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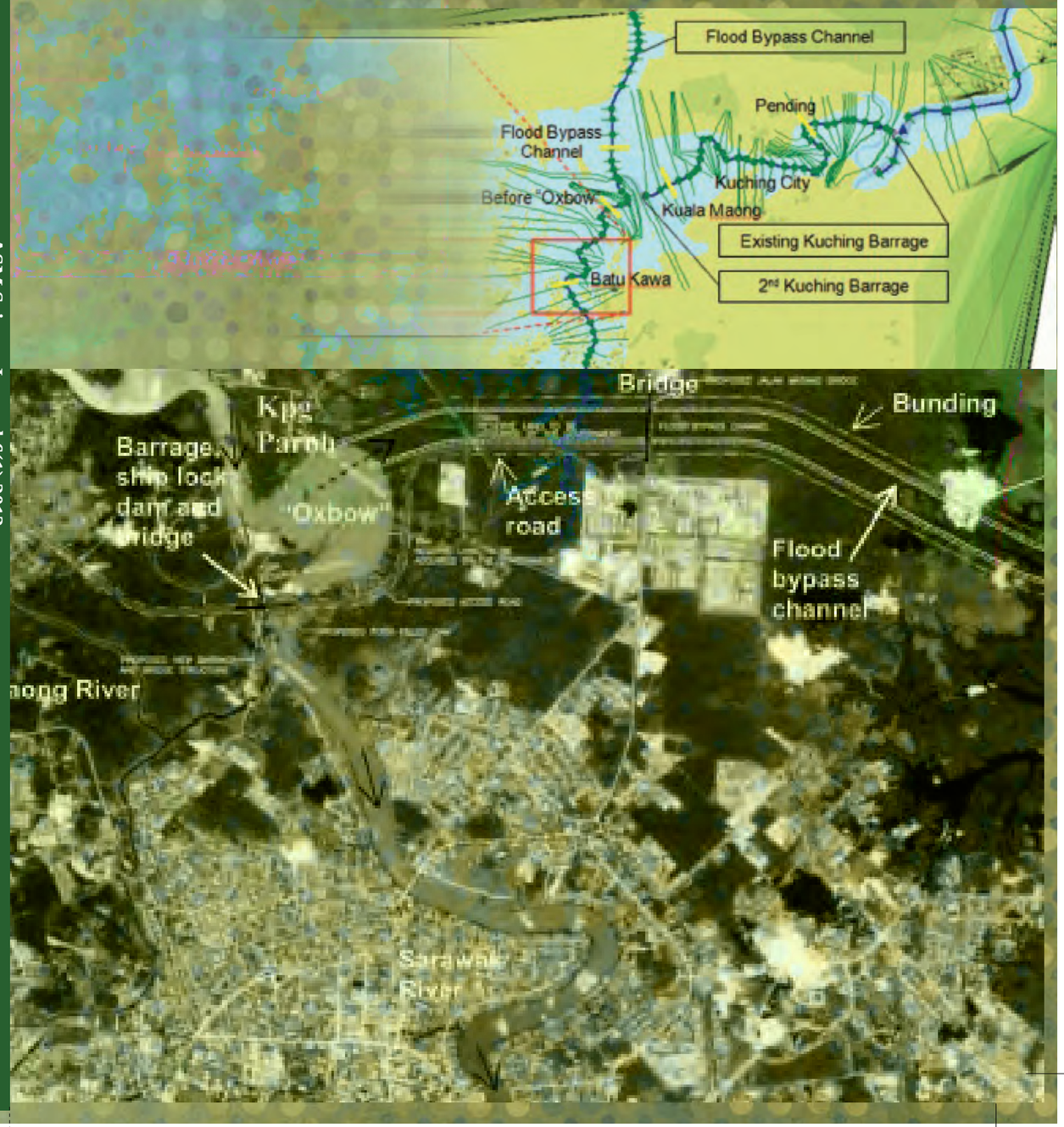

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ASM Science
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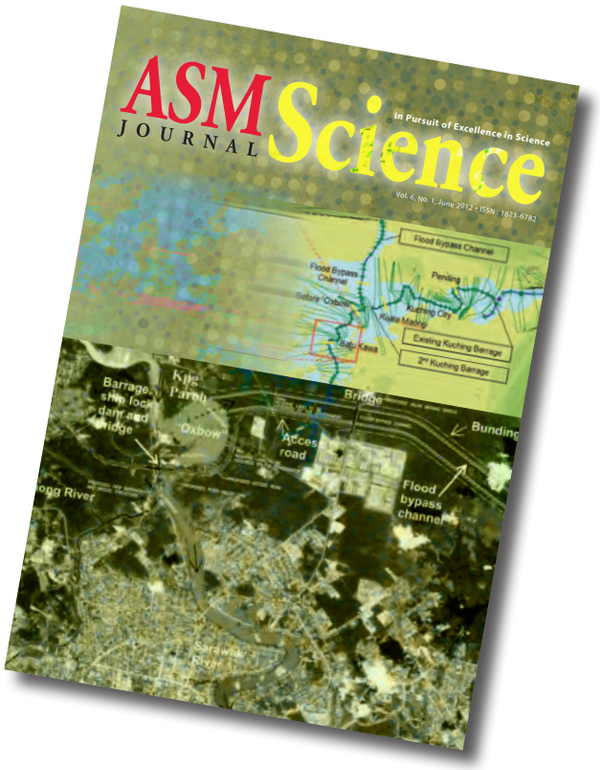
Cover:

Two figures are depicted—emanating from the findings of researchers from the Faculty of Engineering, University of Malaysia Sarawak in the article entitled *Tools for Integrated River Flood Management (Hydraulics Modeling and Logical Framework Analysis)*, (pp. 47–60). In the context of the various problems attributed by climate changes, river basin management is vital in 'achieving the protection, improvement and sustainable use of the water environment'. This article discusses how hydraulic simulation could be used as a supporting tool in planning and developing a framework for river management such as Integrated Flood Management for a river basin. It also demonstrates how a hydraulic model for the Sarawak River Basin was run using InfoWorks River Simulation software. The model was used as a tool to provide necessary decision parameters in developing the logical framework which could act as a guide for planning involving various stakeholders' participation.

The figure on the upper section of the cover (*Figure 7*, pp. 56) shows the simulation of the January 2004 flood event with the flood bypass channel in the lower Sarawak River. The lower image on the cover (*Figure 2*, pp. 49) is a technical drawing of the flood bypass structure superimposed on a satellite image. The flood bypass would include an 8 km long, 250 m base width, 10 m depth earth-dug (nature-like) rectangular channel (Jurutera Jasa Consulting Engineers) which is expected to be completed by 2015.



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- To provide a forum for the interchange of ideas among scientists, engineers and technologists
- To promote national awareness, understanding and appreciation of the role of science, engineering and technology in human progress
- To promote creativity among scientists, engineers and technologists
- To promote national self-reliance in the field of science, engineering and technology
- To act as a forum for maintaining awareness on the part of the Government of the significance of the role of science, engineering and technology in the development process of the nation and for bringing national development needs to the attention of the scientists, engineers and technologists
- To analyse particular national problems and identify where science, engineering and technology can contribute to their solution and accordingly to make recommendations to the Government
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- To formulate policy relating to the functions of the Academy
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The Future

Creativity and innovation are recognised the world over as the key measure of the competitiveness of a nation. Within the context of K-Economy and the framework of National Innovation System (NIS), ASM will continue to spearhead efforts that will take innovation and creativity to new heights in the fields of sciences, engineering and technology and work towards making Malaysia an intellectual force to be reckoned with.

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Female Shrouded Connector Production Process Variability Monitoring: A Robust Approach

R.M. Salleh[1,2]* and M.A. Djauhari[1]

A monitoring procedure was introduced for process variability in a multivariate setting based on individual observations which was a combination of (i) robust high breakdown point approach in the set-up stage to determine the reference sample and (ii) the use of Wilks chart in the mass production stage. This setting is what the Malaysian manufacturing industry is currently lacking in, especially when a robust approach must be used. The advantage of this procedure was revealed by using the case of a female shrouded connector production process in a Malaysian industry. Moreover, this procedure could also be used in any process quality monitoring and for any industry. A recommendation for quality practitioners was also addressed.

Key words: Medical devices production; robust parameter estimates; manufacturing process; multivariate statistical process control; Wilks' statistic

This paper is about action research in the area of the healthcare industry, aimed to give contributions to the economic development of the country and motivated by the fact that (i) the global market requirement for industry products of high quality has become more and more complex from time to time, to fulfil this requirement, the only way is to consider quality as a multivariate entity; (ii) multivariate consideration of the manufacturing process in Malaysia is still not well developed due to the lack of expertise.

The situation is very unfortunate because the manufacturing sector is one of the principal contributors to Malaysian economic development as will be explained in the next sub-sections.

Contribution of the Manufacturing Sector

It has been recognized internationally that the history of Malaysia economic development is remarkable; from a low income country in the early period of independence, to the middle in just a few decades and now towards a high income country. One of the most principal contributors to that achievement was and is the manufacturing sector. According to the World Bank report released in 2011, the proportion of manufactured production grew from roughly 20 percent of Gross Domestic Product (GDP) in the early 1980s to 31.5 percent of GDP in the late 1990s. However, it was reported to have decreased to 26.17 percent in 2008, 25.53 percent in 2009 and was last reported at 26.11 percent in 2010. This situation has given a positive impact to the Malaysia GDP which is worth 238 billion US dollars or 0.38% of the world economy. In general, the trend was always increasing except for certain periods but then it immediately recovered. In the last decade, the manufacturing sector had made a very significant contribution of more than 25% each year to the GDP.

Due to the urgent and important role of the manufacturing sector, this research effort was conducted in order to improve the competitiveness of Malaysian manufacturing products in the global, as well as regional and local markets.

Why Healthcare Industry?

Malaysia's journey towards achieving a high income economy had gained momentum as reflected by a remarkable leap in its world competitiveness ranking from 18th position in 2009, to 10th in 2010 and 16th in 2011. It had been confirmed that the capability of Malaysian manufacturing industries was trusted worldwide. Among the top 10 exported manufacturing products, electrical and electronic products remained the most significant driver of the Malaysian economy. In general, the export-driven

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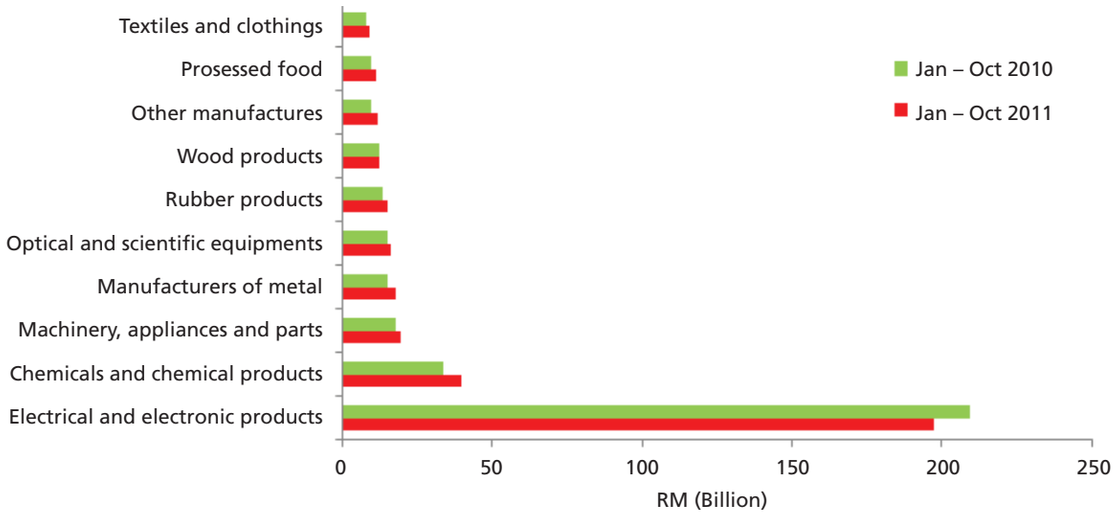

(Source: *MITI Weekly Bulletin*, Vol. 171.)

Figure 1. Top 10 exported manufacturing products.

economy was encouraged by high technology, knowledge-based and capital-intensive, creative ICT's such as in the healthcare manufacturing industries.

For this research project we chose the healthcare manufacturing industry or more specifically medical devices manufacturing, as our focus for the following reasons:

(i) The medical devices manufacturing industry was a knowledge-based and capital-intensive industry. Driven by rapid transfer of technology, this industry had changed in the past years and would continue to do so for producing durable and non-durable tools.
(ii) Compared to other industries, the manufacture of medical devices had a higher growth rate, smaller sized products, lower production volume, tighter government regulation, rigorous testing of long-term effects, higher costs and severe penalties for mistakes in design or manufacturing.

Therefore, the medical devices manufacturing process and so many other biomedical manufacturing processes (Shih 2008), needs special attention from the government in terms of their quality.

How to monitor the quality of such a manufacturing process? This is what we want to present in this paper. As a case study, we discuss about monitoring a female shrouded connector (FSC) production process in a Malaysia industry, in Johor Bahru. Due to its confidentiality, the name of the industry is kept anonymous. In this process, the overall quality of product is defined by a number of correlated quality characteristics. Therefore, since the correlations among characteristics must be taken into consideration, companies are not allowed to control each characteristic one by one. This means that companies cannot escape from a multivariate scheme. Consequently, the implementation of multivariate statistical process control (MSPC) is a must (Djauhari 2011) to fulfil global market requirements. See, for example, Sellick (1993), Shahian *et al.* (1996), Hanslik *et al.* (2001), Mohammed *et al.* (2001), and Woodall (2006) for further discussions on the role of MSPC in the healthcare industry and public health surveillances.

Current Situation

Recently, Rahman *et al.* (2009) mentioned that, in general, Malaysian companies preferred to operate using simple control charts and manual systems using paper and pencil to monitor the quality of production process. They did not implement MSPC. This was far from global market standard (Montgomery 2005; Woodall 2006). The implementation of MSPC was really new in Malaysian companies (Talib 2011). Other problems or barriers to the implementation of MSPC techniques were due to the lack of commitment and support from top management. If those situations continuously happened, what was next for our manufacturing industry?

These situations had motivated us to conduct research on the implementation of MSPC to monitor the quality of the female shrouded connector production process. Since quality is the reciprocal of process variability, our discussion would be focused on process variability monitoring. Furthermore, since the products had an

immediate impact on human life, the quality of process manufacturing had to be monitored to be as robust as possible. This meant that the reference sample issued as from Phase I operation or equivalently the set-up operation or start-up stage was obtained by using a robust estimation method. Vargas (2003), Jensen *et al*. (2007) and Chenouri *et al.* (2009) provide further discussions on robust Phase I. For our purpose, we had used a fast minimum covariance determinant (FMCD) as the robust estimation method for the following reasons:

(i) It gives a high breakdown point estimator which ensures a high degree of robustness (Rousseeuw 1985 & Hampel 2001).
(ii) It has a bounded influence function which ensures that the presence of outliers can only have a small effect on an estimator (Hubert *et al*. 2008).
(iii) The estimators are affine equivariants which ensure that any affine transformation does not affect the degree of its robustness (Hubert *et al.* 2008).

With the reference sample (RS) as the baseline, in process monitoring operation in Phase II or also called mass production process, we used the most recent technique based on Wilks' statistic introduced by Mason *et al.* (2009).

The rest of the paper is organized as follows. In the following sections we briefly explain the production process of the female shrouded connector and present the implementation of FMCD in Phase I operation to obtain the robust reference sample. The result will be compared to that issued from the non-robust method to illustrate the advantage of the implementation of Wilks chart during the Phase II operation to monitor the process. A discussion, followed by some conclusions are also shown. This paper will be closed by a recommendation in the last section.

QUALITY CHARACTERISTICS OF FEMALE SHROUDED CONNECTOR

A female shrouded connector, (Figure 2) is one of the components of intravenous drip in the medical devices industry. The production of this item applies an injection plastic mould and the raw material is Lustran ABS. Injection moulding involves taking plastic in the form of pellets or granules and heating this material until a melt is obtained. Then the melt is forced into a split-die chamber where it is allowed to 'cool' into the desired shape. The mould is then opened and the part is ejected, at which time the cycle is repeated.

However, in the biomedical industry, the raw materials and the metal involved in injection moulding process were very specific in order to avoid chemical reactions that would affect the end users.

Figure 2. Two dimensional picture of female shrouded connector.

The sample of final product from the mass production operation undergoes functional checks using Luer gauging test and liquid leakage test. The final product is rejected if there is formation of one air bubble that releases from the connector surface and replaces itself in ten seconds. One important way to handle this problem is to monitor the variability of the production process.

The quality of the products is measured based on the behaviour of $p = 3$ interrelated quality characteristics also called critical to qualities (CTQ), namely:

(i) Outer diameter of the lowest part (Q_1)
(ii) Length of the neck (Q_2), and
(iii) Diameter of the inner part (Q_3).

The CTQs Q_1, Q_2 and Q_3 refer to the important measurements of parts represented by asterisks in Figures 3 and 4. All measurements are taken on-line by using a smart scope.

PHASE I OPERATION

In the plastic industry, the term cavity represents the sampled products used in process control. There were 32 cavities available as historical data set (HDS) for Phase I operation to obtain the RS that would be used to monitor the process during mass production in Phase II. The main problem in the phase was to estimate the covariance matrix to define variability. That estimate should come from the clean data subset of HDS which were free from the presence of even one single outlier (Jensen *et al.* 2007). That data subset was the RS that we needed.

We selected the RS from HDS by using FMCD since it possessed commendable properties such as high breakdown point, bounded influence function and affine equivariant. The output of the phase were robust estimates of mean vector and covariance matrix. Since $n > 25$, and $n - p > 25$ to 30, as suggested by Hubele (1989) the cut-off

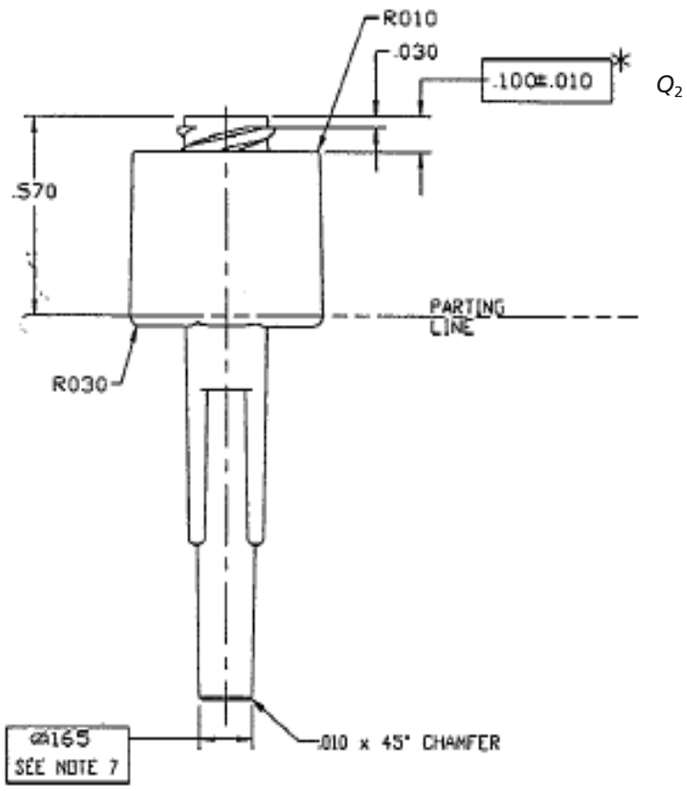

Figure 3. Technical drawing of FSC (side view).

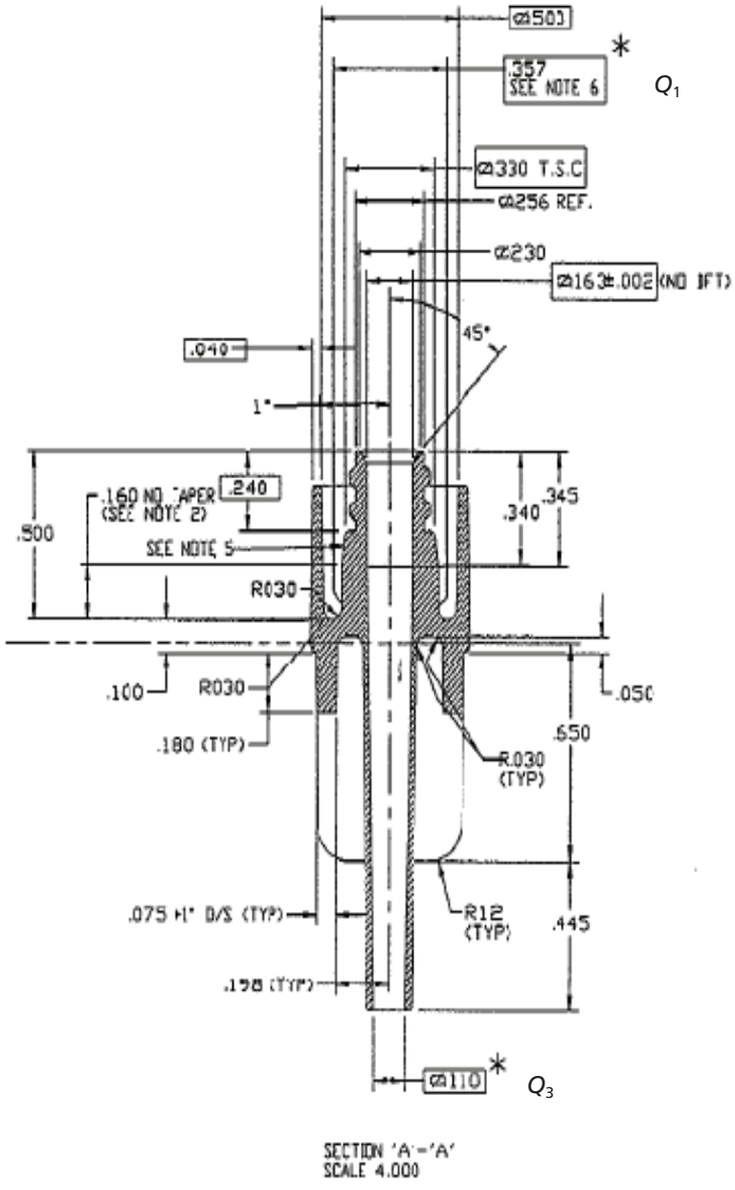

Figure 4. Technical drawing of FSC (cross section view).

value or equivalently, the upper control limit (UCL) could be determined by using chi-square approximation, $\chi^2_{a,p}$; the (1–α)-th quantile of chi-square distribution with p degrees of freedom.

