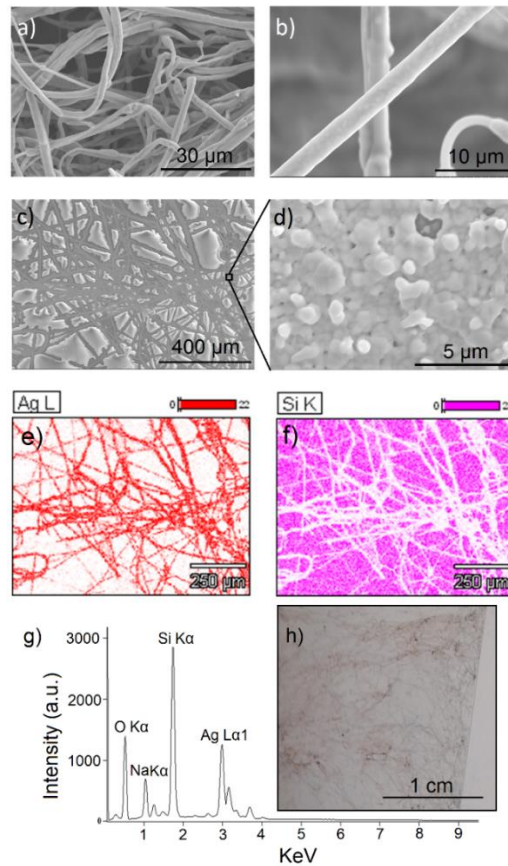
Figure 1: (a) SEM of electrospun AgPVP (b) magnified AgPVP (c) AgPVP on glass surface after sintering (d) a magnified region after the sintering process (e) EDX of Ag Lα map for area in Figure 1(c) (f) EDX of Si Kα map for the area shown in Figure 1(c) (g) EDX for the area in Figure 1(c) (h) photographic image on sintered AgPVP microfibers

Figure 1(h) shows a macroscopic image of sintered AgPVP microfibers on a glass target. The resultant deposit was silvery brownish in color and appeared as an interconnected network even to the naked eye. The network density was not uniform across the surface due to inhomogeneous deposition of AgPVP. Transmission of the light through the glass target (through 1 cm x 1 cm area) varied from ~50% to ~10% depending on the density of the deposit.

To further study the sintering process of the electrospun AgPVP structure, TGA measurements were carried out and are shown in Figure 2(a). The TGA thermogram shows a gradual reduction of weight till 210°C followed by a very rapid loss of weight within a 10°C temperature range. This rapid loss is closely followed by a peak (exo up direction) in the

differential thermogram. The gradual reduction up to 210° C can be attributed to the drying and solvent evaporation from the PVP material. material.
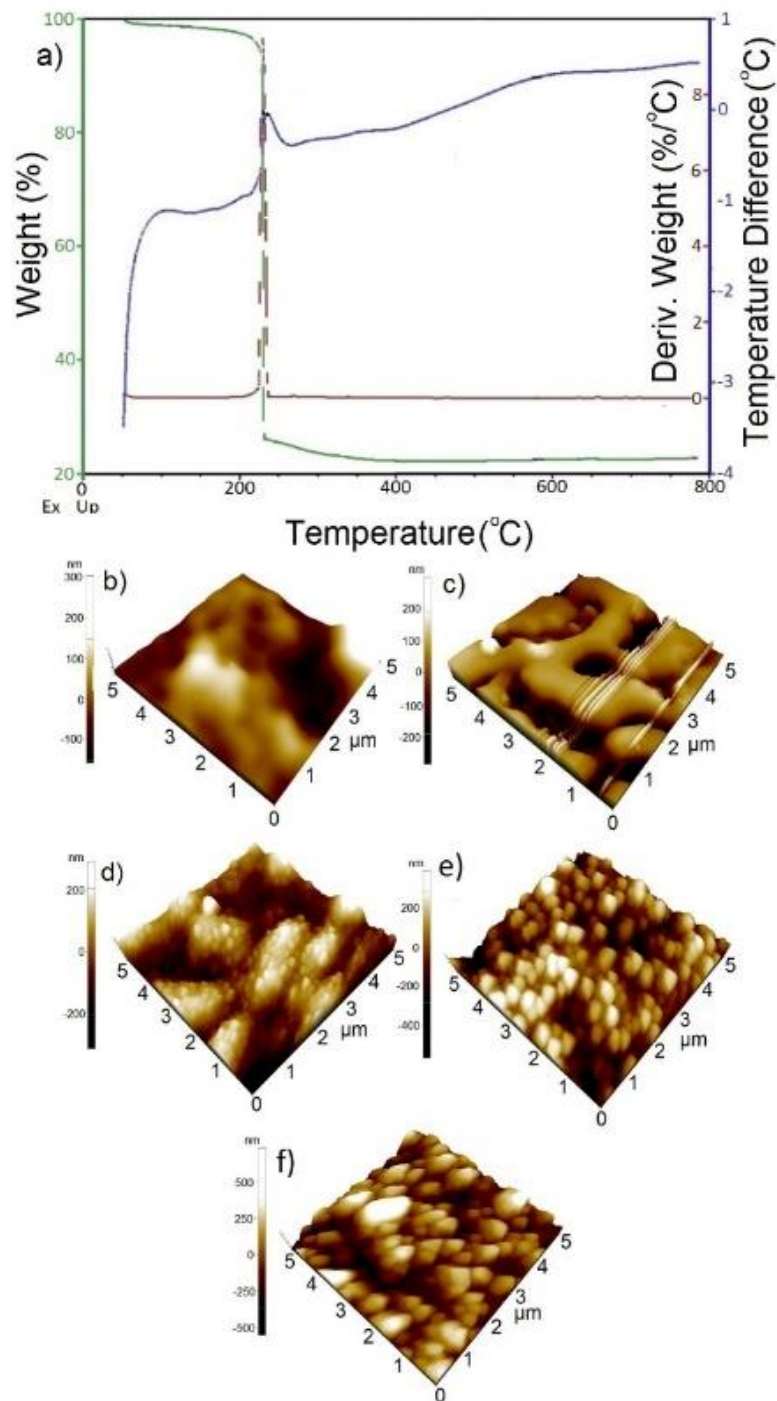