In Figure 5 we present the control chart T^2 which represents the history of robust Phase I operation based on 32 cavities with $\alpha = 0.025$. The horizontal axis is the cavity number and the vertical axis is the robust Mahalanobis square distance (MSD) or equivalently, Hotelling's T^2 statistic for each cavity i from 1 until 32,

$$T^2(i) = \left(X_i - \bar{X}_{\text{FMCD}}\right)' S^{-1}_{\text{FMCD}} \left(X_i - \bar{X}_{\text{FMCD}}\right) \quad (1)$$

Here X_1, X_2, ..., X_n are the HDS which are assumed to follow a 3-variate normal distribution, $\bar{X}_{\text{FMCD}}$ and S_{FMCD} are the robust estimates of the mean and covariance matrix, respectively, obtained by using FMCD, while S^{-1}_{FMCD} is the inverse of S_{FMCD}. Each observation vector X_i consists of 3 components which represent the random variable Q_1, Q_2 and Q_3, respectively. The details of FMCD can be found in Rousseeuw and van Driessen (1999) and for practical purpose, its algorithm can be seen in Herwindiati *et al.* (2007).

Figure 5 shows that sample 12 was out of control. Therefore, the RS consisted of 31 cavities after removing

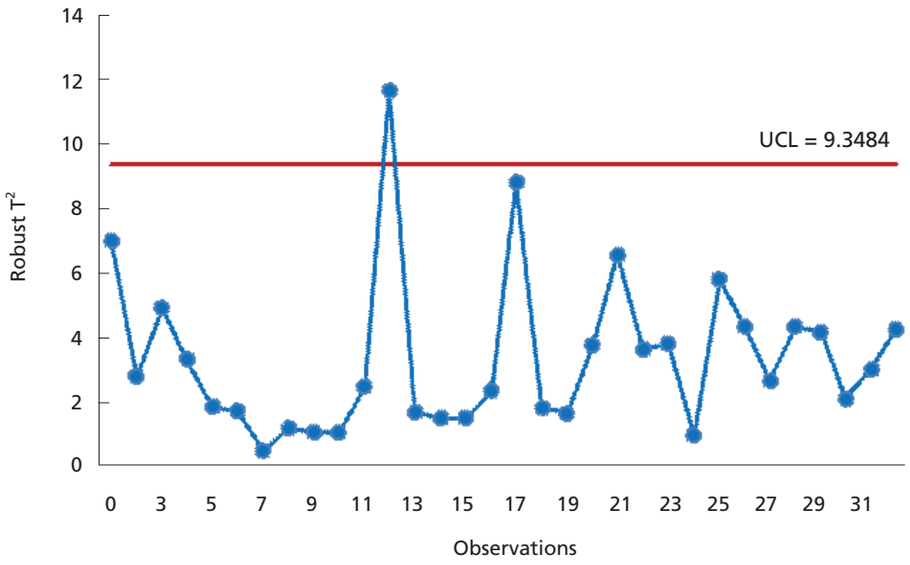

Figure 5. Robust Phase I operation.

that sample point from HDS. After some calculations, this RS gave us the following robust estimates of the mean vector and covariance matrix of the process,

$$\bar{X}_{RS} = \begin{pmatrix} 0.3557 \\ 0.1014 \\ 0.1669 \end{pmatrix} \text{ and } S_{RS} = \begin{pmatrix} 3.7E-06 & -2.1E-07 & -6.0E-08 \\ -2.1E-07 & 6.5E-07 & 1.8E-07 \\ -6.0E-08 & 1.8E-07 & 3.4E-06 \end{pmatrix}.$$

These were the baselines of the parameters, mean vector and covariance matrix that would be used during Phase II operation. Before we proceed to Phase II operation, it was important to underline that based on non-robust approach, the control chart in Phase I operation gave us a different history of process variability as can be seen in Figure 6. More importantly, this approach gave HDS as RS because no out of control signal occurs in that figure. As we all know, non-robust approach is referring to the classical Hotelling's T2 (Tracy *et al*. 1992 & Montgomery 2005).

PHASE II OPERATION

Wilks's statistic is an appropriate statistical test to detect the shift in process variability based on individual observations after a reference sample has been determined. In practice, that statistic works as follows. Let X_1, X_2,..., X_n be the reference sample and X_{n+1} be an individual sample that will be used to conduct Phase II operation. Wilks's statistic (Wilks 1962, 1963) is defined as:

$$W = \left(\frac{n-1}{n} \right)^{p} \frac{|S|}{|S_A|}$$

where $|S|$ and $|S_A|$ are the determinants of covariance matrix issued from reference sample and the augmented data set (ADS), respectively. Here ADS refers to X_1, X_2,..., X_n and X_{n+1} which are assumed to follow a multivariate normal distribution with mean vector μ and covariance matrix positive definite.

In Table 1, we present 32 individual observations that we used in Phase II operation collected half hourly. Based on these data, and the robust estimate of covariance matrix issued from Phase I, we calculated Wilks' statistic for each observation. The results are presented in Table 2.

To construct a Wilks' control chart, let us use the probability of false alarm α = 0.025 (Mason & Young 2002). In terms of hypothesis testing, α is the so called type I error. With that value of α, the lower control limit (LCL) is the α-th quantile of beta distribution, $Beta\left(\frac{n_1 - p}{2}, \frac{p}{2}\right)$ with n_1 = 31, i.e. LCL = 0.7202. This LCL together with data from Table 2 are plotted in Figure 7. This figure shows that an out of control signal occurs at the fifth sample.

It is important to note that when the non-robust method is used in Phase I, the RS issued from that phase and data in Table 1 lead to the control chart in Figure 8. This figure, compared to Figure 7, tell a different history of process variability. Figure 8 shows there is no out-of control signal.

To illustrate what happened to sample 5 in Figure 7, we will compare the structure of covariance matrix issued from robust reference sample with that issued from ADS in

$Beta\left(\frac{n_1 - p}{2}, \frac{p}{2}\right)$

Table 1. Observations in Phase II monitoring operation.

No	Q_1	Q_2	Q_3	No	Q_1	Q_2	Q_3
1	0.3571	0.1013	0.1659	17	0.3530	0.1008	0.1698
2	0.3554	0.1020	0.1699	18	0.3554	0.1017	0.1667
3	0.3531	0.1008	0.1692	19	0.3559	0.1023	0.1683
4	0.3559	0.1002	0.1699	20	0.3551	0.1012	0.1649
5	0.3540	0.0987	0.1682	21	0.3589	0.0999	0.1684
6	0.3559	0.1013	0.1683	22	0.3540	0.1008	0.1689
7	0.3563	0.1022	0.1678	23	0.3554	0.1020	0.1649
8	0.3582	0.1010	0.1674	24	0.3574	0.1011	0.1697
9	0.3557	0.1012	0.1653	25	0.3585	0.1025	0.1653
10	0.3584	0.1008	0.1659	26	0.3534	0.1016	0.1656
11	0.3561	0.1002	0.1662	27	0.3533	0.1013	0.1669
12	0.3567	0.0987	0.1659	28	0.3549	0.1000	0.1659
13	0.3583	0.1013	0.1679	29	0.3536	0.1014	0.1643
14	0.3548	0.1022	0.1662	30	0.3562	0.1026	0.1684
15	0.3588	0.1010	0.1672	31	0.3574	0.1015	0.1643
16	0.3588	0.1012	0.1664	32	0.3560	0.1029	0.1697

Table 2. Wilks' statistic.

No	Wilks	No	Wilks	No	Wilks	No	Wilks
1	0.9749	9	0.9743	17	0.8441	25	0.8495
2	0.9163	10	0.9253	18	0.9951	26	0.9382
3	0.8708	11	0.9278	19	0.9513	27	0.9474
4	0.8470	12	0.7274	20	0.9575	28	0.8914
5	0.6789	13	0.9375	21	0.8232	29	0.9035
6	0.9806	14	0.9597	22	0.9115	30	0.9204
7	0.9624	15	0.9203	23	0.9418	31	0.9155
8	0.9429	16	0.9226	24	0.9051	32	0.8582

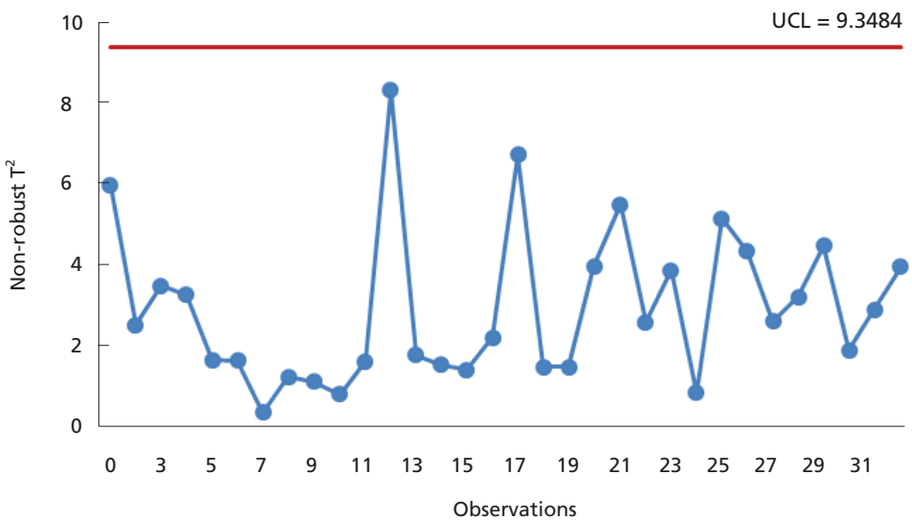

Figure 6. Non-robust Phase I operation.

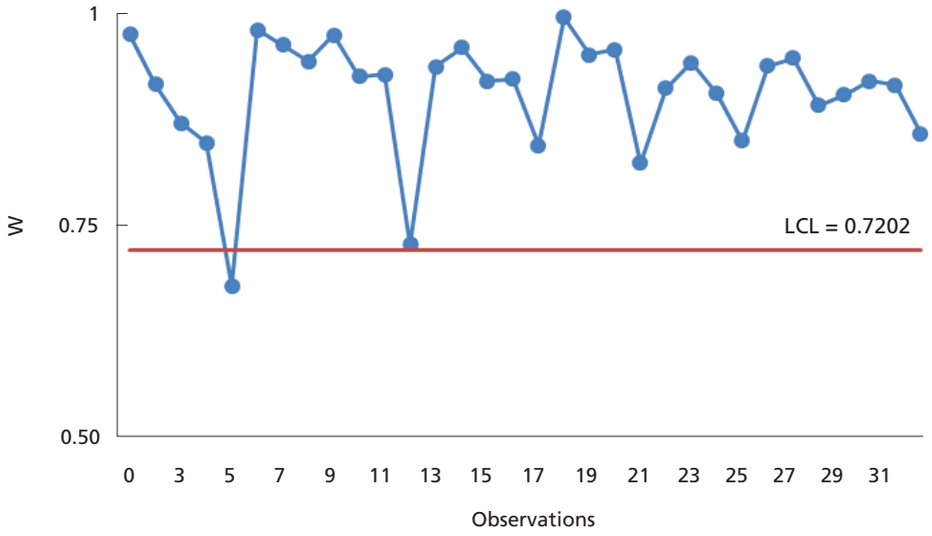

Figure 7. Wilks' chart of robust Phase 1.

terms of total variance shift, variance shift and correlation shift.

Total Variance Shift

The value of total variance (TV) from robust RS as in Section 3 is $T_r(S_{RS})$ = 7.79318E-06. By using this value as the baseline, for each observation in Phase II, we calculated the total variance of the corresponding ADS. The shift from the baseline for each observation is visualized in Figure 9 in the form of a run chart of total variance shift.

This figure indicates that the out-of-control signal at sample 5 is not caused by the shift of total variance because according to the total variance, sample 17 is higher than sample 5 but the former is not an out of control sample.

Variance Shift

The same procedure was used to visualize the shift in variance of each quality characteristic. The results are presented in Figure 10 where s11, s22, and s33 are the variance of the 1st, 2nd and 3rd characteristic, respectively. According to this figure, it seems that the signal that occurred at sample 5 was caused by the shift in variance of the second characteristic.

Correlation Shift

In order to support the finding in Figure 7, we further analyzed from the viewpoint of correlation structure. We compared the value of correlation coefficient given by ADS with that given by the robust reference sample as the baseline. The results for each of the two different characteristics are visualized in Figure 11. In this figure, r12, r13 and r23 are the correlation coefficients of the 1st and 2nd, 1st and 3rd, and 2nd and 3rd characteristics, respectively.

This figure shows the large shift of r12 and r23 at sample 5. Therefore, the out-of-control signal showed by Figure 7 was seemingly caused by the shift of correlation of the 1st and 2nd characteristics and the correlation of the 2nd and 3rd characteristics. This indicated that more attention should be paid to the quality characteristic 'length of the neck of female shrouded connector' (Q_2).

DISCUSSION

In the monitoring procedure presented above, it was assumed that HDS came from a multivariate normal distribution. It was so with data used in Phase II. Therefore, the above results depended on the appropriateness of that assumption. Thus, we need to check that assumption. In Figures 12 and 13 we present, respectively, the QQ plot of HDS used in Phase I and that of all observations used in Phase II. These figures show that the multivariate normality assumption was not violated. For HDS (Figure 12), the degree of linearity in terms of probability plot correlation coefficients (PPCC) between the theoretical and experimental quantiles is 0.9892 while for the data set during Phase II (Figure 13), it is 0.9672. See SEMATECH at <http://www.itl.nist.gov/div898/handbook/index.htm> for details of PPCC. These correlations are extremely high. Therefore, the results presented above are valid.

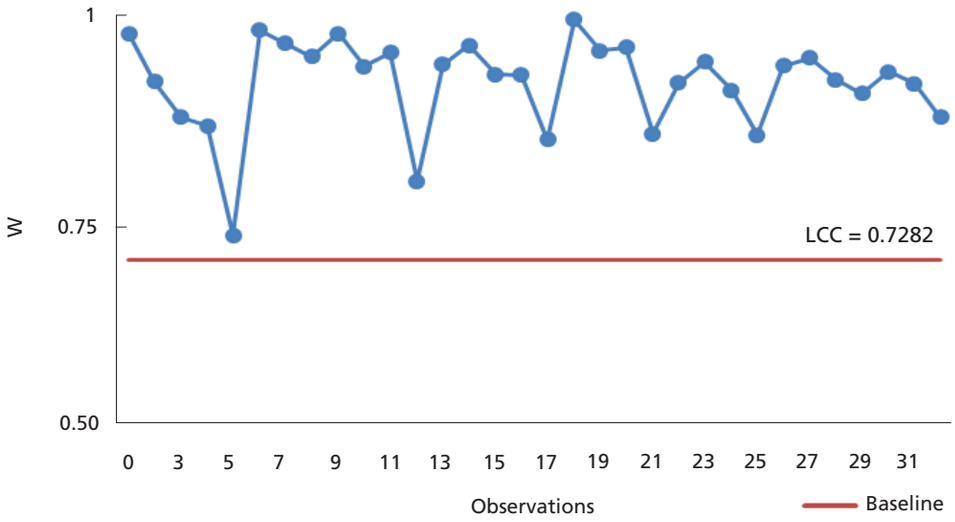

Figure 8. Wilks chart on non-robust Phase I.

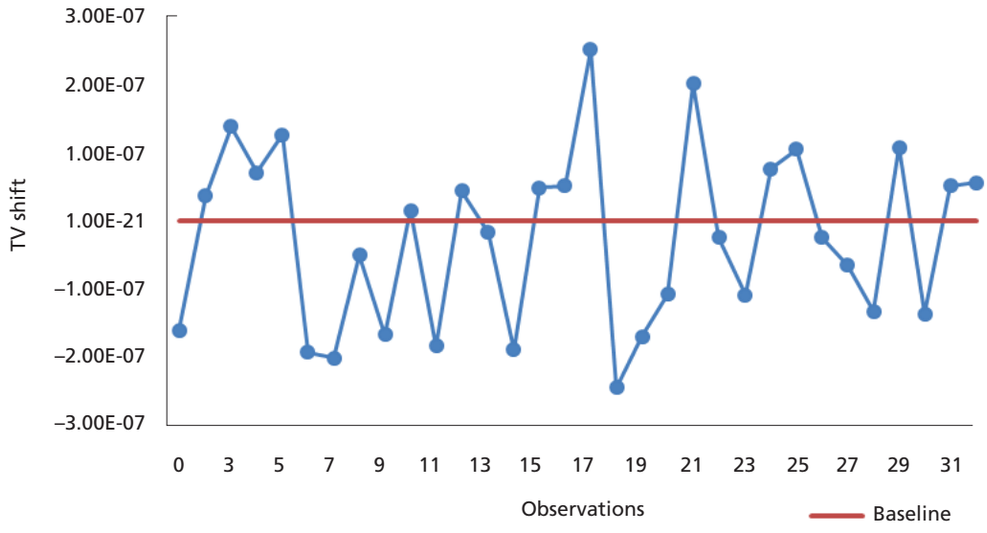

Figure 9. Run chart of total variance shift.

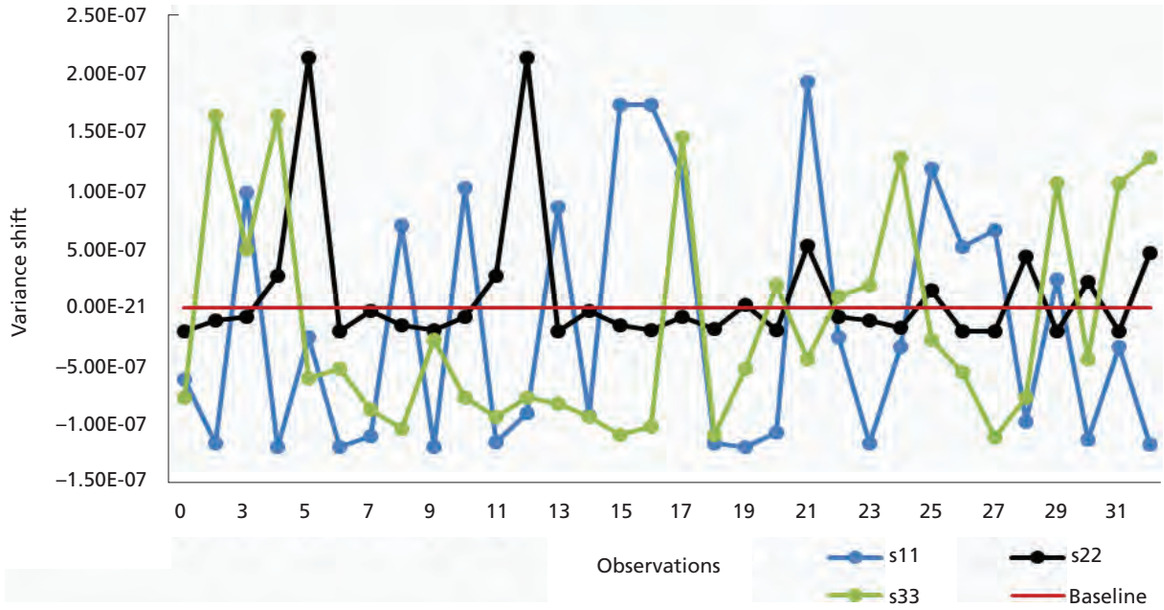

Figure 10. Run chart of variance shift.

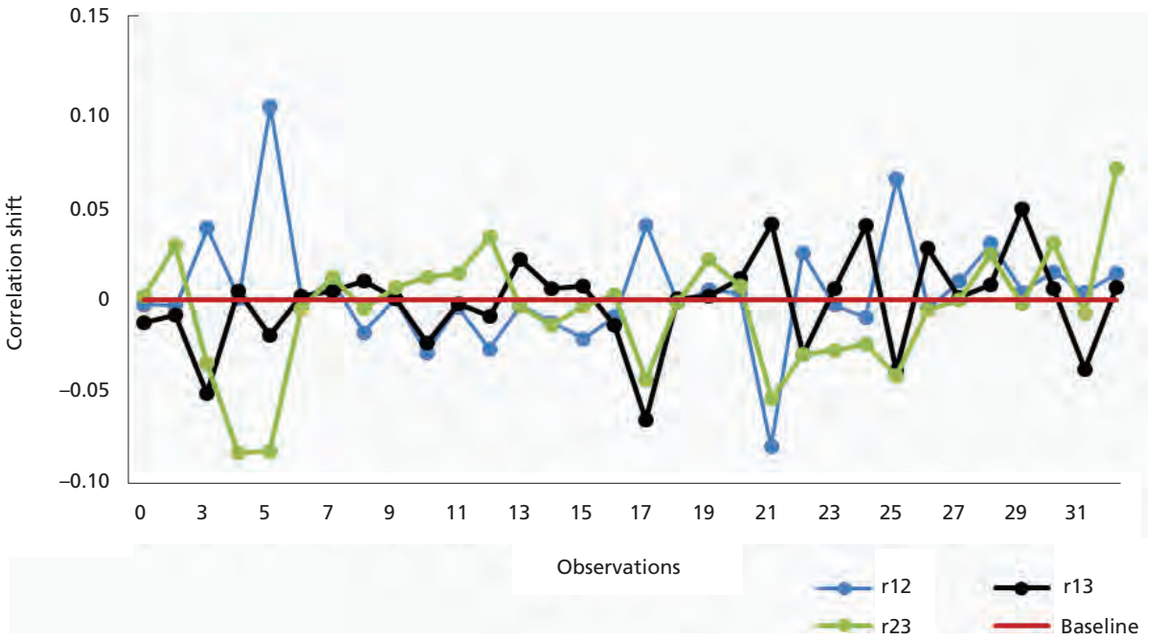

Figure 11. Run chart of correlation coefficient shift.

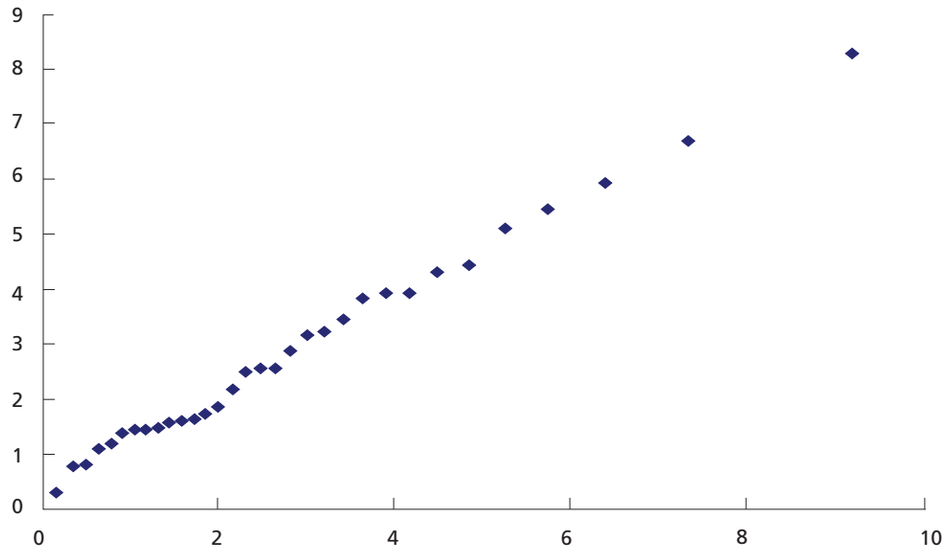

Figure 12. QQ plot for HDS in Phase I.

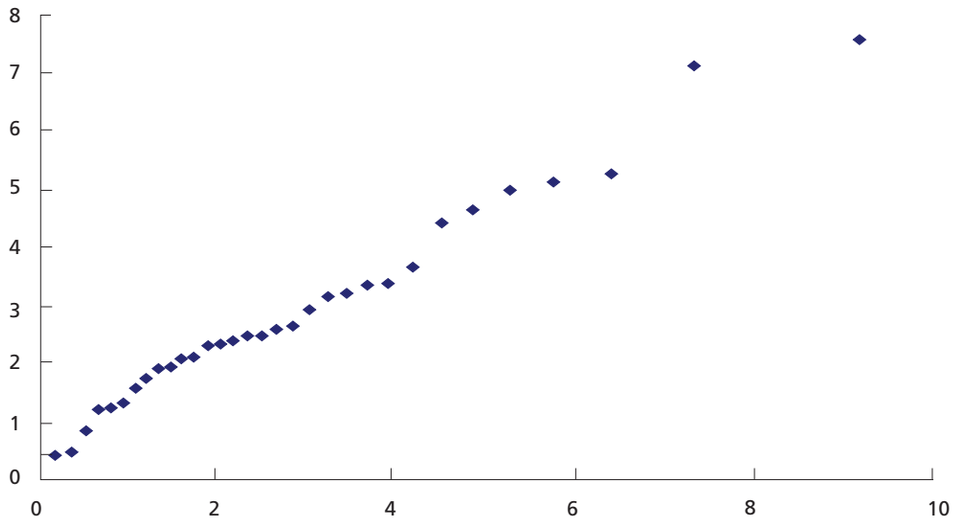

Figure 13. QQ plot for observations in Phase II.

Figures 5 and 6 which present Phase I operation using robust and non-robust approaches respectively, show the advantage of the robust approach as compared to the non-robust. It is so with Figures 7 and 8 which show the advantages of using Wilks's statistic based robust reference sample and that based on a non-robust one.

The same analysis as in Total Variance Shift until the Correlation Shift above has been conducted for non-robust approach. The results were quite interesting. The non-robust approach was not able to detect the abnormality in terms of the shift in correlation coefficients.

The analyses show that the robust method was more effective in detecting the shift than the non-robust one.

CONCLUSIONS

The use of FMCD in Phase I operation to determine the robust reference sample followed by the use of Wilks's statistic in Phase II, was an improved procedure of process variability monitoring based on Wilks chart which covered both the phases.

The procedure would guarantee that the estimates of all parameters of female shrouded connector production process were robust with high breakdown points. Therefore, the history of process variability, portrayed by Wilks's statistic in Figure 7, was robust.

It was interesting to note that the non robust approach in Figure 8 gave a different signal. That showed the advantage of the robust approach and simultaneously warned us that the use of the non-robust Phase I would jeopardize the process monitoring in Phase II.

Further analysis showed that the out of control signal at sample 5 in Figure 7 was caused by:

(i) The shift in variance of the second characteristic 'length of the neck of female shrouded connector' (Q_2).
(ii) The shift in correlation of the 1st and 2nd characteristics and the correlation of the 2nd and 3rd characteristics.

That indicated that more attention should be paid to the quality characteristic 'length of the neck of female shrouded connector' (Q_2) in the next production.

RECOMMENDATIONS

(i) Customer requirements, especially in the global market, have become more and more complex to agree with the customer's level of appreciation with the product. In order to survive and be able to satisfy the customer, companies are required to ensure that their production processes are of high quality. For this purpose, companies are required to frequently and continuously monitor the quality of the process.
(ii) Since, quality involves complex production systems which statistically mean that quality is multivariate in nature, the use of robust MSPC is a must. The application of the procedure used above shows its advantages.
(iii) The company needs to stay at the frontier of process monitoring technology or risk losing a potential customer and business.

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Sludge-derived Fuel from Latex Products Manufacturing Industry

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Malaysia is the world's top manufacturer of examination and surgical natural rubber (NR) gloves, exported mainly to the USA and Europe. The glove manufacturing process yields effluent which must be treated to comply with the stringent regulatory requirements imposed by the Malaysian Department of Environment. To make glove manufacturing an eco-friendly process, efforts are geared towards minimizing and utilizing waste or converting it into raw material for making value-added products. Waste generated from the glove industry is mainly rubber sludge which is obtained from the chemical flocculation stage of the effluent treatment process and consists of mainly rubber, remnants of compounding ingredients and water. R&D work by the Malaysian Rubber Board on waste utilization and resource recovery investigations have revealed many uses for this sludge. This paper briefly outlines only one of the many options available, which is the conversion of the sludge into sludge derived fuel (SDF). Preliminary study has identified three formulations of SDF with calorific values (CV) exceeding 16 000 kJ/kg, matching a good grade coal. This was considered as promising results which warrant explorative work for further increasing the CV of SDF to turn it into a viable fuel substitute in the latex products manufacturing industry and subsequently apply for a Clean Development Mechanism status to generate income.

Key words: Eco-friendly; wastewater; chemical flocculation; latex sludge; calorific value; fuel substitute; Clean Development Mechanism

Rubber Products Manufacturing Industry

In 2009, the Malaysian rubber products industry was made up of more than 348 manufacturers producing latex products, tyres and tyre-related products as well as industrial and general rubber products. The industry employed more than 56 476 workers and contributed RM10.59 billion to the country's export earnings. Rubber products accounted for 1.9% of Malaysia's total exports and 1.91% of Malaysia's exports from the manufacturing sector (Malaysian Rubber Statistics 2009).

Manufacturing of latex products. The latex products sub-sector was the largest within the rubber products industry, comprising 125 manufacturers producing medical, household and industrial gloves; catheters, latex threads, balloons, finger stalls and foam products which contributed RM9.7 billion to the country's export earnings in 2009. This sub-sector accounted for 79% of the total value of rubber exports, largely contributed by gloves, catheters and latex threads. Malaysia continues to maintain its position as the world's leading producer and exporter of catheters, latex threads and natural rubber medical gloves, supplying more than 80% of the world market for catheters, 70% for latex threads and 60% for rubber gloves (Malaysian Rubber Statistic 2009).

Environmental Concern

Manufacturing of latex products poses a potential threat to the environment due to the use of certain toxic and non-biodegradable chemicals. Thus, indiscriminate discharge of latex product manufacturing effluent can cause water pollution, resulting in the deterioration of the normal living ecosystem of the rivers and streams. The practice of using chemical flocculants to remove the potentially toxic chemicals from the effluent in the form of sludge has become the norm in the latex products manufacturing factories, which in turn necessitate chemical sludge disposal. Figure 1 show the sludge generation in the 'activated sludge' effluent treatment system, which is commonly used to treat rubber glove manufacturing effluent. In view of its importance to the nation and mindful with the rapid expansion of this industry, it is essential for the latex products industry to avoid creating serious environmental problems and turn eco-friendly, to project a 'green' image as well as to reduce the cost of disposing of the sludge by incineration (Devaraj *et al*. 2006).

Regulatory Requirements

The Malaysian government gazetted the *Environmental Quality Act* in 1974 and Environmental Quality (Sewage

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and Industrial Effluents) Regulations in 1979 to inhibit indiscriminate discharge of effluents into watercourses. As specified in the Third Schedule of the Environmental (Sewage and Industrial Effluents) Regulations 1979, the effluent from rubber products manufacturing factories had to be treated to meet the effluent regulatory standards before it could be discharged into watercourses. There were two sets of standards applicable, *Standard A* for factories located upstream of water intake and *Standard B* for factories located downstream of water intake. In addition, rubber product manufacturing factories had to comply with the Environmental Quality (Scheduled Wastes) Regulations, 2005. These regulations set out the requirements for storage, collection, packaging, labelling, treatment and disposal of scheduled waste (Department of Environment Malaysian 2005, 2007; Devaraj *et al*. 2003).

Sludge from Latex Products Manufacturing Industries

Malaysia is the world's top producer of examination and surgical gloves. In 2009, the gloves produced in Malaysia reached a value of 23 133 million pairs (Malaysian Rubber Board 2009). It was estimated over 50 000 metric tons of sludge were generated in 2009 by the latex products manufacturing industry in Malaysia. The sludge generated during the manufacturing process of various latex products is shown in Table 1.

Chemical flocculation was part of the effluent treatment process whereby the metallic components of the effluent were flocculated with the addition of flocculating agents such as lime or polyelectrolytes. The constituents of the sludge are as shown in Table 2. Coagulated latex made up the bulk of the total organic carbon (TOC), the nitrogen was from the latex preservation system, phosphorus was added in the form of phosphoric acid to adjust the pH during the effluent treatment process while the rest of the metallic components were from the latex formulation (dipping polymer). The metallic components such as lead, cadmium and nickel were found only in trace amounts. The bulk of the remaining component in the sludge was moisture content (Mohd Zin 1999; Nambiar *et al*. 2000).

High Cost of Sludge Disposal

The government had granted Kualiti Alam Sdn Bhd exclusive rights to operate an integrated scheduled waste management system for Peninsula Malaysia. The facilities available at the site for the scheduled treatment and disposable of waste included secure landfill and incineration. The costs incurred depended on the TOC levels of the sludge, which varied between RM495 per ton for direct landfill and RM2790 per ton if incineration was required (Kualiti Alam Sdn. Bhd.). The cost of RM2790 per ton for disposal of the sludge by incineration was considered high. This was a financial burden for the latex products manufacturers, as it increased the operating cost in the midst of stiff competition from neighbouring countries to capture the latex dipped products market. Some factories had to close down, as the profit margin was too low to stay in business, while others had to move to neighbouring countries where the regulatory requirements were less stringent (Nambiar *et al*. 2000).

R&D Programme by Malaysian Rubber Board (MRB) on Sludge Utilization

The secured land filling option was not the permanent option proposed by MRB, the more sustainable option proposed was to find ways to turn the sludge into raw material for

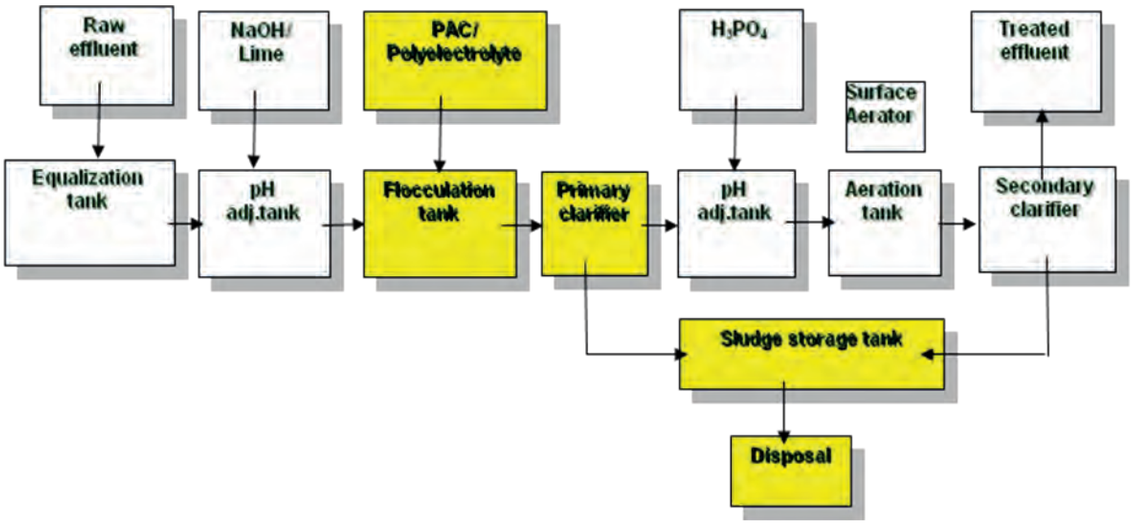


Figure 1. Schematic diagram showing the sludge generation using the 'activated sludge system' designed to treat rubber glove effluent (Devaraj and Zairossani 2010).

Table 1. Amount of sludge generated by various latex products[a].

Type of product	Sludge production
Examination glove	3 g – 250 g/1000 pieces
Household glove	175 g – 1300 g/1000 pieces
Latex thread	2 g – 3 g/kg latex thread

[a]Mohd Zin 1998, 1999.

Table 2. Characteristics of sludge from latex products manufacturing[a].

Parameter	Glove		Latex Thread		Catheter		Condoms	
	Range (%)	Mean (%)	Range (%)	Mean (%)	Range (%)	Mean (%)	Range (%)	Mean (%)
TOC	2.8 – 42.1	17.6	2.0 – 8.9	7.2	9.3 – 30.5	17.8	9.6 – 21.4	15.9
Biodegradable TOC	0 – 23.9	3.4	0 – 2.0	0.4	0 – 6.8	2.9	0.3 – 3.6	2.3
Nitrogen	0.5 – 3.6	1.3	0.3 – 1.9	1.2	0.6 – 4.3	1.9	1.0 – 2.1	1.5
Phosphorous	0.1 – 3.9	0.8	0.1 – 0.8	0.4	0.6 – 2.2	1.4	0.3 – 1.2	0.7
Potassium	0 – 0.7	0.1	0 – 0.1	0.1	0 – 0.6	0.3	0 – 0.1	0.1
Magnesium	0 – 4.7	0.7	0 – 2.8	0.8	0.1 – 3.0	1.1	0 – 0.1	0.1
Calcium	0 – 13.3	5.6	0 – 13.6	4.9	0.5 – 14.9	5.6	0.3 – 0.7	0.5
Zinc	0.3 – 8.1	2.2	12.2 – 44.3	27.8	0.3 – 3.8	2.2	0.7 – 1.1	0.9

[a]Nambiar *et al.* 2000.

making other value added products. This was because the latex product manufacturing sludge contained valuable ingredients but they were not in the ideal composition for making other rubber-based products directly, thus requiring pre-treatment.

In the wake of environmental conservation, waste utilization and recycling become good options for factory owners to find new uses for their sludge. From a recent report on characterization of sludge and effluent from latex product manufacturing by MRB, a good number of factories produced sludge which had useful constituents for recycling and utilizing in non-latex rubber product manufacturing industries as for rubber mats, shoe soles and carpet underlay (Nambiar *et al*. 2000). In industries like brick making and cement manufacture, where a lot of filler materials were required, latex product sludge could become useful material and had a great chance of improving the quality of the products (Zaid 2003; Meriam 1998). High quality raw material was readily available in the form of latex product manufacturing sludge, which by systematic R&D work, could be converted into value added products, instead of being burnt as waste in the incinerators incurring high costs. The utilization of sludge could bring about an increase in revenue and a substantial reduction in the amount of sludge that had to be disposed, thus reducing the environmental impact caused by the latex products manufacturing industries. The technology developed could also be expanded to countries like Thailand and Indonesia for a lucrative income on a franchise basis, as latex product manufacturing was one of the important activities over there (Nambiar *et al*. 2000; Garber & Anderson 1990).

In view of this, MRB had embarked in carrying out R&D work using sludge from latex products manufacturing industries as raw material since 2000, for making products like carpet underlay and bricks. MRB has since assisted a number of glove factories in using their sludge for making carpet underlay (Zaid 2003). The proportion of heavy metal content has been reduced to a save level (2 p.p.h.) by mixing with virgin rubber (latex) in the formulation (Zaid 2003).

Land application. MRB carried out a study on land application of the sludge in the late nineteen eighties (Mohd Zain 1998, 1999). The study showed that land application was a logical choice as it was found to be economical. Preliminary studies showed that by using sludge from examination glove factories as cultivation medium for the plant, *vetiver spp.* could support good growth comparable to that as grown on soil. Lead, copper, nickel and cadmium were not detected in the leachate from the sludge used as the cultivation medium (Mohd Zin 1998) while the zinc content of the leachate was less than 1 mg/l. However, certain guidelines needed to be developed, such as the effect of heavy metals on soil, underground water, micro-organisms and plants needed to be studied as indiscriminate application could cause soil contamination, phytoxicity, accumulation of undesirable high levels of trace elements in the soil and contamination of groundwater (Mohd Zin 1998, 1999).

Brick making. Latex products manufacturing sludge was used as one of the ingredients for brick making. The study was a collaborative project between MRB and University of Malaya. It showed that an ideal compressive strength, which is an important criterion for making a high quality brick could be easily attained. The brick made from rubber sludge regularly showed compressive strength values of between 6 MPa – 10 MPa, whereas common brick according to specification (Malaysian Standard 1972, Brick) ranged between 5 MPa – 6 MPa. The leaching of heavy metals was below regulatory requirements (using TCLP method and measured values included Zn, Cd, Cr and Mn). Incorporating solid waste in fired clay bricks had proved to encapsulate the hazardous substance successfully. Bricks which were made from latex product manufacturing sludge had improved aesthetical aspects (very smooth and shiny surfaces with minimum breakage at the corners) and sludge as filler material contributed to the reduction in weight of high-rise buildings. The Department of Environment (DOE) did not give a blanket approval for the utilization of sludge for making other products. Factory owners could get approval on a case by case basis upon request from DOE to process sludge into raw materials at their factory premises for making other products and subsequently to sell them to prospective buyers. The set back of the consumers acceptance was not very encouraging, as they were sceptical about using bricks for their building from sludge which might contain hazardous waste like Zn (Garber & Anderson 1990; Meriam & Aziz 1998).

Slow Uptake of Sludge Utilization Options

All the above R&D work carried out on the sludge utilization studies did not induce any commercial interest. Various factors contributed to the lukewarm interest shown by the industry for making products from latex products manufacturing sludge. This was because Malaysia is a resource rich country and products made from recycling or utilizing of waste did not command a competitive price. Furthermore, the DOE regulations are quite elaborate and stringent and to make products utilizing even a small percentage of schedule waste required extensive procedures to convince the authorities on their compliance to the regulatory requirements.

With the price of oil skyrocketing to well over USD100 per barrel during the peak period in mid-2008, turning latex product manufacturing sludge into a fuel source was one of the worthy options which was considered exploring (Devaraj 2001). Although a study was carried out by MRB in 2001 to convert latex product manufacturing sludge into refuse derived fuel (RDF), it was not continued further as there was no urgency in its utilization. This was prior to the formation of the Kyoto Protocol which was adopted in Kyoto, Japan, on 11 December 1997 and enforced from 16 February 2005 (United Nations 1997). The Clean Development Mechanism (CDM), defined in Article 12 of the 'The Kyoto Protocol', which allowed a country with an emission-reduction project to earn saleable certified emission reduction (CER) credits; each equivalent to one tonne of CO2, which could be counted towards meeting Kyoto targets, was very much unknown then. The global warming concern had not reached an alarming stage and most importantly the price of oil was still reasonably priced during that period (United Nations 1997).

Sludge-derived Fuel (RDF) as a Form of Refuse Derived Fuel

RDF is a popular method of turning municipal solid waste (MSW) into a fuel source in EU countries and Japan. RDF is classified as an innovation of waste-to-energy technology created by shredding and drying out MSW material. The raw material mostly used for conversion is the combustible fraction of waste which usually consists of plastics and biodegradable matter. RDF facilities are usually located near landfills and dumpsites for efficiency of access and acquisition of waste materials and less transportation cost. Sludge-derived fuel (SDF) is a sub-sector of RDF where the sludge is mainly organic in nature, originating from effluent treatment plants, organic sediments from food processing plants, biological flocculates as well as biological waste (coagulated natural rubber latex) mixed with chemicals (flocculating agents) from latex products manufacturing effluent treatment plants (Hasselriis 1989; Demirbas *et al.* 2011; Chang *et al*. 1998; Marsh *et al.* 2007; Chen *et al*. 2011).

The main purpose of the study was to research and develop a suitable recycling method for turning the latex product manufacturing sludge into a sludge-derived fuel that would not pollute the environment and at the same time further increase the added value from the recycling of the sludge. The process in turn would be able to produce an effective fuel substitute and be able to reduce the cost of disposing of the sludge by incineration.

Therefore this paper describes preliminary R&D work carried out to study the feasibility of turning latex product manufacturing sludge into SDF and subsequently apply for CDM status.

MATERIAL METHOD

Preparation of Sludge Derived Fuel

Sludge samples with a moisture content of 30%–40% were collected from commercial glove factories after having undergone dewatering process through a filter press. They were then characterized to determine the composition of their content. Different batches of SDF samples

were prepared using varying proportions of latex glove manufacturing sludge, latex coagulum (sediment from latex dipping tanks), carbonaceous material (rubber vulcanizate after undergoing size reduction) and were bound by waste latex. These mixtures were homogenised by mixing and masticating in a mortar with the addition of a small amount of water. The samples were then pressed into a mould of, 3 cm – 4 cm in diameter which was slowly inverted to remove the mould. The compressed SDF samples removed from the mould were as shown in Figure 2 (a) and (b). The SDF samples, fresh from the mould and having a moisture content of 30%–40% were dried in an oven which was set at a constant temperature of 80ºC. The drying was continued until a constant weight was attained. They were then cooled in desiccators and were sent for calorific value analysis (Devaraj *et al*. 2009; Devaraj & Zairossani 2010).

Determination of Calorific Value of SDF Samples

Calorific values (CV) of the RDF samples were determined experimentally by using a bomb calorimeter. Bomb calorimeters give a CV which is called *gross* or *high heating value* (Kathiravale *et al*. 2003).