Figure 2: (a) TGA of AgPVP (b) surface morphology of AgPVP (c) surface morphology of AgPVP after thermal treatment for 0.5 min (d) after 1.0 min (e) after 2.0 min (f) after 3.0 min

The second steep weight loss was attributed to the oxidation of PVP. Silver is a strong oxidizing agent particularly at higher temperatures (Jin *et al.*, 2006, Bober *et al.*, 2010) which can drive an oxidation reaction in PVP fiber matrix resulting a weight loss. Evidences for PVP

oxidation and parallel silver reduction (Navaladian *et al.*, 2006) can also be seen in AFM images of fibers taken at various stages of the thermal treatment. Prior to the thermal treatment, the PVP fiber surface was comparatively smooth and free of noticeable surface features (Fig.2 (b)).

Immediately (0.5 min) after the thermal treatment, depressions were seen to appear on the polymer surface (Fig.2 (c)) indicating polymer oxidation. Careful investigation of these depressions revealed the presence of particles at the center of the craters. A number of these particles were seen to increase with extended thermal treatment (Fig. 2(d)) and grow in size (Fig. 2(e)) and reach their maximum after 3.0 min (Fig. 2(f)). Surface roughness was also seen to increase with the time of the thermal treatment. The surface roughness of untreated AgPVP was 58.12 nm which increased to 68.34 nm after 0.5 min, 86.10 nm after 1.0 min, 109.64 nm after 2.0 min before finally reaching a value of 156.70 nm after 3.0 min of thermal treatment.
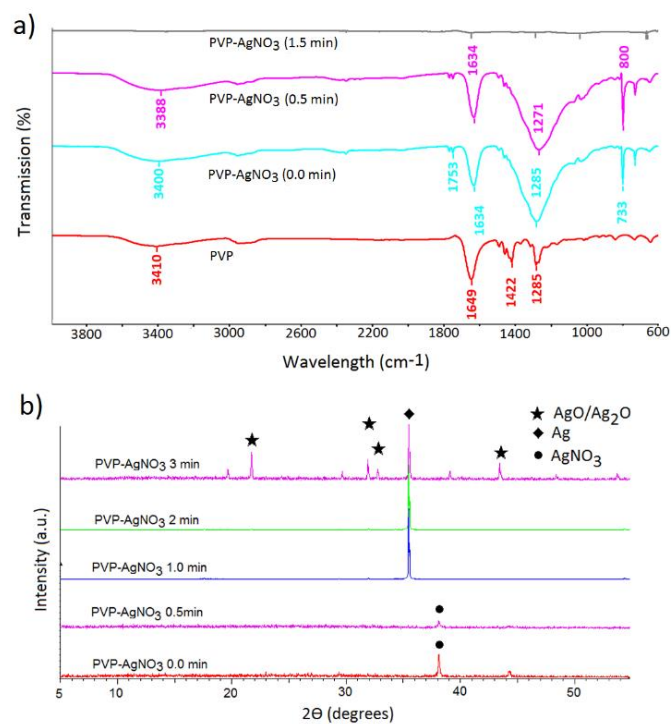