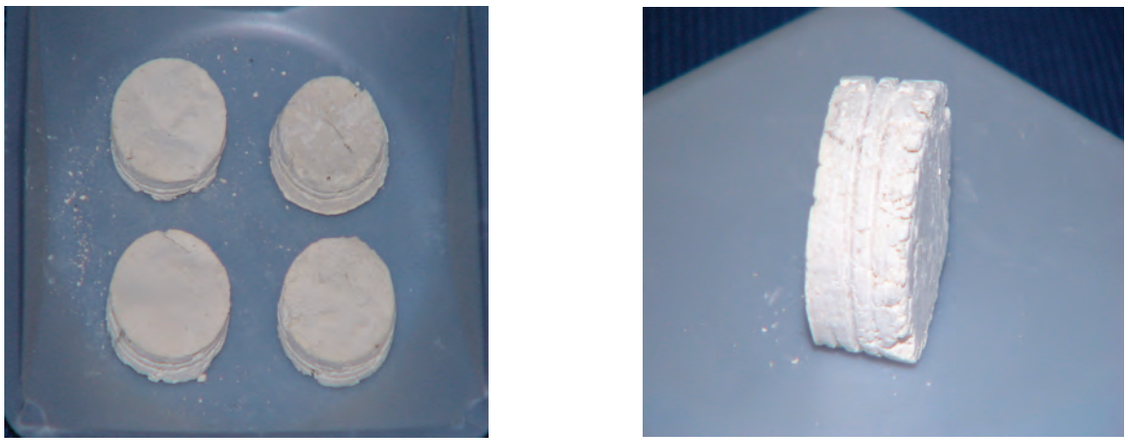
The calorific value of a fuel is the quantity of heat produced by its combustion — at constant pressure and under 'normal' conditions (i.e. 0ºC at a pressure of 1013 mbar). The combustion process generates water vapour and certain techniques may be used to recover the quantity of heat contained in this water vapour by condensing it. The higher calorific value [or gross calorific value (GCV)] is based on the supposition that the water of combustion is entirely condensed and that the heat contained in the water vapour is recovered. The lower calorific value [or net calorific value (NCV)] supposes that the products of combustion contain the water vapour and that the heat in the water vapour is not recovered (Kathiravale *et al*. 2003; Sheng & Azevedo 2005; Demirbas 1997; Dennis *et al*. 2004).

RESULTS AND DISCUSSION

Table 3 shows the calorific values of the 14 samples of SDF analysed. These were the average values of three replicates made from each of the RDF formulations (Devaraj *et al*. 2009; Devaraj & Zairossani 2010).

It was apparent that out of the 14 formulations of the SDF sample (formulations A to N), the CV of formulations A, G and I were outstanding with values of 16 702 kJ/kg, 16 765 kJ/kg and 16 411 kJ/kg, respectively. These samples of formulations contained sludge with small amounts of vulcanizate (4%–5%) and waste latex as the binding agent (2%–3%). The vulcanizate samples were added to increase the carbon content thus increasing the CV. Only a minimal amount was added so as to prevent the excessive release of SO_x gas during combustion from the sulphur used as the cross-linking agent found in the vulcanizate. The waste latex used as the binder was pre-vulcanized latex (PVL) which also contained sulphur in its formulation. This component too was added at a minimal amount in SDF formulations.

The three highest CV values of the RDF formulation, which exceeded 16 000 kJ/kg, matched CV values of bituminous coal, normal coal and lignite (Table 4). SDF made from latex products manufacturing sludge had good potential to be turned into fuel substitute, since the CV values obtained matched that of high grade coal. With improved formulations, such as by adding on other rubber wastes (vulcanized off-specification rejects and powdered rejected gloves) in optimum proportions, the CV values of the SDF could be further improved. The complete



(a) (b)

Figure 2. SDF Samples made from latex products manufacturing sludge with a diameter of 3.5 cm.

Table 3. Calorific value of RDF sample analysed.

SDF sample reference	Calorific value (kJ/kg) Mean (±SD)
A	16 702 (±835)
B	3916 (±313)
C	4135 (±248)
D	8896 (±623)
E	10 190 (±611)
F	12 350 (±741)
G	16 765 (±963)
H	8209 (±575)
I	16 411(±1148)
J	9935 (±596)
K	9091 (±636)
L	3331(±234)
M	4268 (±341)

Table 4. Higher calorific values for some common fuels[a].

Fuel	Higher calorific value (gross calorific value — GCV) (kJ/kg)
Anthracite	32 500 – 34 000
Bituminous coal	17 000 – 23 250
Butane	49 510
Charcoal	29 600
Coal	15 000 – 27 000
Wood (dry)	14 400 – 17 400
Diesel	44 800
Ethanol	29 700
Gasoline	47 300
Hydrogen	141 790
Lignite	16 300
Methane	55 530
Oils (vegetable)	39 000 – 48 000
Petrol	48 000
Tar	36 000
Turpentine	44 000

[a]www. Engineering Tool Box.com

evaluation of SDF formulations made from latex products manufacturing sludge requires full analysis of the flue gases as well as toxicity test (TCLP) of the ash.

To make this project viable the preliminary study should be extended by carrying out further work which should include repeated CV analysis of the three highest valued SDF formulations which gave calorific values of high grade coal to ascertain their consistencies. Full flue analysis needs to be carried out to determine any release of toxic gases such as SO_x, NO_x and dioxin during their combustions. These determinations are crucial because any release of highly toxic gases during combustion would make the production of SDF from latex products manufacturing sludge not feasible. If the gases released were relatively harmless then the flue gas treatment facility could be designed and subsequent up-scaling work on the conversion of sludge to SDF could be formulated.

CONCLUSION

The success of this project would depend a lot on a number of factors. The foremost would be obtaining a SDF formulation that would yield an optimum calorific value, which would later be established as an ideal replacement for the current source of fuel required in the latex manufacturing factories. In addition the flue gases emitted should be relatively non-toxic and cost effective in treatment before being discharged safely into the atmosphere. If these

requirements are met, then it would be an easier task to convince the DOE of Malaysia to promote the use of SDF as a fuel substitute in the latex product manufacturing industries. The use of SDF as a fuel substitute could qualify as a CDM project and would be income generating. The latex products manufacturing factories do not have to bear the cost of disposing the sludge, in the landfills nor in the incineration plants. Individual factories could treat their own sludge and turn it into SDF or process into a new raw material and sell it to SDF making factories. Therefore, an alternative cheap energy source such as SDF would be easily available so that the industry does not experience a severe setback. The latex products manufacturing industry is very competitive and the profit margin would get thinner if the fuel price starts to escalate in the future.

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A Class of Estimators for Assessing the Population Mean under Non-response Using Auxiliary Information

M.K. Chaudhary[1], R. Singh[1], M. Kumar[1], A. Kr. Singh[2] and A.A. Adewara[3]*

Khoshnevisan and some researchers in 2007 proposed a general family of estimators for assessing the population mean of the variable under study. In this paper, their estimator is studied in the presence of non-response. An empirical study was carried out to demonstrate the performance of the suggested estimator and it was found that the empirical results supported the theoretical study.

Key words: Auxiliary variate, non-response, double sampling, bias, mean sum of square; estimator; theoretical efficiency comparison

The problem of non-response in sample surveys is common and it is more prevalent in mail surveys than in personal interviews. The usual approach to non-response is to contact the non-respondent and obtain as much information as possible. Hansen and Hurwitz (1946) considered the problem of non-response while estimating the population mean by taking a sub sample from the non-respondent group with the help of some extra effort and an estimator was proposed by combining the information available from response and non-response groups. E1-Badry (1956) further extended Hansen and Hurwitz (1946) technique.

In estimating population parameters like the mean, total or ratio, sample survey experts sometimes use auxiliary information to improve precision of the estimates. The estimation of population mean $\overline{Y}$ of the study variable y, when the population mean $\overline{X}$ of the auxiliary variable x is known and in presence of non-response, has been discussed by Cochran (1977), Rao (1986), Khare and Srivastava (1997), Singh and Kumar (2008 a, b), Chaudhary *et al.* (2010) and Singh *et al.* (2010).

Assuming that the population is divided into two groups, those who do not respond are called non-response class. Let N_1 and N_2 be the number of units in the population that belong to the response class and the non-response class, respectively ($N_1 + N_2$). Let n_1 be the number of units responding in a simple random sample of size n drawn from the population and n_2 the number of units not responding in the sample. We may regard the sample of n_1 respondents as a simple random sample from the response class and the sample of n_2 as a simple random sample from the non-response class. Let h_2 denote the size of the subsample from n_2 non-respondents to be interviewed, then $f = \frac{n_2}{h_2}$. Let $\overline{y}_1$ and $\overline{y}_{h2}$ denote the sample means of Y character based on n_1 and h_2 units, respectively. The estimator proposed by Hansen and Hurwitz (1946) is given by:

$$\overline{y}^* = \frac{n_1\overline{y}_1 + n_2\overline{y}_{h2}}{n} \tag{1}$$

The estimator $\overline{y}^*$ is unbiased and has variance:

$$V(\overline{y}^*) = \left(\frac{1}{n} - \frac{1}{N}\right) S_y^2 + (f-1)\frac{N_2}{N}.\frac{S_{y2}^2}{n} \tag{2}$$

The population mean square of the character y is denoted by S^2_y and the population mean square of y for N_2 non-response units of the population is denoted by S^2_{y2}.

We assume that information on the auxiliary variable x is obtained from all the sample units and the population mean $\overline{X}$ of the auxiliary variable is known, but some sample units might fail to supply information on the study variable y. The usual ratio and product estimators under this situation are defined, respectively, as:

$$t_R^* = \overline{y}^* \frac{\overline{X}}{\overline{x}} \text{ and} \tag{3}$$

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$$t_P^* = \bar{y}^* \frac{\bar{x}}{\bar{X}} \quad (4)$$

The MSE of t^*_R and t^*_P are given respectively by:

$$\text{MSE}(t^*_R) = f\bar{Y}^2\left[C_y^2 + C_x^2 - 2\rho C_y C_x\right] + \frac{(k-1)}{n} W_2 S_{y2}^2 \quad (5)$$

$$\text{MSE}(t^*_P) = f\bar{Y}^2\left[C_y^2 + C_x^2 + 2\rho C_y C_x\right] + \frac{(k-1)}{n} W_2 S_{y2}^2 \quad (6)$$

Khoshnevisan *et al*. (2007) proposed a family of estimators for estimating population mean $\bar{Y}$ as:

$$t = \bar{y}\left[\frac{a\bar{X}+b}{\alpha(a\bar{x}+b)+(1-\alpha)(a\bar{x}+b)}\right]^g \quad (7)$$

where, $a \neq 0$, b are either real numbers or the functions of known parameters of the auxiliary variable x such as standard deviation (σ_x), coefficient of variation (C_x), skewness [$\beta_1(x)$], kurtosis [$\beta_2(x)$] and correlation coefficient (ρ) [for proper choice of a and b, see Singh *et al*. (2007), Singh *et al*. (2008) and Singh and Kumar (2010)].

The objective of this paper is to study Khoshnevisan *et al*. (2007) estimator under non-response.

Suggested Estimator

The Khoshnevisan *et al*. (2007) estimator t under non response will take the form:

$$t^* = \bar{y}^*\left[\frac{a\bar{X}+b}{\alpha(a\bar{x}+b)+(1-\alpha)(a\bar{x}+b)}\right]^g \quad (8)$$

To obtain bias and mean square error (M.S.E.) of the estimator t^*, we write:

$$\bar{y}^* = \bar{Y}(1+e_0^*), \quad \bar{x} = \bar{X}(1+e_1)$$

Such that:

$$E(e_0^*) = E(e_1) = 0$$

and $E(e_0^{*2}) = \frac{V(\bar{y}^*)}{\bar{Y}^2}$,

$$E(e_1^2) = \frac{V(\bar{x})}{\bar{X}^2}, = \left[\frac{1}{n} - \frac{1}{N}\right] C_x^2$$

$$E(e_0^* e_1) = \text{cov}(\bar{y}^*, \bar{x}) = \left[\frac{1}{n} - \frac{1}{N}\right]\rho C_y C_x$$

Expressing the estimator t^* in terms of e's, we have:

$$t^* = \bar{y}(1+e_0^*)(1+\alpha\lambda e_1)^{-g} \quad (9)$$

where, $\lambda = \frac{a\bar{X}}{a\bar{X}+b}$

We assume that $|\lambda e_1| < 1$ so that the right-hand side of Equation 9 is expandable in terms of the power series. Expanding the right-hand side of Equation 9 and neglecting the terms in e's having power greater than two, we have:

$$t^* = \bar{Y}\left[1 + e_0^* - \alpha\lambda g e_1 + \frac{g(g+1)}{2}\alpha^2\lambda^2 e_1^2 - \alpha\lambda g e_0 e_1\right] \quad (10)$$

Subtracting Y from both sides of Equation 10 and then taking expectation, we get the bias of t^* to the first degree of approximation, as:

$$B(t^*) = f\bar{Y}\left[\frac{g(g+1)}{2}\alpha^2\lambda^2 C_x^2 - \alpha\lambda g\rho C_y C_x\right] \quad (11)$$

Squaring both sides of Equation 11 and then taking expectation, we get the MSE of t^* as:

$$\text{MSE}(t^*) = f\bar{Y}\left[C_y^2 + \alpha^2\lambda^2 g^2 C_x^2 - 2\alpha\lambda g\rho C_y C_x\right] + \frac{(f-1)}{n} w_2 S_{y2}^2 \quad (12)$$

where, $w_2 = \frac{N_2}{N}$

Minimization of Equation 12 with respect to yields its optimum value as:

$$\alpha = \frac{k}{\lambda g} = \alpha_{\text{opt}}(\text{say}), \quad (13)$$

where $k = \rho\frac{C_y}{C_x}$.

Substitution of Equation 13 in Equation 12 yields the minimum value of the MSE of t^* as:

$$\min.\text{MS.E}(t^*) = f\bar{Y}^2 C_y^2(1-\rho^2) + \frac{(f-1)}{n} W_2 S_{y2}^2 \quad (14)$$

The min. MSE of t^* at Equation 14 is the same as that of regression estimator under non-response.

SUGGESTED ESTIMATOR IN TWO-PHASE SAMPLING

In many situations of practical importance, the problem of estimating the population mean $\bar{Y}$ of the study variable y assumes importance when the mean $\bar{X}$ of the population x is not known in the presence of non-response. In such a situation, the estimate of mean $\bar{X}$ of the population x is furnished from a large first phase sample of size n' drawn from a population of N units by simple random sampling without replacement. A smaller second phase sample of

size *n* is drawn from *n'* by SRSWOR and the variable *y* under investigation is measured in it. If there is non-response in the second phase sample, a subsample of the non-respondents units is taken and recontacted.

With this background, the estimators t^*_R, t^*_P, and t*in two phase sampling can be written, respectively, as:

$$t^*_{Rd} = \bar{y}^* \frac{\bar{x}'}{\bar{x}}, \tag{15}$$

$$t^*_{Pd} = \bar{y}^* \frac{\bar{x}}{\bar{x}'} \text{ and} \tag{16}$$

$$t^*_d = \bar{y}^* \left[\frac{a\bar{X}'+b}{\alpha_1(a\bar{x}+b)+(1-\alpha_1)(a\bar{x}'+b)} \right]^g \tag{17}$$

where, $\bar{x}'$ represents the mean of *x* based on *n'* units.

The MSE of t^*_{Rd} and t^*_{Pd} respectively, are given as:

$$\text{MSE}(t^*_{Rd}) = \bar{Y}^2 \left(\frac{1}{n}-\frac{1}{n'}\right)\left(C_y^2 + C_x^2 - 2\rho C_y C_x\right) + \bar{Y}^2 \left(\frac{1}{n'}-\frac{1}{N}\right) C_y^2 + \frac{(k-1)}{n} W_2 S_{y2}^2 \tag{18}$$

$$\text{MSE}(t^*_{Pd}) = \bar{Y}^2 \left(\frac{1}{n}-\frac{1}{n'}\right)\left(C_y^2 + C_x^2 + 2\rho C_y C_x\right) + \bar{Y}^2 \left(\frac{1}{n'}-\frac{1}{N}\right) C_y^2 + \frac{(k-1)}{n} W_2 S_{y2}^2 \tag{19}$$

To obtain the bias and M.S.E. of the estimator t^*_d, we write:

$$\bar{y}^* = \bar{Y}(1+e_0^*), \quad \bar{x} = \bar{X}(1+e_1) \text{ and } \quad \bar{x}' = \bar{X}(1+e_1')$$

Such that $E(e_0^*) = E(e_1) = E(e_1') = 0$

and

$$E(e_1') = \frac{V(\bar{x}')}{\bar{X}^2} = f' C_x^2,$$

$$E(e_0 e_1') = \frac{\text{Cov}(\bar{y}^*, \bar{x}')}{\bar{Y}\bar{X}} = f' \rho C_y C_x,$$

$$E(e_0 e_1') = \frac{\text{Cov}(\bar{y}^*, \bar{x}')}{\bar{Y}\bar{X}} = f' \rho C_y C_x,$$

$$E(e_1 e_2) = \frac{\text{cov}(\bar{x}, \bar{x}')}{\bar{X}^2} = f' C_x^2$$

Other expectation values are the same as used for suggested estimator above.

Now expressing t^*_d in terms of *e*'s, we have:

$$t^*_d = \bar{Y}(1+e_0)(1+\lambda e_1')^g \left[1+\lambda(\alpha_1 e_1 + (1-\alpha_1)e_1')^g\right] \tag{20}$$

Now expanding the right hand side of Equation 20 and neglecting the terms involving powers of *e*'s greater than two, we have:

$$\left(t_d^* - \overline{Y}\right) = \overline{Y}\left\{-g\lambda\left[\alpha_1 e_1 + (1-\alpha_1)e_1'\right] + \frac{g(g+1)}{2}\lambda^2\left[\alpha_1^2 e_1^2 + (1-\alpha_1)^2 e_1'^2 + 2\alpha_1(1-\alpha_1)e_1 e_1'\right] + g\lambda e_1' - g^2\lambda^2 e_1'\left[\alpha_1 e_1 + (1-\alpha_1)e_1'\right] + \frac{g(g-1)}{2}\lambda^2 e_1'^2 + e_0 + g\lambda e_0\left[\alpha_1 e_1 + (1-\alpha_1)e_1'\right]\right\} \quad (21)$$

Taking expectations of both sides of Equation 21 we get bias of the estimator t^*_d as:

$$\mathrm{B}\left(t_d^*\right) = \overline{Y}g\lambda\left\{f\left[\frac{(g+1)}{2}\lambda\alpha_1^2 C_x^2 - \alpha_1\rho C_y C_x\right] + f'\left[\left(\frac{(g+1)}{2}\lambda(1-\alpha_1)^2 - g\lambda(1-\alpha_1) + \frac{(g-1)}{2}\lambda\right)C_x^2 - (1-\alpha)\rho C_y C_x + \left((g+1)\lambda\alpha_1\right)\right]\right\} \quad (22)$$

MSE of t^*_d can be obtained as:

$$\begin{aligned}\mathrm{M.S.E}(t_d^*) &= E\left(t_d^* - \overline{Y}\right)^2 \\ &= \overline{Y}^2\left\{-g\lambda\left[\varepsilon_1 e_1 + (1-\alpha_1)e_1^*\right] + g\lambda e_1' + e_0\right\}^2 \\ &= \overline{Y}^2\left\{g^2\lambda^2\left[f\alpha_1^2 - 2f'\alpha_1^2 + f'\left((1-\alpha_1)^2 + 2(1-\alpha_1) + 1\right)\right]C_x^2 \right. \\ &\left. + 2g\lambda\left[f' - f\alpha_1 - f'(1-\alpha_1)\right]\rho C_y C_x + fC_y^2 + \frac{(k-1)}{n}W_2\frac{S_{y2}^2}{\overline{Y}^2}\right\}\end{aligned} \quad (23)$$

Minimization of Equation 23 with respect to μ yields its optimum value as:

$$\alpha_1 = \frac{\rho C_y}{g\lambda C_x} = \alpha_{(\mathrm{opt})}\text{say} \quad (24)$$

Optimal Values of *n*, *n'* and *k*

Following Singh and Kumar (2008), let the cost function be:

$$c'' = c_1 n' + c_1 n + c_2 n_1 + \frac{n_2}{k} \quad (25)$$

where,

c'_1 = The unit cost associated with the first phase sample of size n'

c_1 = The cost of the first attempt on y with second phase sample

c_2 = The unit cost for processing the respondent data on y at the first attempt in n_1

c_3 = The unit cost associated with the sub-sample units.

From Equation 18, the expected cost is:

$$C' = E(c'') = c_1' n' + \left(c_1 + c_2 w_1 + c_3\frac{w_2}{k}\right) \quad (26)$$

In order to obtain the optimum values of n', n and k, we minimize MSE of t^*_d for the given cost c' and for that we define a function by:

$$\Phi = \mathrm{MSE}\left(t_d^*\right) + \mu C' \quad (27)$$

here μ is Lagrange's multiplier. Now differentiating Φ with respect to *n*, *n*' and *k*, and equating to zero, we get:

$$n' = \frac{\overline{Y}\sqrt{D}}{\sqrt{\mu c_1'}} \tag{28}$$

$$n = \frac{\overline{Y}\sqrt{B}}{\sqrt{\mu c\left(A + \frac{c_3 w_2}{k}\right)}} \tag{29}$$

and,

$$\frac{n}{k} = \frac{S_{y2}}{\sqrt{\mu c_3}} \tag{30}$$

where,

$$A = \sqrt{c_1 + c_2 w_1}$$

$$B = \sqrt{g^2\lambda^2\alpha^2 C_x^2 + 2g\lambda\rho C_y C_x + C_y^2 - \frac{w_2 S_{y2}^2}{\overline{Y}^2}}$$

and,

$$D = g^2\lambda^2\left\{2\alpha(2-\alpha) + \left[(1-\alpha)^2 + 2(1-\alpha) + 1\right]\right\} C_x^2 + 2g\lambda(2-\alpha)\rho C_y C_x.$$

Solving Equations 28, 29 and 30, we get the values of μ, and optimum values of *n*, *n*' and *k* as:

$$\sqrt{\mu} = \frac{1}{c'}\left[\overline{Y}\sqrt{c_1'} + \left(\overline{Y}AB + \sqrt{c_3 w_2 S_{y2}}\right)\right] \tag{31}$$

$$n'_{opt} = \frac{c'\overline{Y}D}{\left[\overline{Y}\sqrt{c_1'}D + \left(\overline{Y}AB + \sqrt{c_3 w_2 S_{y2}}\right)\right]\sqrt{c_1'}} \tag{32}$$

$$n_{opt} = \frac{c'\overline{Y}\sqrt{B^2 + \frac{\sqrt{c_3 w_2 S_{y2}} B}{\overline{Y}A}}}{\sqrt{A^2 + \frac{\sqrt{c_3 w_2 S_{y2}} A}{\overline{Y}B}\left[\overline{Y}\sqrt{c_2}D + \left(\overline{Y}AB + \sqrt{c_3 w_2 S_{y2}}\right)\right]}} \tag{33}$$

and,

$$k_{opt} = \frac{\overline{Y}\sqrt{c_3}B}{S_{y2}A} \tag{34}$$

THEORETICAL EFFICIENCY COMPARISON

First, we compare the efficiency of the proposed estimator t^* with $\overline{y}^*$

$$\min.\text{MS.E}(t^*) \le V(\overline{y}^*)$$

$$f\overline{Y}^2 C_y^2(1-\rho^2) + \frac{(k-1)}{n} W_2 S_{y2}^2 \le f\overline{Y}^2 C_y^2 + \frac{(k-1)}{n} W_2 S_{y2}^2 \tag{35}$$

Or if:

$$\rho^2 \geq 0, \text{ This is always true.} \quad (36)$$

Next we compare the efficiency of the proposed estimator t^* with the estimator t^*_R. The estimator t^* will be better than the estimator t^*_R, if:

$$\text{min.MS.E}(t^*) \leq \text{MSE}(t^*_R)$$

Or, if

$$(C_x - \rho C_y)^2 \geq 0, \text{ this is always true.} \quad (37)$$

The estimator t^* will perform better than the estimator t^*_P, if:

$$\text{min.MS.E}(t^*) \leq \text{MSE}(t^*_P)$$

Or, if:

$$(C_x + \rho C_y)^2 \geq 0, \text{ this is always true.} \quad (38)$$

In the case of two phase sampling, the estimator t^*_d will perform better than the estimator $\bar{y}^*$ when,

$$\text{min.MS.E}(t^*_d) \leq V(\bar{y}^*)$$

Or, if:

$$\left(\frac{1}{n'} - \frac{1}{n}\right)\bar{Y}^2 C_y^2 \rho^2 \leq 0$$

This is always true because $n < n'$.