Figure 3: (a) FTIR spectra of PVP and AgPVP at various thermal treatment stages (b) XRD spectra of AgPVP at various thermal treatment stages

Chemical changes to AgPVP at various stages of thermal treatment was analyzed using FTIR and presented in Fig. 3(a). Pure PVP shows four major FTIR peaks located around 3410 cm^{-1}, 1649 cm^{-1}, 1422 cm^{-1} and 1285 cm^{-1} which can be attributed to O-H, C=O, C-H, and C-N bond stretchings respectively. The C=O absorption peak shows a strong shift from 1649 cm^{-1} to 1634 cm^{-1} in AgPVP. Such a reduction of C=O absorption stretching can be attributed to bond weakening as a result of back bonding. It can be expected that partial lone pair electron donation occurs from the carbonyl oxygen atom in PVP to Ag atoms which eventually forms a coordination type of interaction in the polymer matrix. Furthermore, in AgPVP bond attributed to C-H is significantly reduced with the significant broadening of the C-N absorption band with the overlapping of the C-O absorption region indicating strong coordination of Ag atoms in the PVP polymer matrix.

When AgPVP is subjected to thermal treatment for 0.5 min., a significant shift of the C-N peak was observed from 1285 cm^{-1} in untreated AgPVP to 1271 cm^{-1}. Also, this peak became broader encompassing absorption regions that are typical for a C-O stretch. This is strong evidence for polymer oxidation (Borodko *et al.*, 2006)

No strong absorption peaks were observed in the AgPVP microfiber sample after the thermal treatment of 1.5 min. This is indicative of almost complete thermal oxidation of the PVP matrix. These results complement the morphological transformation of the AgPVP matrix observed in AFM.

XRD was carried out to study the composition of the resultant material from the thermal treatment process and is shown in Fig. 3 (b). The XRD spectrum for AgPVP, prior to the thermal treatment showed a peak corresponding to the $AgNO_3$ crystals indicating the presence of $AgNO_3$ crystals in the polymer matrix. The intensity of this peak was seen to diminish with the thermal treatment as seen in the XRD spectra that corresponds to the 0.5 min thermal treatment. This could be due to further dissociation and reduction of $AgNO_3$. With extended thermal treatment strong Ag(0) was observed indicating the nucleation of silver(0). This was clearly seen in the XRD spectra corresponding to the 1.0 min and 2.0 min thermal treatment. With further thermal treatment (3.0 min) XRD peaks corresponding to Ag_2O started to emerge. Furthermore, the intensity of the Ag (0) peaks were seen to reduce indicating thermal oxidation of silver.

The pattern of silver reduction and further oxidation to Ag_2O was also reflected in the sheet resistance measurements of the thin film samples. Prior to the thermal treatment the sheet resistance of the thin film prepared by electrospinning AgPVP microfibers on to the glass collector was reaching infinity. After 0.5 min of thermal treatment, the sample showed a sheet resistance of $73.2 \pm 10.0 \ \Omega/\square$, which further reduced to a value of $12.0 \pm 5.3 \ \Omega/\square$ when the treatment continued for a duration of 1.0 min. From thereon, sheet resistance continued to increase to $23.1 \pm 7.3 \ \Omega/\square$ and to $45.3 \pm 8.9 \ \Omega/\square$, finally reaching $153.2 \pm 32.1 \ \Omega/\square$ at 1.5 min, 2.0 min and 3.0 min time durations respectively.

It's evident that the conductivity increased with the nucleation of silver nano/microparticles which reached its maximum at 1.0 min of thermal treatment. The reduction of conductivity at further treatment durations can be attributed to the oxidation of silver particles to Ag_2O.

4. CONCLUSION

$AgNO_3$ rich PVP microfibers were prepared on a glass target using electrospinning. These fibers were annealed at 300 ºC to prepare conductive thin films under atmospheric conditions. Electrical conductivity is due to formation of densely fused conductive networks of silver particles. Electrical conductivity of the thin film was observed to be a function of treatment time. The proposed method can be an interesting pathway to prepare conductive thin films using facile conditions.

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