Next we compare the efficiency of the proposed estimator t^*_d with t^*_{Rd}.

The estimator t^*_d will be better than the estimator t^*_{Rd} if:

$$\left(\frac{1}{n} - \frac{1}{n'}\right)(C_x - C_y\rho)^2 \geq 0$$

which is always true as $n < n'$.

Finally we compare the efficiency proposed estimator t^*_d with t^*_{Pd}.

The estimator t^*_d will be better than the estimator t^*_{Pd} if:

$$\left(\frac{1}{n} - \frac{1}{n'}\right)(C_x + C_y\rho)^2 \geq 0 .$$

EMPIRICAL STUDY

Population I—Khare and Sinha (2004).

The data belongs to the data on physical growth of upper-socio-economic group of 95 schools children of Varanasi under an ICMR study, Department of Paediatrics, BHU from 1983–1984. The first 25% (i.e. 24 children) units have been considered as non-response units.

CONCLUSION

From Tables 1 and 2, we conclude that the proposed estimator t^* under optimum conditions performed better

Table 1. Percent relative efficiency (PRE) of the estimators with respect to $\bar{y}^*$.

Values of w, k		MSE of estimators				PRE of estimators w. r. t. $\bar{y}^*$			
w	k	y^*	t^*_R	t^*_P	t^*(min)	y^*	t^*_R	t^*_P	t^*(min)
0.1	1.5	0.1750	0.0925	0.3047	0.0555	100	189.3508	57.4392	301.4847
	2.0	0.1830	0.1004	0.3127	0.0634	100	182.2975	58.5177	263.7828
	2.5	0.1909	0.1083	0.3206	59.5428	100	176.2764	59.5428	234.4623
	3.0	0.1988	0.1162	0.3285	0.0792	100	171.0763	60.5186	211.0080
0.2	1.5	0.1829	0.1063	0.3127	0.0633	100	182.2975	58.5177	263.7828
	2.0	0.1988	0.1162	0.3286	0.0792	100	171.0762	60.5185	211.0080
	2.5	0.2146	0.1479	0.3444	0.0951	100	162.5478	62.3353	175.8299
	3.0	0.2305	0.1479	0.3603	0.1109	100	155.8467	63.9921	150.7051
0.3	1.5	0.1909	0.1083	0.3206	0.0713	100	176.2764	59.5428	234.4623
	2.0	0.2146	0.1320	0.3444	0.0950	100	162.5478	62.3353	175.8299
	2.5	0.2384	0.1558	0.3682	0.1188	100	153.0072	64.7672	140.6558
	3.0	0.2622	0.1796	0.3919	0.4261	100	145.9920	66.9040	117.2087
0.4	1.5	0.1988	0.1162	0.3286	0.0792	100	171.0762	60.5185	211.0080
	2.0	0.2305	0.1479	0.3602	0.1109	100	155.8467	63.9922	150.7051
	2.5	0.2622	0.1796	0.4236	0.1743	100	145.9920	66.9040	117.2087
	3.0	0.2939	0.2113	0.3919	0.1426	100	139.0936	69.3801	95.8946

Table 2. Percent Relative Efficiency (PRE) of the estimators with respect to $\bar{y}^*$ (in two phase sampling).

Values of w, k		MSE of estimators				PRE of estimators w. r. t. $\bar{y}$			
w	k	$\bar{y}^*$	t^*_{Rd}	t^*_{Pd}	t^*_d(min)	$\bar{y}^*$	t^*_{Rd}	t^*_{Pd}	t^*_d(min)
0.1	1.5	0.1750	0.1097	0.2778	0.0804	100	159.6351	63.0278	217.8472
	2.0	0.1829	0.1176	0.2856	0.0883	100	155.6166	64.0533	207.2701
	2.5	0.1909	0.1255	0.2936	0.0962	100	152.1054	65.0233	198.4353
	3.0	0.1988	0.1334	0.3015	0.1041	100	149.0113	65.9425	190.9449
0.2	1.5	0.1829	0.1176	0.2856	0.0882	100	155.6165	64.0532	207.2716
	2.0	0.1988	0.1334	0.3015	0.1041	100	149.0113	65.9425	190.9449
	2.5	0.2146	0.1493	0.3173	0.1199	100	143.8084	67.6432	178.9325
	3.0	0.2305	0.1651	0.3332	0.1358	100	139.6041	69.1819	169.7231
0.3	1.5	0.1909	0.1255	0.2936	0.0962	100	152.1054	65.0233	198.4352
	2.0	0.2146	0.1492	0.3174	0.1199	100	143.8084	67.6432	178.9325
	2.5	0.2384	0.1731	0.3412	0.1437	100	137.7908	69.8977	165.8798
	3.0	0.2622	0.1968	0.3649	0.1968	100	133.2266	71.8586	156.5316
0.4	1.5	0.1988	0.1334	0.3015	0.1041	100	149.0113	65.9425	190.9449
	2.0	0.2305	0.1651	0.3332	0.1358	100	139.6041	69.1819	169.7231
	2.5	0.2622	0.1968	0.3649	0.1675	100	133.2268	71.8586	156.5315
	3.0	0.2939	0.2285	0.3966	0.1992	100	128.6182	74.1075	147.5375

Table 3. Optimum values of n, n', k and PRE of t^*_d(min.) with respect to $\bar{y}^*$

w_2	$n'_{(opt)}$	$n_{(opt)}$	$k_{(opt)}$	MSE of t^*_d	PRE
0.1	44.56908	28.64912	2.865705	0.1020099	192.84249
0.2	42.32565	28.69083	3.021992	0.1365323	169.36713
0.3	40.37407	28.93183	3.194679	0.1767883	153.57174
0.4	38.67039	29.38295	3.387432	0.22379	142.32029

than the Hansen Hurwitz (1946) estimator, usual ratio and product estimators under non-response. It is also observed from the tables that the PRE of various estimators decreases with the increase of non- response.

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Effect of High Silica Loading on Uncured Properties of Epoxidised Natural Rubber Compounds

M.K. Mazlina and M.S. Che Su[1]

A 'green tyre' concept has the advantage of low rolling resistance, improved wet grip and enhanced handling. It has been reported that 3% decrease in rolling resistance is equivalent to 1% fuel saving, thus giving the 'green tyre' economic benefits and customer satisfaction. In this study, epoxidised natural rubber (ENR) compounds containing various loading of silica filler were prepared. The processibility and viscoelastic properties were investigated using the rubber processing analyser and Mooney viscometer. Results showed that the properties were adversely affected by the poor dispersion of silica as supported by the bound rubber measurement. In addition, a reversion in the cure behaviour was also observed as the curing temperature was increased to 170ºC.

Key words: viscoelasticity; dispersion; bound rubber; reversion; processability; curing behaviour

A wide variety of particulate fillers are used in the rubber industry, the most important purposes are for reinforcement, reduction in material costs and improvements in processing. For most applications, carbon black (CB) and silica are used as the main reinforcing fillers thereby increasing the usefulness of rubbers. Silica provides a unique combination of tear, abrasion, and ageing resistance with adhesive properties. In tyre tread, silica offers lower rolling resistance, equal wear resistance and wet grip than carbon black (Rauline 1993). However, the introduction of high silica loading in the rubber compounds leads to poor filler dispersion which is due to the large surface area and strong intermolecular hydrogen bonding with the silanols. Major drawbacks of silica include poor mixing and difficult processing conditions which require dedicated approaches and attentions, *e.g*. a longer mixing time and careful control of mixing temperature (Wolff & Wang 1992). Due to these factors, coupling agents such as bis(triethoxysilylpropyl) tetrasulphane (TESPT) (Murakami *et al*. 2003; Ansarifar *et al.* 2005; Wolff *et al.* 1994; Poh, Chen & Ding 1996) have been widely used in order to increase rubber filler interaction. TESPT ensures the silanization of the silica surface, i.e. the reaction between the silanol groups present on the silica surface with the ethoxy groups of the silane molecules with elimination of ethanol. This reaction causes a reduction of the polarity of the silica surface, enhancing the compatibility between rubber and the silica surface.

Owing to that, a significant interaction can also be obtained with rubbers which possess similar surface chemistry to silica such as ENR and nitrile butadiene rubber (NBR). The choice of this polar rubbers enables the possibility of avoiding the use of a silane coupling agent.

In this study, silica filled ENR vulcanisates with different filler loadings were prepared. Torque rheometry and rubber processing analyser (RPA) were used to predict the curing behaviour and viscoelastic properties. Bound rubber content of the rubber compounds were measured and compared in order to determine the level of dispersion.

Experimental Sample Preparation

ENR 25 having 25 mol% of epoxidation was used as the base elastomer. The filler used was Silica: Zeosil® 1165 MP with 165 (m^2/g) BET surface area with other compound ingredients such as zinc oxide, stearic acid, sulphur, calcium stearate and poly-2,2,4-trimethyl-1,2-dihydroquinoline (TMQ) which were of commercial grades and used without purification. The compound formulations are listed in Table 1. Compound mixing was carried out in the internal mixer, Banbury 1600. The mixing of the compound was carried out in three stages. In the first stage of mixing the starting temperature was 90ºC and fill factor was 0.7 for all compounds. All the ingredients except the curatives were added in the first and second mixing stages. The third mixing was done by using a two roll mill for the addition of curatives. Later the viscosity and curing characteristics were assessed by Mooney viscometer and oscillating disc curemeter at 100ºC and 170ºC, respectively. The compounds were then cured with an electrically heated press to a 90% cure at 170ºC.

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Table 1. Formulation of silica ENR compounds.

Material	(p.h.r.)
Epoxidised natural rubber (ENR 25)	100
Silica	50–80
Carbon black (N234)	5
Naphtenic Nytex 840	16
Zinc oxide	3
Stearic acid	3
Antioxidant (6PPD)	1
Anti oxidant (TMQ)	1
Calcium stearate	2
Sulphur	1.8
TBBS	2.4

Silica (Zeosil® 1165 MP (Rhodia Silica.)
6 PPD – N-(1,3-Dimethylbutyl)-N-phenyl-p-phenylenediamine)
TMQ – 2,2,4- Trimethyl- 1,2- dihydroquinoline polymerized
TBBS – N – tert –butyl-2 benzothiazolsulfenamide.

Measurement of Dynamic Properties

In this study, the dynamic rheology of the uncured compounds was analysed using a rubber processing analyser (RPA2000) (Monsanto, USA) with strain sweep 1% – 100% at 100ºC and a frequency of 1 Hz.

Bound Rubber Measurement

Bound rubber measurements were made in duplicate on the uncured finalized compound, after it had been allowed to rest for 7 days after mixing by swelling a weighed amount of compound (approx 250 mg) in toluene (50 ml) kept in a stopper flask at room temperature in the dark for 7 days. The flask was gently swirled several times during this period to agitate it without disrupting the swollen gel. The swollen gel was then weighed on pre-weighed lens tissue after removing excess solvent and then dried at 40ºC to a constant weight. Bound rubber and volume swelling values were calculated.

Bound rubber measurements were also carried out under an atmosphere of ammonia, swelling the compound in toluene using an open vessel in a closed desiccators that also contained a beaker of 32% aq. ammonia solution.

RESULT AND DISCUSSION

Viscoelastic Properties of the Uncured Compound

The influence of silica loading on the dynamic modulus of the uncured compound can be seen in Figure 1. It can be observed that modulus increases with addition of filler. The decrease in modulus with increase in strain was due to the Payne effect, the breakdown of the filler- filler and polymer –filler network.

Figure 1 shows that the highest modulus and greatest Payne effect are obtained with silica loading 80>75>70>60>50 p.h.r. The results indicate that the high dynamic stiffness was due to strong filler:filler interactions leading to agglomeration. The agglomerates led to an increase in modulus by immobilising rubber between particles and so increasing the effective volume fraction of filler. However, as the strain increased, some of the silica agglomerates broke down and the trapped rubber was released. Hence a lower modulus is obtained at a higher strain as shown in Figure 1. The viscosity values of the compounds shown in Figure 2 follow the same pattern as the dynamic viscous modulus.

Cure Characteristics

The rheometer cure profiles for the compounds are provided in Figure 3, measured at 170ºC. It was observed that there was a delay or induction period before the torque began to rise appreciably until optimum cure time. After the optimum cure, the torque increased slowly to maximum torque, and then there was a reversion period which could be seen with the decrease in torque. The minimum and maximum torques (ML and MH) of ENR-silica compound increased with increasing loading of silica.

Figure 3 shows two types of induction period for ENR-silica compound. For compounds with silica loading at 50

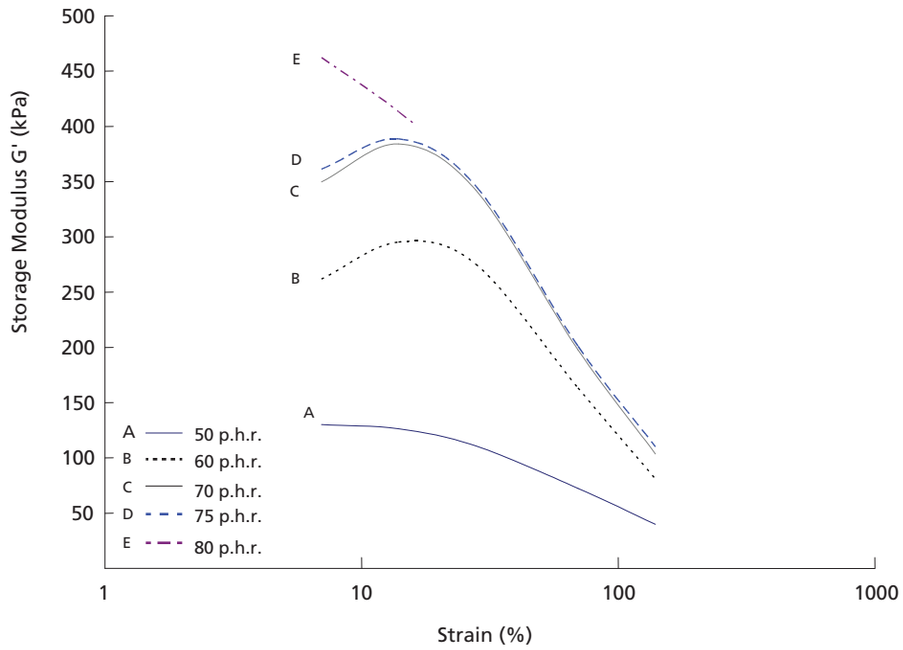

Figure 1. Influence of silica loading and strain on elastic dynamic modulus (1 Hz) of ENR compound.

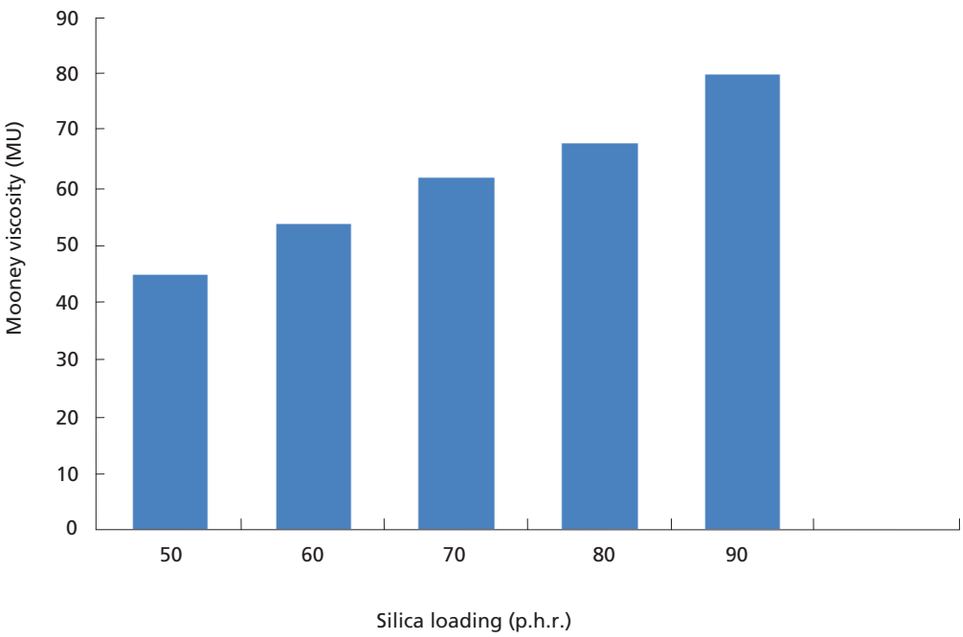

Figure 2. Variation of Mooney viscosity with silica loading in ENR compound.

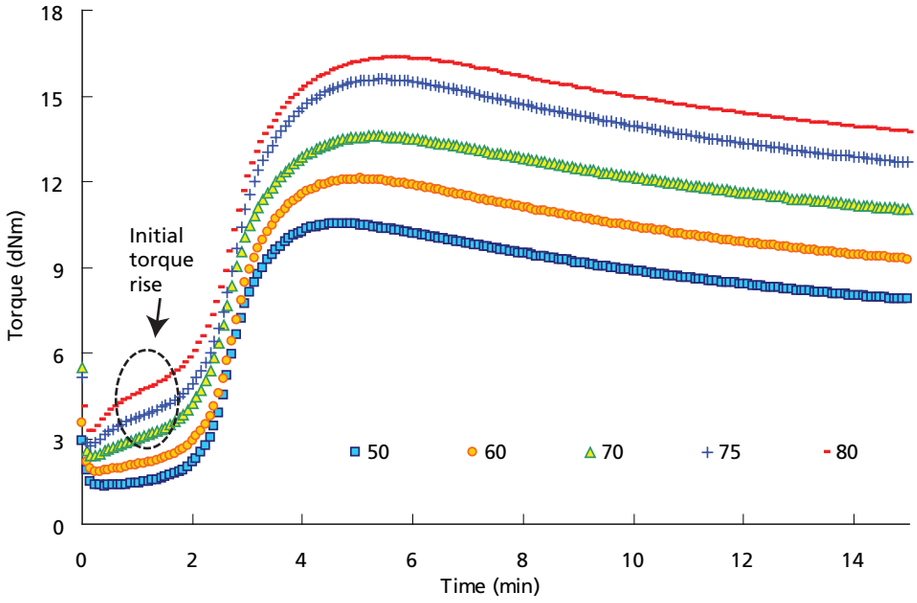

Figure 3. Rheometer curve of ENR filled with silica at various loadings (p.h.r.).

p.h.r. and 60 p.h.r. the rheometer curve shows the normal induction period as seen for rubber compound. Nonetheless, for ENR-silica compounds at higher loading of silica at 70, 75 and 80 p.h.r., the induction period in the rheometer curve shows an interesting behaviour where there was a sign of torque rise, which is denoted as initial torque rise.

The occurrence of initial torque rise in the cure characteristics of high loading silica-ENR compounds was believed to be associated with silica flocculation or the re-agglomeration of silica particles after rubber compounding. As with the viscous dynamic modulus and viscosity results, the high value was attributed to a silica filler network or silica aggregates formed as a result of interparticulate hydrogen bonding. In addition, Figure 3 shows that silica filled compounds exhibit reversion with time.

Figure 4 shows the effect of silica compounds at various temperatures of curing. It was observed that reversion increases with increasing temperature of vulcanisation. Poh *et al.* (1996) concluded that below 160ºC, reversion of ENR was associated with the decomposition of di and polysulphidic crosslinks, whereas at above 160ºC additional breakdown of mono and ether crosslinks occured. In another study, he also discovered that reversion behaviour depended on the epoxidation level, type of filler and accelerator used (Poh, Kurok & Lim 1995). In other studies it was found that reversion occurred when the trans-methine structure appeared in sufficiently large quantities (Chen *et al*. 1982; Chen *et al*. 1981).

Bound Rubber Content

The amount of bound rubber for a given elastomer depends on a number of factors such as surface area, structure and surface energy of the filler and the dispersion state. The bound rubber can be composed of three different types of polymer bounded on the silica surface: chemical-bonding, physical bonding and occluded rubber. The bound rubber content (BRC) of compounds filled with silica is shown in Figure 5.

The specific bound rubber g/g silica reduced slightly with silica loading up to 70 p.h.r. and it seemed to plateau with further increase in silica loading to 75 p.h.r. and 80 p.h.r. The decrease in bound rubber content with increasing filler loading indicated that there was a decrease in rubber to filler interaction. This resulted from the flocculation or re-agglomeration that occured with increasing filler loading, when more silica-silica networks were formed, which followed the viscosity and rheometer measurement discussed earlier.

Ammonia treatment BRC on the compounds was also carried out. It was reported that ammonia treatment of bound rubber measurement would cleave the physically bound rubber (Wolff, Wong & Tan 1993; Polmanteer & Lentz 1975). Hence, the ammonia modified bound rubber measurement could be used to estimate hydrogen bonding between rubber and silica in ENR-silica compound. It was observed that there was considerable reduction in

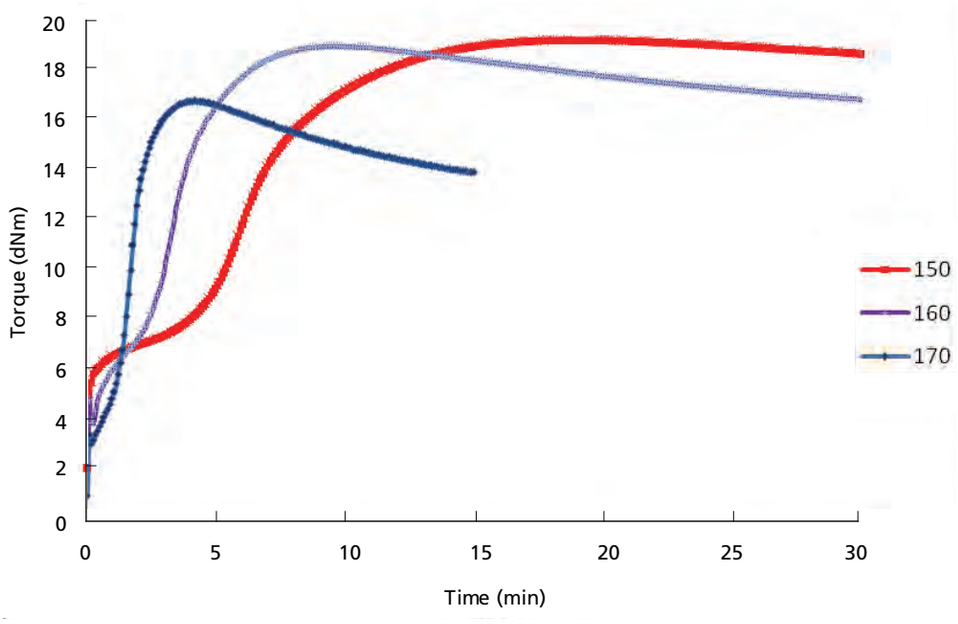

Figure 4. Rheometer curve of ENR filled with 70 p.h.r. silica at various curing temperatures.

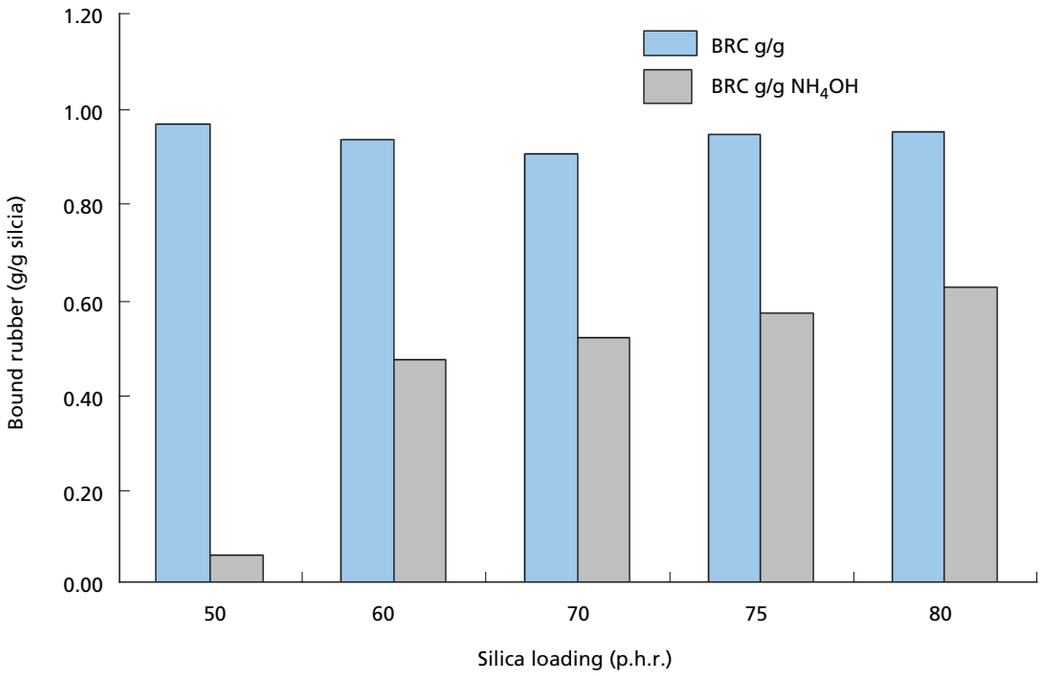

Figure 5. Bound rubber content in g/g silica and ENR-silica compound as a function of silica loading.

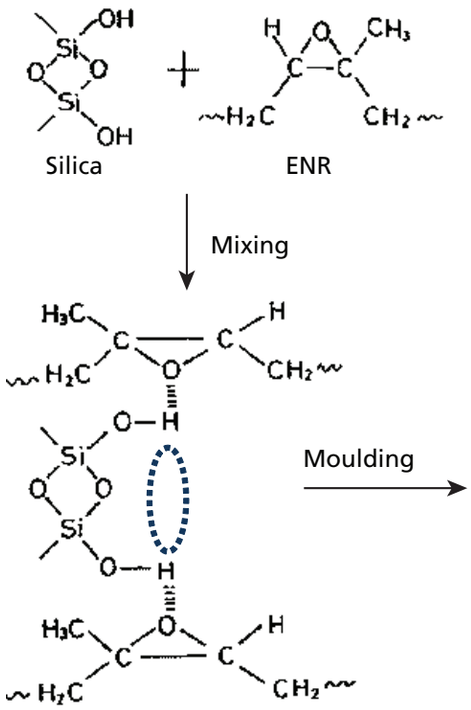

Figure 6. The probable mechanism of bonding between ENR and precipitated silica (Ajay, De & Tripathy 1999).

bound rubber after ammonia treatment. This showed that a significant amount of interaction between ENR and silica was formed through hydrogen bonding. This was due to the hydrophilic characteristics of silica surface. Modified bound rubber measurement was also carried out on the finalized compound. Interestingly, most of the bound rubber of the finalized compounds was completely destroyed after ammonia treatment. That again showed that most of the interactions in the ENR-silica compound were based on the strong hydrogen bonding between ENR and silica. The probable mechanism of bonding between ENR and silica is shown in Figure 6 (Ajay, De & Tripathy 1999).

CONCLUSION

In this work, it was found that high silica filler loading resulted in agglomeration which affected the viscosity, shear modulus and bound rubber properties. Indeed, silica filled compounds exhibited reversion behaviour as the curing temperature approached 160ºC and above which was probably due to additional breakdown of mono-and ether crosslinks.

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Insights from the Preliminary Autocorrelation Analysis of Low Frequency Neuronal Oscillations during Quran Listening

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The human brain generates different oscillations at different frequencies during various consciousness levels. When these brain waves synchronize with exogenous rhythmic stimulation, the brain experiences strong, yet relaxing emotion that could be involved in the formation of memory. We investigated the character of rhythmic oscillatory dynamics by electroencephalography (EEG) of subjects listening to a short verse of the Holy Quran compared to resting and Arabic news listening. The mean power amplitudes of each frequency band for wavelet-based time-frequency analysis were obtained from 5000 ms of segmented EEG recordings during rest, news and Quran listening conditions. The time series analysis of power from each of three conditions in each frequency band from the grand averaged data was then subjected to autocorrelation study. The results showed significant cyclic overall trends of increasing and decreasing patterns of power in the low frequency brain wave oscillation of different head regions especially global, frontal and temporal sites. These results provided a basis for prediction of the periodicity of the power of the oscillatory brain dynamics of delta and robustly in theta regions which occurred during Quran listening. Despite several limitations, our data offered a plausible scientific basis to the emotional induction during Quran listening that mimics recognized as data from music listening studies. This offered a promising perspective for future studies in translational neurophysiological, cognitive and biofeedback on Quran listening to modify brain behaviour in health and disease.

Key words: Brain waves; cognitive functions; rhythmic oscillatory dynamics; electroencephalography; oscillatory brain dynamics; brain behaviour; health; disease

The human brain generates different oscillations at different frequencies during various states of consciousness levels. In the presence of exogenous rhythmic stimulation, synchronization of these brain waves with such a source has been often linked with an emotional state of composure which might influence the formation of memory and other cognitive tasks. It has been said that listening to the Holy Quran has a calming and relaxing effect, irrespective of the listeners' native language and /or culture, and even without knowing its meaning (as it is in Arabic) because of its distinctive rhythm. This experience is primarily accustomed to billions of Muslims worldwide and is hinted at by a verse in the Quran that reads "and recites the Quran with a measured rhythmic recitation or in a slow style" [Al-Quran, Part 29, chapter 73; verse 4]. In addition, a well known Prophet's companion, Abu Hurairah had narrated that the Prophet (peace be upon him) said, "Allah (God) does not listen to anything as He listens to the Prophet reciting the Quran in a nice, loud and pleasant tone". Sufyan the companion said, "This hadith (Saying of Prophet) means: The Prophet regards the Quran as something that makes him dispense with much worldly pleasure" (Sahih Al-Bukhari, Vol. 6, Hadith No. 542). However, the neuronal mechanisms underlying this pleasing effect from rhythmic Quranic listening remain unclear.

The relaxing effect of prostration during a salat (Muslim prayer) has been studied using electroencephalographic (EEG) spectral analysis by autoregressive modeling (Salleh & Ibrahim 2009). Another study suggested that the natural music of a 'recitation of Quran' was able to relax and eliminate mental stress by using visual and multimedia systems (Nawsher *et al*. 2010). The use of Quran recitation as complementary and alternative therapy has also been documented in a cross-sectional study of 1408 individuals in Riyadh to improve their common health problems (Norah Al-Rowais *et al*. 2010) as well as in a randomized control trial and double blind study of 120 premature infants in Iran to improve their physiological state (Keshavars *et al*. 2010). A review of 176 completed questionnaires showed that 99 parents (56%) had used the complementary and alternative medicine (CAM) on children attending a pediatric neurology clinic in North Jordan for their child's specific neurological illness and the most common modalities

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(77%) were prayer/reciting the Quran (Aburahma 2010). Other listening methods resembling music had been chosen for their soothing effect on psychological patients (Morgan *et al*. 2010) with Nasyid music seeming more relaxing than rock music (Kadir *et al.* 2010). There was several studies on the technical aspect of EEG studies on Chinese poems (Li & Yang 2010) and on voice features matching for Quran readers to prevent mistakes during Quran reciting (Muhammad *et al*. 2010). However, scientific exploration of neuronal oscillations during melodious Quran listening remain scarce and several questions about the efficiency of the entrainment effect of emotion and relaxation in memory formation of Quran listening had yet to be answered. For our study, we conducted research on Quran listening with the aim of describing the dynamic patterns of the power of neuronal oscillation of brain waves during Quran listening using wavelet-based time-frequency analysis, supported by the time series analysis of the autocorrelation of EEG recordings.

METHODS

Subjects

Seven (n=7) healthy right handed (Muslim) volunteers (one female, mean age ± STD, 35.5 y ± 6.6) without any neurological disorders including no hearing disturbances and without drug history were recruited. The volunteers were habitual daily Quran listeners. Informed consent was obtained from all subjects prior to testing. This study was approved by the Human Ethical Committee of University Sains Malaysia (USMKK/PPP/JEPeM [234.3.(09)]

Data Acquisition

Assessment of any artifact or environmental noise in the EEG room that might affect the measured signal was performed using a non-human biological item, a Pamelo fruit using a similar set-up prior to human testing and the data was compared with the real experiment as in Figure 1(a).

EEG recordings were done at the MEG and ERP centre, Department of Neurosciences, Hospital University Sains Malaysia (HUSM). EEG values were recorded from subjects seated on comfortable chairs in a sound-treated quiet room with dimmed light by using a 128-electrode sensor net (Electrical Geodesics, Inc) as shown in Figure 1(b). The sampling rate was 250 Hz. The electrode impedances were 10 KΩ – 50 KΩ. The EEG readings were recorded with eyes closed under three conditions (resting, listening to Arabic news and listening to verses from the Quran). Equal sound pressure labels 60 dB were used. Seven verses from the first chapter of the first part of the Quran (Al-Fatihah) were chosen. The seven verses were of different lengths and Sheikh Qari Abdul Basit 'Abd us-Samad, a renowned *qari* of the Holy Quran recited those verses in 5, 8, 6, 6, 10, 8 and 20 s, respectively as shown in a schematic diagram in Figure 1(c). The same lengths of seven ordinary and random Arabic language sentences were selected from the mainstream Arabic TV News. In a resting condition, the subjects wore the head phone without any sound stimulus and EEG samples were segmented according to the desired lengths that resembled the Arabic News and Quran listening. The EEG data was filtered with low pass 30 Hz and high pass 0.3 Hz for analytical purposes.

Data Analysis

The artifact-free and baseline-corrected EEG samples were analyzed. Morlet wavelet-based time-frequency analysis was done to obtain the mean amplitude of power from an equal first 5 sec epoch of all segments for beta (13–30 Hz), alpha (7–13 Hz), theta (4–7 Hz) and delta (1–4 Hz) frequency bands. Power was analyzed between 1 and 30 Hz. Power represents the amplitude squared, which is a measure of the magnitude of the strengths of the EEG data in frequency bands. The EEG data was analyzed from 19 electrodes according to International 10 – 20 system (Fp1, F3, F7, Fp2, F4, F8, C3, C4, T3, T4, P3, T5, P4, T6, 01, 02, Fz, Cz, Pz). The electrodes were grouped into six different regions: (1) Global (Fp1, F3, F7, Fp2, F4, F8, C3, C4, T3, T4, P3, T5, P4, T6, 01, 02, Fz, Cz, Pz); (2) Frontal (Fp1, F3, F7, Fp2, F4, F8, Fz); (3) Central (C3, C4, Cz); (4) Temporal (T3, T4, T5, T6); (5) Parietal (P3, P4, Pz) and (6) Occipital (O1, O2). The layout of three regions involving the global, frontal and temporal areas is shown in Figure 1 (d). With the mean power or amplitude value from all subjects obtained, the autocorrelation analysis was performed on the grand averaged data to obtain the increasing and decreasing pattern of power in every frequency band by PASW SPSS 18 statistical software.

RESULTS

First, we obtained the wavelet coefficients representing the magnitude and phases of power in each frequency band with representative graphs in Figure 2 from the one-off Pamelo and serial test subjects at rest, at the Arabic news listening and during Quran listening. Next, we studied the increasing and decreasing models of mean power or amplitude in each frequency band and plotted a 3-D graph in Figure 3. This was followed by the autocorrelation time series analysis which depicted the significant autocorrelations in the delta and theta frequency bands in global (Table 1), frontal (Table 2) and temporal regions (Table 3). The robustness of the correlation for the up and down patterns of power in the theta frequency band was the most pronounced amongst the recorded bands (Table 2). The power of alpha and beta frequency bands did not show significant results in any head region in our experimental conditions.

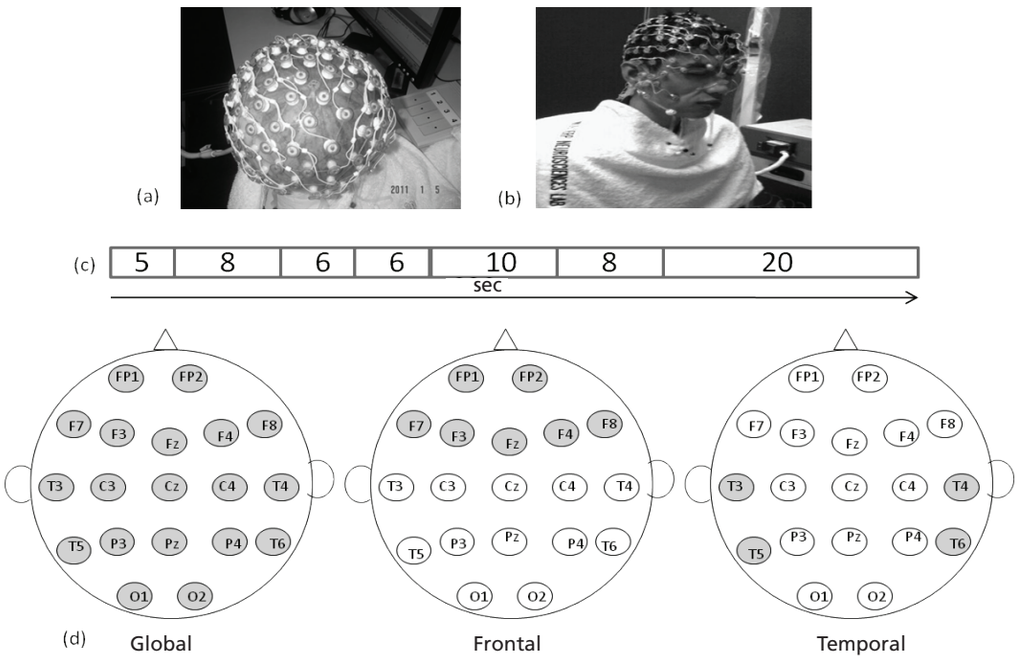

Figure 1. Figure 1(a) shows a phantom recording to check the artifacts from a non-human biological item like Pamelo fruit. Figure 1(b) is the preparation of a volunteer for recording EEG for experimentation. Figure 1(c) is the schematic diagram for the listening time series of the experiment. Figure 1(d) shows the layout of global, frontal and temporal head regions (shaded area), respectively.

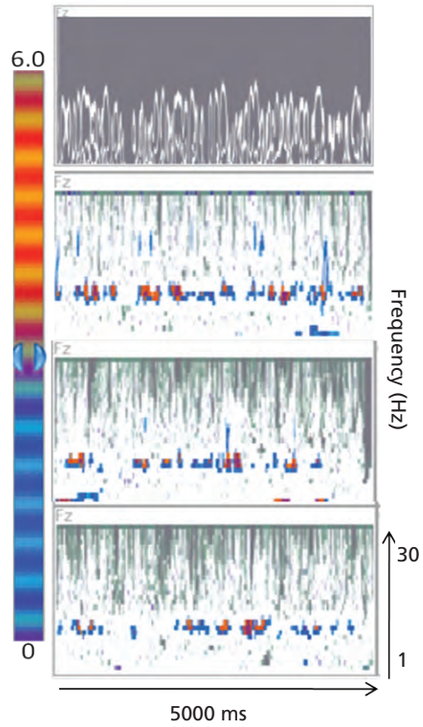

Figure 2. Representative wavelet graph from Pomelo (upper), at rest (upper-middle), at news listening (lower-middle) and during Quran listening (lower panel) from the Fz region. X-axis is the time and Y-axis is the frequency of 1 Hz to 30 Hz .The left bar is the color code for the intensity of mean power. Red and blue colours represent high and low power, respectively.

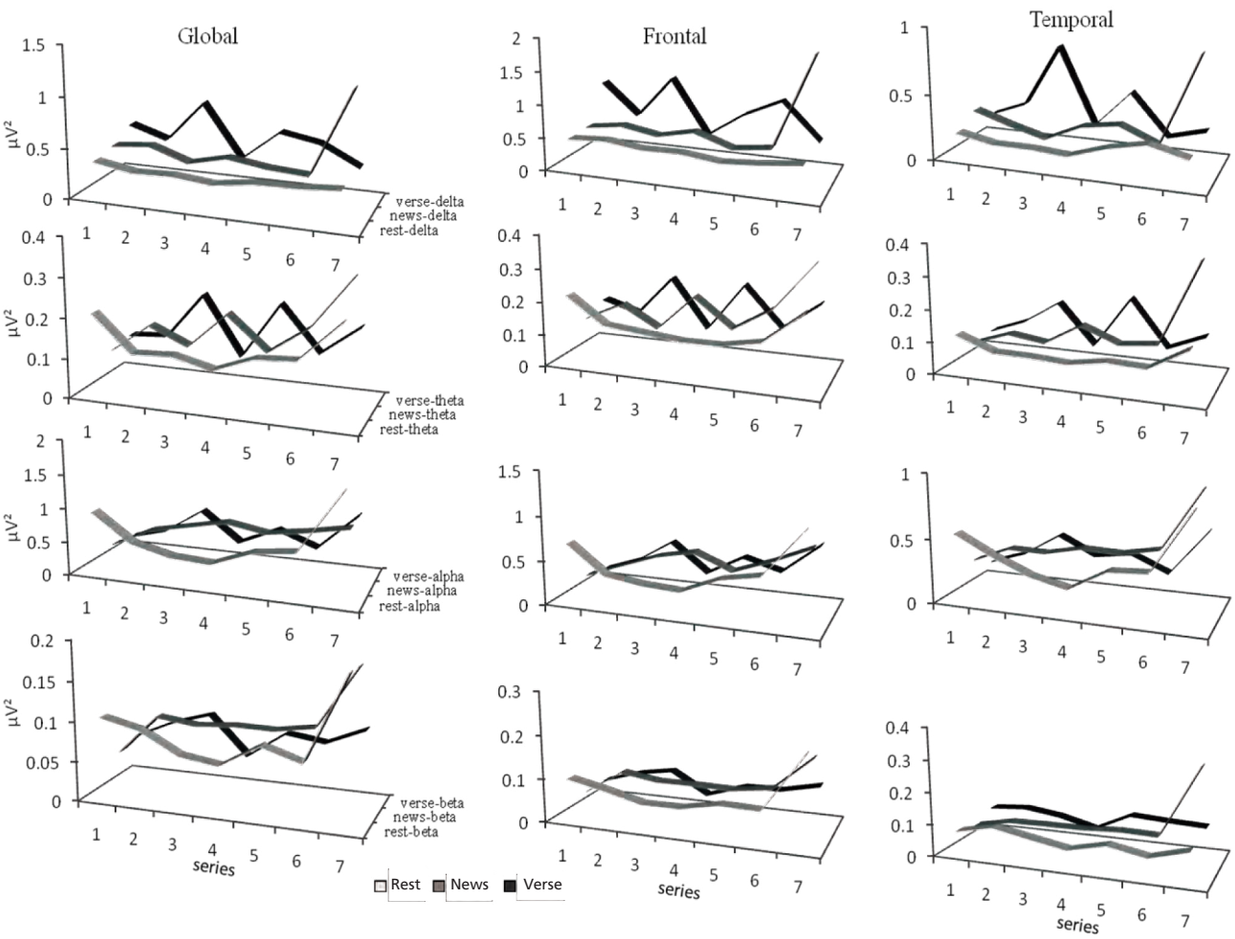

Figure 3. 3-D graph of power (amplitude squared) of delta, theta, alpha and beta frequencies during rest, news and Quran listening from grand averaged data (n=7) from global, frontal and temporal regions. Light, medium and deep colours indicate the experimental conditions of resting, news and Quran listening, respectively.

DISCUSSION

This study investigated the periodicity of oscillatory brain responses during Quran listening compared to resting and Arabic news listening. Power (squared amplitude) of delta, theta, alpha and beta band frequencies of resting, Arabic news and Quran listening conditions were acquired first by wavelet-based time-frequency analysis. The subsequent time series analysis by autocorrelation revealed that the recurring rising and descending prototypes of power in delta and theta appeared significantly rhythmic in the global, frontal and temporal brain regions during Quran listening. The power changing patterns in the theta frequency band were more obvious in the frontal brain region (Figure 3 and Table 2). The global auto correlated power in theta frequency band indicated the relaxing effect of Quran listening as in the frontal and temporal regions signifying emotional processing, which were consistent with other findings on studies examining the pleasant effect of listening to music (Kobuto *et al*. 1993; Koelsch *et al*. 2006). In fact, the correlation between frontal midline theta power changes and emotional processing has been documented in a study involving listening to pleasant music (Sammler *et al*. 2007), although it was not specifically addressed in our study for a deductive comparison. Data from a functional magnetic resonance imaging (fMRI) study had also shown activation of the temporal poles with other areas like amygdala, hippocampus and parahippocampus during pleasant music listening (Koelsch *et al*. 2006). In our study, the example of power changing in the delta frequency range was also significant though not as robust as theta power as an indicator of the pleasing and calming effect of Quran listening when associated with emotional responses from studies involving music (Kobuto *et al*. 1993, Yuan-Pin Lin *et al*. 2010).

On the basis that pleasing emotions enhance memory processing and music evokes strong emotion, music might

Table 1. Autocorrelation output table for delta and theta power from the global region. P value in bold-italic is significant ($p < 0.050$) and in bold is near significant ($0.050 < p < 0.100$).

Series: Verse-Delta		Region : Global			
Lag	Autocorrelation	Std. Error [a]	Box-Ljung Statistic		
			Value	df	Significance [b]
1	–0.636	0.309	4.253	1	***0.039***
2	0.159	0.282	4.571	2	0.102
3	0.19	0.252	5.141	3	0.162
4	–0.24	0.218	6.348	4	0.175
5	0.083	0.178	6.567	5	0.255
Series: Verse-Theta					
Lag	Autocorrelation	Std. Error [a]	Box-Ljung Statistic		
			Value	df	Significance [b]
1	–0.746	0.309	5.847	1	***0.016***
2	0.468	0.282	8.605	2	***0.014***
3	–0.219	0.252	9.358	3	***0.025***
4	0.063	0.218	9.442	4	***0.051***
5	0.007	0.178	9.443	5	***0.093***

[a] The underlying process assumed is independence (white noise).
[b] Based on the asymptotic chi-square approximation.

Table 2. Autocorrelation output table for delta and theta power from the frontal region. P value in bold-italic is significant ($p < 0.050$) and in bold is near significant ($0.050 < p < 0.100$).

Series: Verse-Delta		Region: Frontal			
Lag	Autocorrelation	Std. Error [a]	Box-Ljung Statistic		
			Value	df	Significance [b]
1	–0.572	0.309	3.436	1	***0.064***
2	0.096	0.282	3.552	2	0.169
3	0.174	0.252	4.027	3	0.259
4	–0.237	0.218	5.209	4	0.267
5	0.187	0.178	6.31	5	0.277
Series: Verse-Theta					
Lag	Autocorrelation	Std. Error [a]	Box-Ljung Statistic		
			Value	df	Significance [b]
1	–0.878	0.309	8.085	1	***0.004***
2	0.667	0.282	13.696	2	***0.001***
3	–0.423	0.252	16.508	3	***0.001***
4	0.210	0.218	17.43	4	***0.002***
5	–0.073	0.178	17.599	5	***0.003***

[a] The underlying process assumed is independence (white noise).
[b] Based on the asymptotic chi-square approximation.

be involved in forming memories (Jäncke 2008). In this present study, we demonstrated equivalent emotion being induced from the Quran listening which might also be involved in the formation of memory. Cumulatively, data from these music studies and that of our preliminary observations tempt us to speculate that emotional processing during rhythmic Quran listening underlies the inter-relation with the entrainment to neural oscillation in different brain structures to facilitate memory processing, as modeled in Figure 4. In this perspective, brainwave synchronization following periodic stimulation is recognised to produce tonic and phasic synchronization in delta and theta wave ranges, indicating rhythmic entrainment on cognitive functions involved in learning and memory tasks (Will & Berg 2007). However, despite technical limitations such as small numbers for auto correlation study (from the short first part of the Quran which consists of seven verses and a small sample size), this study raises further research queries. For instance, is the Quran perception similar to music and language perception or does it relate to both? In the study,

Table 3. Autocorrelation output table for theta power from the temporal region. P value in bold-italic is significant ($p < 0.050$) and in bold is near significant ($0.050 < p < 0.100$).

Series: Verse-Theta			Region: Temporal		
Lag	Autocorrelation	Std. Error [a]	Box-Ljung Statistic		
			Value	df	Significance[b]
1	–0.717	0.309	5.396	1	***0.020***
2	0.295	0.282	6.495	2	***0.039***
3	0.011	0.252	6.497	3	***0.090***
4	–0.162	0.218	7.047	4	0.133
5	0.109	0.178	7.423	5	0.191

[a] The underlying process assumed is independence (white noise).
[b] Based on the asymptotic chi-square approximation.

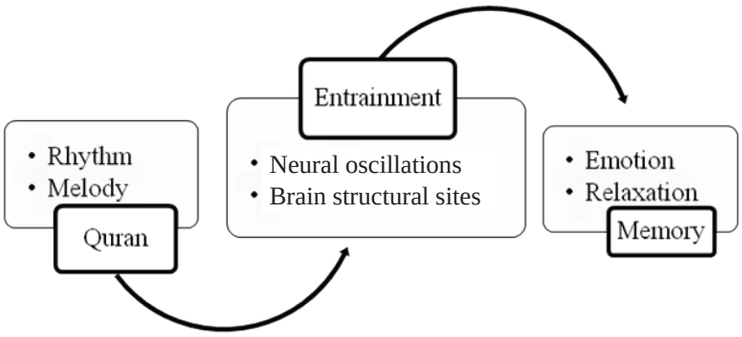

Figure 4. Conjectural schematic (theoretical) model of the effect of Quran listening.

the subjects were non-native Arabs and to entertain the raised question in specific terms, it should be best tested among native Arabs or those who understand the Arabic language. In addition, findings from this study also suggest that Quran listening might serve as a memory enhancer for certain cognitive-impaired patients such as with dementia, although reaching this goal demands the transformation of the reciting voice. This is because the structure of music such as tempo, mode and degree of resonance changes would affect the emotional induction during music listening and hence similar events might occur in the case of Quran listening if the recitation was restructured.

CONCLUSION

We investigated the character of the rhythmic oscillatory dynamics in the EEG of subjects during Quran listening compared to resting and Arabic news listening. We analysed the mean power amplitudes of each frequency band by wavelet-based time-frequency analysis obtained from 5000 ms of segmented EEG recordings during conditions of rest, news and Quran listening. We have presented the time series analysis of power from each of three conditions in each frequency band with grand averaged data by autocorrelation analysis. The analysis showed significant cyclic overall trends of increasing and decreasing patterns of power in the low frequency brain wave oscillation in different head regions. These results provided a prediction of the periodicity of the power of the oscillatory brain dynamics of delta and robustly in theta that occur during Quran listening. Overall, this study has provided a plausible scientific basis to emotion induction during Quran listening that mimics the data from music listening studies. This in turn, offers a promising perspective for future studies on Quran listening to provide translational neurophysiological, cognitive and biofeedback to modify brain behavior in health and disease.

ACKNOWLEDGEMENT

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Tools for Integrated River Flood Management (Hydraulics Modeling and Logical Framework Analysis)

C.H.J. Bong[1#], D.Y.S Mah[1], F.J. Putuhena[1], S. Said[1] and R.A.Bustami[1]

Hydraulics simulation can be used as a supporting tool for planning and developing a framework, such as Integrated Flood Management for river management. To demonstrate this, a hydraulics model for the Sarawak River Basin was run using InfoWorks RS software by Wallingford Software, UK. InfoWorks River Simulation (RS) was chosen because its applicability has been proven and widely used to model Malaysian rivers. The extraction of computed floodwater level and flood maps for different time intervals would produce the rate of floodplain submergence from river bank level. This information could be incorporated into a logical framework to support decisions on flood management measures. Thus, hydraulics models can be used as tools to provide the necessary decision parameters for developing logical frameworks which would act as to guide the planning when it involved various stakeholders' participation.

Key words: Hydraulics simulation; integrated river management; Sarawak river basin, supporting tool; flood warning; stakeholder participation; monitoring; evaluation

Managing a river basin so that it meets the needs of various stakeholders is a daunting task. The management of a river basin in an integrated and holistic manner is the current trend towards meeting these needs and provide solutions for problems related to water resources. Implementing an integrated approach requires tools that could act as an interface to communicate effectively between these various stakeholders. In developing the communication interface, data and information from various stakeholders is needed and a computer model such as a hydraulics model could be used to help visualise the system under study so that it is understandable amongst all the stakeholders.

Various agencies and stakeholders are involved in looking towards solutions for the flood problems in the Sarawak River Basin. To utilize the efficiency of these various stakeholders, it would be wise to approach the problem in an integrated way by adopting Integrated Flood Management (IFM). Logical Framework was adopted as the designing tool for outlining the proposed set of action plans for achieving the Integrated Flood Management settings and objectives for a collaborative network among the responsible agencies.

This paper demonstrates how the supporting tool Logical Framework was used as the communication interface and hydraulics model as to provide the necessary information for decision making in developing the Logical Framework. For carying out this purpose, the development of the Logical Framework for Integrated Flood Management (IFM) for the Sarawak River Basin was discussed and a hydraulic model using InfoWorks River Simulation (RS) software was applied to the basin to provide inundation analysis. Results from the hydraulics simulation would provide the necessary data for the sub-logical framework to serve an early flood warning system.

The developed Logical Framework from this paper could facilitate workshops in the future towards integrated development and management of the Sarawak River Basin. It could help to convince various stakeholders to meet and participate actively in the discussions towards an integrated approach. It could also help in monitoring and evaluating whether the planned and implemented management and development plan was moving in the right direction and take the necessary actions when the unexpected happened.

BACKGROUND OF THE SARAWAK RIVER BASIN

The Sarawak River Basin as shown in Figure 1 has an area of 2459 km^2 and consists of two main tributaries, namely

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Sarawak River Kanan and Sarawak River Kiri. It was in this basin that Kuching, the capital city of Sarawak was located. Flooding was a common occurrence in the basin, the most severe flood happened in January 1963 with about 6.1 metre of water at some low-lying areas (DID 2012b). Examples of other major floods were the floods in February 2003 with flood levels of between 0.3 m to 1 m, in January 2004 with flood levels of between 0.3 m to 1.5 m and in January 2009 and with flood levels of between 0.1 m to 0.6 m for some low-lying areas in Kuching city (DID 2012b). Studies have shown that the main reasons for these flood occurrences were the limited channel conveyance of the river, limited storage of the river and tidal influence (Jurutera Jasa Consulting Engineers 2003). To protect Kuching city from floods, the Sarawak State Government established the Kuching Barrage in 1998 which was aimed to control the river and tidal flows under the Sarawak Regulation Scheme (KTA Consulting Engineers 1994) and a flood bypass channel was currently under construction. The flood bypass channel was designed to start from an 'oxbow', the natural river bent like a horseshoe shape near Kpg. Paroh and ended by passing floodwaters into the Salak River. Figure 2 shows a technical drawing of the flood bypass structure superimposed on a satellite image. The flood bypass would be 8 km long and have a 250 m base width with a 10 m deep earth-dug (nature-like) rectangular channel (Jurutera Jasa Consulting Engineers 2006). It would be sided with a 1 m high earth bund on reserve land of 125 m width on both sides. There would also be two low-level bridges across the bypass channel; one with a tidal gate and the other had three bays of 25 m wide gated barrages with ship lock. The flood bypass channel was expected to be completed by the year 2015.

Various agencies and stakeholders were involved in the planning and development of Sarawak River Basin. To develop a framework for Integrated Flood Management, the involvements of these various stakeholders were needed. Feedback and input from stakeholders were needed as the needs and expectations of each of the stakeholders had to be taken into consideration before developing the framework. Table 1 summarizes the roles and responsibilities of government department stakeholders for Sarawak River Basin.

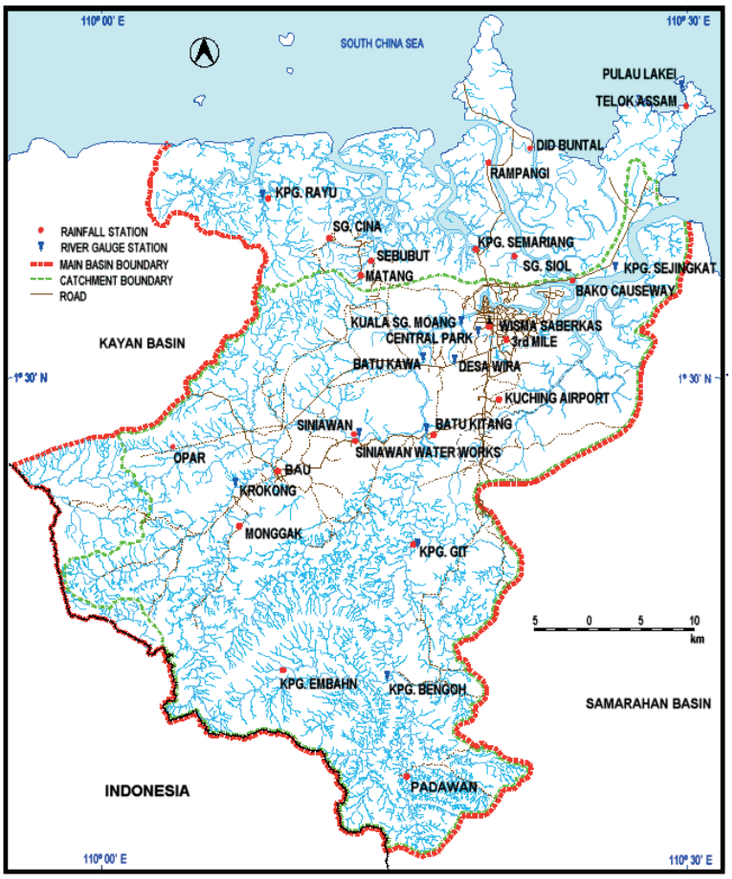


Figure 1. Sarawak River Basin (DID 2012a).

Figure 2. Flood bypass channel of Sarawak River (Jurutera Jasa Consulting Engineers 2006).

METHODOLOGY

Logical Framework

Logical Framework was proposed in this paper as the communication tool amongst the various stakeholders. The logical framework (AusGuidelines 2010), commonly known as 'logframe', is a management and planning tool which links cause and effect through a hierarchy of objectives. It was first adopted by USAID in the early 1970s. The Logical Framework approach is applied during preparation, implementation and evaluation of each project in a program, as such it became an effective tool for Integrated Flood Management.

The Logframe comprises of a 4 × 4 matrix (see Figure 3). Column 1 provides a narrative summary of activities and objectives. Reading from the bottom these steps are *Activities*, *Outputs*, *Objectives* and *Ultimate Goal*. Each of these has a specific definition and role. Column 2 contains *Objectively Verifiable Indicators* [OVI] that provide evidence of the statements in column 1 of the same row that have been achieved. Column 3 provides the *Means of Verification* [MOV] by which the OVI can be measured and is equivalent to the monitoring and evaluation system. Column 4 lists the major assumptions, which influence the progression from a lower to a higher row in the framework.

The flow of logic through the framework starts in the bottom left hand corner at the level of activity and follows a sequence of IF – AND – THEN statements, as illustrated in Figure 4. **IF** the *Activities* are completed **AND** the *Assumptions* hold, **THEN** the *Outputs* can be achieved, **IF** the *Outputs* are completed, **AND** the *Assumptions hold*, **THEN** the *Objectives* can be achieved and so on.

In developing the Logical Framework, the first step was to do problem analysis to identify the existing problems in the basin. Once these problems were known, a stakeholder analysis was carried out to determine the interests and expectations of each of the stakeholders and how they could contribute toward an integrated approach in the management and planning of the river basin. Based on the stakeholder analysis, objectives analysis was carried out to systematically identify, categorize, specify and balance out the objectives of all the stakeholders. Objective analysis might depict several possible strategies or solutions for each existing problem, however as was usually the case, due to limited resources, alternative analysis needed to be done to examine available objectives and to select only the best. Once the best alternative was chosen, the main elements for the implementation needed to be identified such as the ultimate goal, objectives, inputs, activities and outputs. External factors that might affect the progress of the chosen alternative also needed to be taken into consideration. In order to measure and determine the progress towards the stated objectives, indicators and means of verification needed to be determined. Means of verification specify the expected source of the information needed to collect and verify the indicators. Once the project elements, indicators and mean of verifications were drafted, only then could the Logical Framework Matrix be filled up.

Table 1. Government agencies involved in Sarawak River Basin (Bong *et al.* 2009).

Agency/Department	Involvement
Department of Irrigation and Drainage (DID)	• Hydrology and water resources data collection • Total catchment plan studies (flood modeling and catchment modeling) • Irrigation and drainage works • Drainage master plan studies • River engineering • Coastal engineering • Technical advice (on hydropower project and also sand extraction).
Agriculture Department	• Drainage and irrigation • Crop water requirements • Soil conservation
Sarawak Tourism Board	• Promotion of tourism involving water recreation
Land and Survey Department	• Approving and licensing on sand extraction in river • Town and country planning
Forest Department	• Forest research • Logging impact • Sawmill pollution
Sarawak Rivers Board (SRB)	• Navigation • Terminal facilities • River cleanliness • Erosion control • River engineering • Sand extraction
Sarawak Marine Department (SMD)	• Hydrographic survey • Navigation
Sarawak Water Resources Council (SWRC)	• Policy for sustainable water development • Regulation
Natural Resources and Environment Board (NREB)	• Policy • EIA • Regulation
Kuching Water Board (KWB)	• Public water supply
Public Works Department	• Gazette water catchments • Investigate, design, construct and maintain civil works such as dam, wharves, bridges, etc • Water supply to rural area
State Plannig Unit (SPU)	• Formulate state socio-economic development policies • Serve as secretariat to various planning council/committees at state level
Malaysian Meteorological Services (MMS)	• Provide data for rainfall and weather • Provide early warning on adverse weather phenomenon
Department of Environment (DOE)	• Water pollution regulation • EIA • Monitoring the environment
Medical Department	• Monitor water quality

Hydraulic Simulation Model

To support the development of the Logical Framework, especially during the alternative analysis stage, a hydraulics simulation model could be used to provide the necessary information in choosing the best alternative. A hydraulics simulation model such as InfoWorks RS by Wallingford Software was utilized for modelling the Sarawak River Basin as demonstrated in this paper. InfoWorks RS was chosen due to its proven applicability in modelling the Sarawak River system (Jenny *et al.* 2007; Said *et al.* 2009). InfoWorks RS is a known one-dimensional model used for predicting discharge and water level for a wide range of rivers, reservoirs, complex floodplains and narrow estuaries under both steady and unsteady conditions. The performance of one-dimensional models have been tested repeatedly in literature and studies have shown that a one-dimensional model performed equally as a two-dimensional model (Horritt & Bates 2002; Mark *et al.* 2004)

Model description. InfoWorks RS was based on the Saint-Venant equations which consist of the continuity equation; Equation 1; and the momentum equation; Equation 2. The solution of these equations defines the propagation of flood wave with respect to distance along

Ultimate goal	Indicator	Mean of verification	Assumptions
Objectives	Indicator	Mean of verification	Assumptions
Outputs	Indicator	Mean of verification	Assumptions
Activities	Inputs	Budgets	Assumptions

Figure 3. Basic logical framework layout.

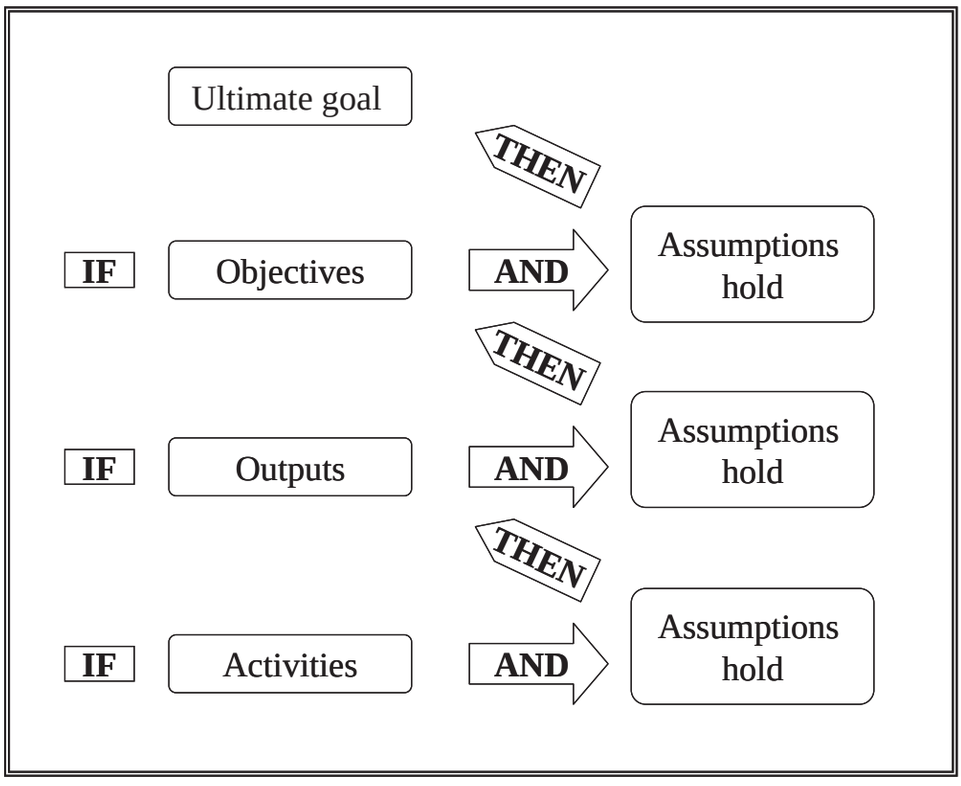


Figure 4. Cause and effect of framework link.

the channel and time which enables it to compute flow depths and discharges:

$$A\frac{\partial V}{\partial x} + VB\frac{\partial y}{\partial x} + B\frac{\partial y}{\partial t} = q \quad (1)$$

where,

$A\frac{\partial V}{\partial x}$ = prism storage

$VB\frac{\partial y}{\partial x}$ = wedge storage

$B\frac{\partial y}{\partial t}$ = rate of rise

A, flow area; B, stream top width; V, velocity; y, river water level; x, distance along the channel; t, time; q, lateral flow into channel per unit length of channel.

$$S_f = S_o - \frac{\partial y}{\partial x} - \frac{V}{g}\frac{\partial V}{\partial x} - \frac{1}{g}\frac{\partial V}{\partial t} \quad (2)$$

where,

S_f, friction slope (frictional forces); S_o, bed slope (gravitational effects); G, gravitational acceleration;

$\frac{\partial y}{\partial x}$, pressure differential

$\frac{V}{g}\frac{\partial V}{\partial x}$, convective acceleration

$\frac{1}{g}\frac{\partial V}{\partial t}$, local acceleration

Model inputs. The river basin elevation model was derived from a survey exercise done in 2000 in conjunction with the Sarawak River Mitigation Options Study (Jurutera Jasa Consulting Engineers 2003). Using ESRI ArcView 3.1 software together with 3D-Analyst 1.0 Extension, a 1:10 000 scaled key plan from the survey exercise in AutoCad format featuring the river basin area with proper geo-referencing was regenerated as a digital basin map in shapefile (SHP) format from which a Triangulated Irregular Networks (TIN) surface model was later generated. The TIN model was exported to the InfoWorks RS environment as a Digital Terrain Model where the ground surface information was extracted for network building. The river network was interacted through the embedded Geographical Plan (GeoPlan) where the entire river network could be comfortably developed through the on-screen method instead of using a digitizer.

The channel cross section and river length data was extracted from the Sungai Sarawak Flood Mitigation Options Study report (Jurutera Jasa Consulting Engineers 2003). Nodes (the lowest mid-point in the river cross sections) were established at convenient points along the modeled river channels. Each node provided ground level and indication of the channel cross section. Links between nodes were given river lengths.

There are boundaries conditions available in InfoWorks RS, however the Flow-Time Boundary and Stage-Time Boundary were applied in this study. For Flow-Time Boundary, no direct measurement of flow data were available; however, rating curves were available for the two upstreams stations of Buan Bidi and Kpg. Git that had been calibrated from time to time (Mah *et al*. 2007). A king tide stage hydrograph from the tidal chart published by Marine Department Sarawak was adopted as Stage-Time Boundary at the downstream Barrage.

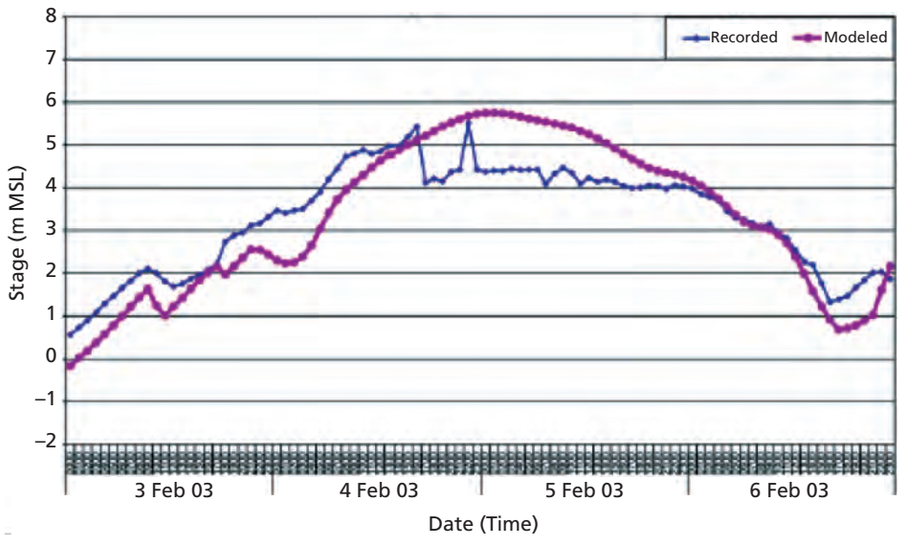
Model outputs. InfoWorks RS calculates the water level and discharge at each cross-section for each time step specified. The results of the simulation could be viewed in InfoWorks RS View as animations or as a time series table for a specified cross-section or along the length of the river. InfoWorks RS View also computed the flood depth and produced the flood map for the whole Sarawak River Basin river system.

Calibration and validation. The February 2003 and January 2000 flood events were used for calibration and validation purposes respectively. Calibration was carried out by adjusting both the channel and floodplain Manning's n values. The model was successfully calibrated with Manning's n value ranging from 0.025 to 0.055. Figure 5 shows that the matching of the recorded and modeled hydrographs during the February 2003 flood event was acceptable with a correlation coefficient of over 0.80. Figure 6 shows the measured and modeled water level at (a) Batu Kawa bridge and (b) Batu Kitang bridge for validation purposes using the data from January 2000 flood events.

Modeling the flood bypass channel. The flood bypass channel was modeled as a river channel extending from the 'oxbow' while the downstream end at Pasir Salak was modeled as stage-time boundary. The stage-time datasets were set at bankfull water levels assuming that the channel would be at maximum conveying capacity during a flood event. Assumptions made were that all of the floodwater would be diverted to Salak River, prohibiting any excess water entering the city by a barrage. The barrage was modeled as radial gates (Wallingford Software 2008).

For the purpose of modeling the river basin response with the flood bypass channel, the Sarawak River Basin model was simulated for the January 2004 flood event

(a)



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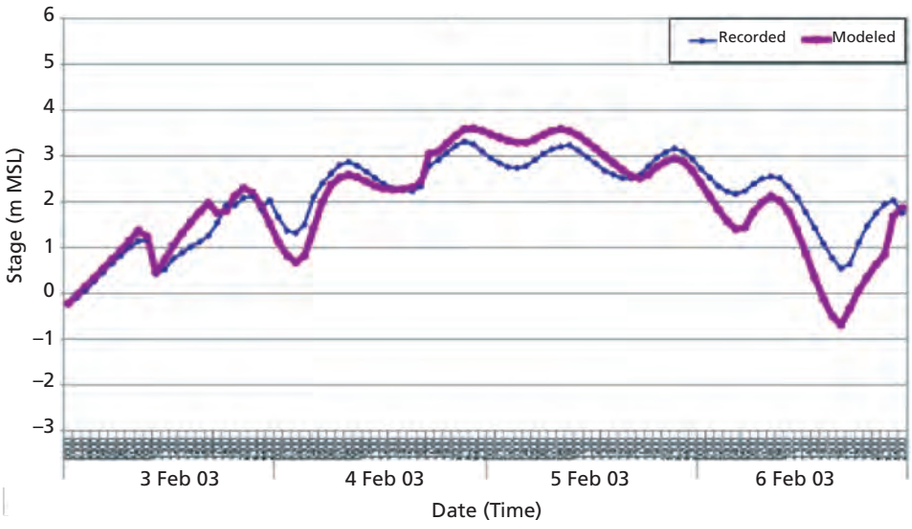


(c)

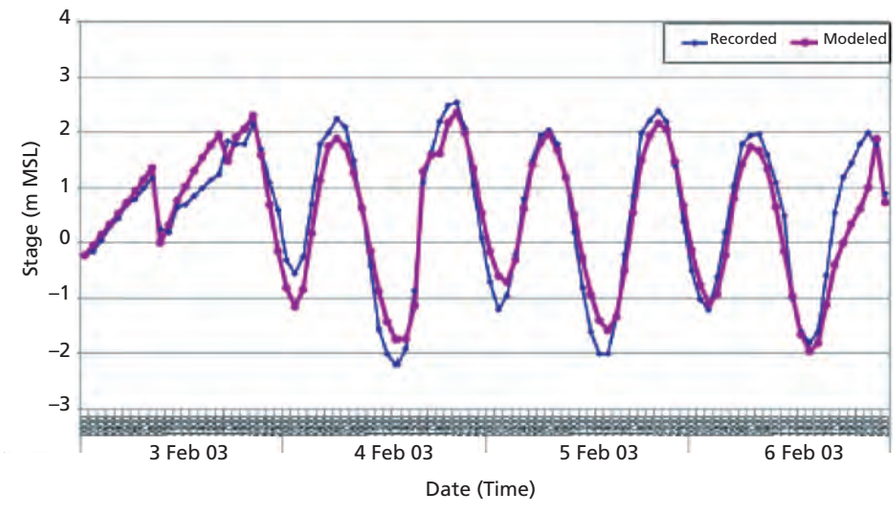
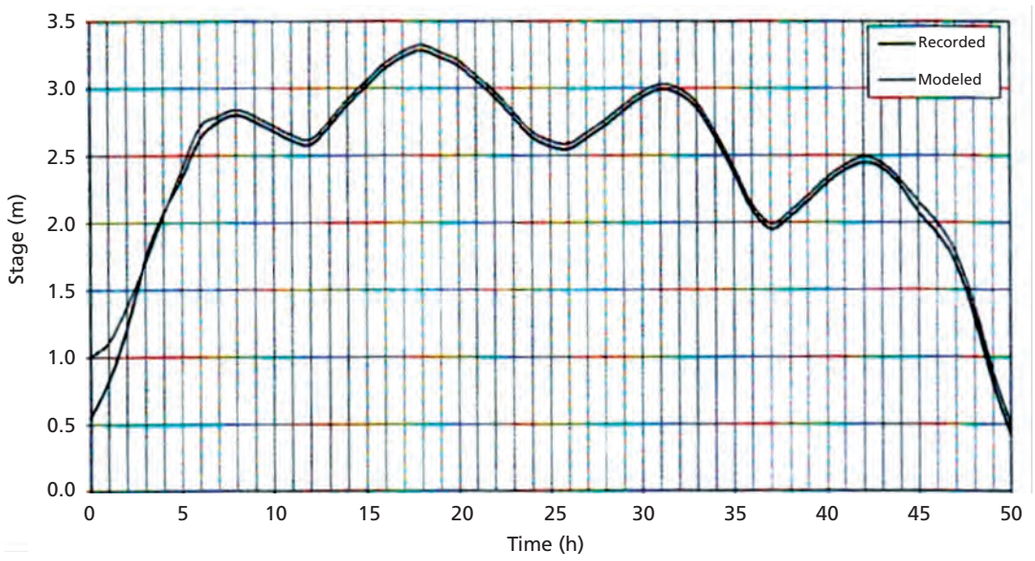
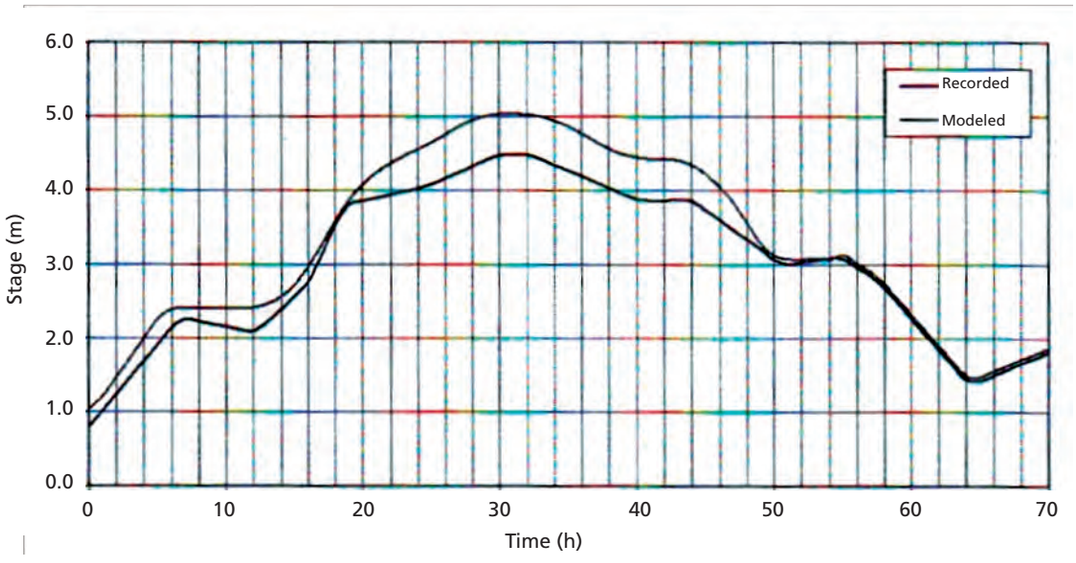


Figure 5. Model calibration of February 2003 flood event at (a) Batu Kawa bridge, (b) Satok bridge and (c) Ship Lock at Muara Tebas.



(a)



(b)

Figure 6. Measured and modeled water levels for validation at (a) Batu Kawa bridge and (b) Batu Kitang bridge.

which was locally known as a 100-year flood. To model the January 2004 flood event, observed hourly water level data for 4 days (21 – 24 January) were fed into the model. Figure 7 shows the simulation of January 2004 flood with the flood bypass channel.

To run the simulation, the flood bypass channel had divided the river into two stretches named by the authors as Lower and Upper Sarawak River. The Lower Sarawak River would be a total regulated river controlled by two barrages. The 100-year flood was run together with the highest astronomical tides at 6.5 m. The bypass channel was to be installed with floodgates allowing one way flow, thus tidal action was not included in this model.

Rate of Flood Plain Submergence

For the purpose of extraction of the computed floodwater level data and flood maps at different time steps from the hydraulics simulation to be used in the Logical Framework, the authors had proposed to use the rate of flood plain submergence from river bankfull level up to a depth of 2 m and calculate using Equation 3. The rate of flood plain submergence would be a reflection of the river flooding severity. The higher the rated value, the more vulnerable the location would be to fast rising and widespread floodwater. In Equation 3, L is the length of affected area from the river bank towards an urban center within the intended time and is the time of floodwater reaching the intended level from bankfull level. Figure 8 shows the definition of Equation 3. The basis of why 2 m was taken as the reference point was that (1) a normal adult height of 1.6 m, (2) human settlements were known to be close to the river, (3) most of the village houses outside Kuching city were single storey, thus beyond 2 m of height would inflict drowning.

$$\text{Rate of floodplain submergence} = \frac{L \text{ in Km}}{t \text{ in hour}} \qquad (3)$$

RESULTS AND ANALYSIS

Logical Framework

Table 2 shows a Logical Framework developed by the authors in the hope that this framework would serve as a guide for government agencies in managing floods for the Sarawak River Basin. The ultimate goal for the Logical Framework as developed by the authors for the purpose of Integrated Flood Management in Sarawak River Basin was to reduce flood damage especially at the two flood-prone areas of Batu Kitang and Batu Kawa. This could be achieved by setting the objectives that all government departments to use Geographical Information System (GIS) flood maps which would enable information regarding the floods be shared and transmitted faster between these agencies; early flood warning, forecasting systems and evacuation centres were in place and operational; and the community was also educated on using the right path for evacuation. In order to achieve these objectives, ground information survey and land use information needed to be obtained to develop a useful GIS platform an early flood warning system and forecasting centres as well as evacuation centres needed to be constructed and a community education program needed to be implemented.

Hydraulic Simulation

In hydraulic simulation, while the 100-year flood flows were diverted by the bypass, the Lower Sarawak River was predominantly tidal, as shown in the water level hydrographs of Pending and Kuala Maong [see Figure 9(a)] which explained the flooding of the Lower Sarawak River which persisted (Figure 7). On the other hand, the Upper Sarawak River was acted on solely by upstream flows. The water levels were lower as floodwaters travelled downstream from Batu Kawa to the flood bypass channel [see Figure 9(b)]. The model had dictated the volume of floodwater to be 397 Mm^3 before the 'oxbow' and 392 Mm^3 on entering the flood bypass channel. However, the floodwaters would form a pool before the bypass channel as shown in Figure 7.

Rate of Flood Plain Submergence

Table 3 shows floodwater rising from bankfull level to 0.5 m, progressively to 1 m, 1.5 m and 2 m as well as the time and affected length. The analysis shows that the Lower Sarawak River was mostly vulnerable to flood risk due to its low elevation. Kuala Maong and Pending had the fastest time factor of water rise, 0.5 m in less than an hour. Both locations would submerge at a rate of 4 – 5.8 km/hour. Upper Sarawak River was ranked moderate but Batu Kawa saw the widest in floodwater spread. Batu Kawa would submerge at a rate of 0.7 – 1.9 km/hour. The upstream tributaries floodplain had a submergence rate of 0.2 – 1.8 km/hour. The data would then be fed in to the Logical Framework to support decisions.

DISCUSSION

Hydraulics models could be used to support decisions on flood management measures. Often the major question was 'How?'. The Logical Framework as developed and mentioned by the authors in the previous section provided a wider picture of the framework in a descriptive nature, while in this section, an attempt would make by the authors to demonstrate an analytical analysis by the nature of flood management framework, by inferring to the output from the Sarawak River modeling.

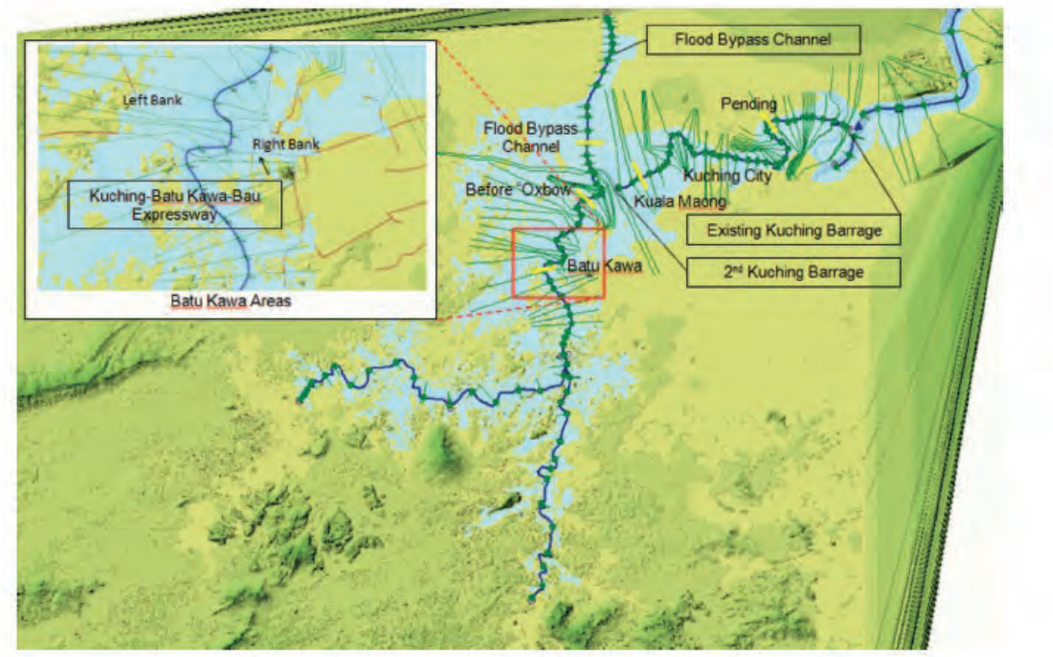


Figure 7. Simulation of January 2004 flood event with flood bypass channel.

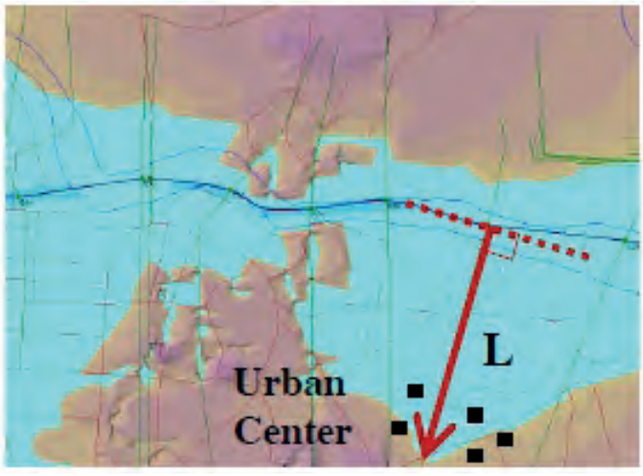


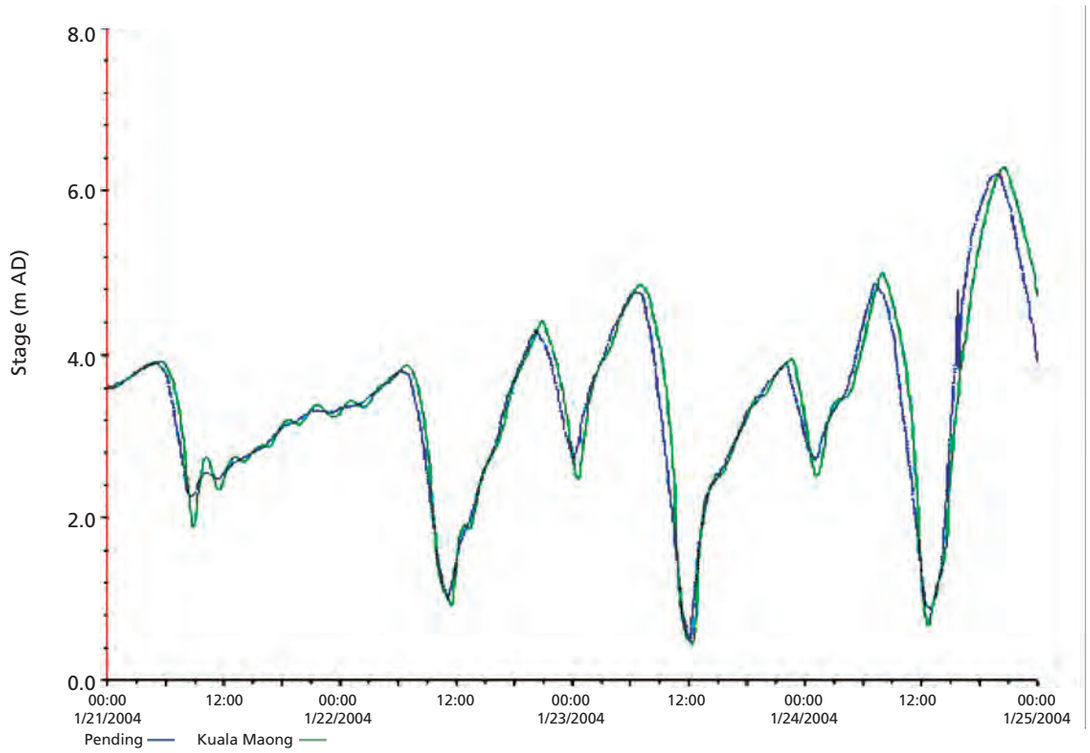
Figure 8. Length of affected area from river bank towards urban center, L.

Table 2. Logical framework for Sarawak River Basin Integrated Flood Management.

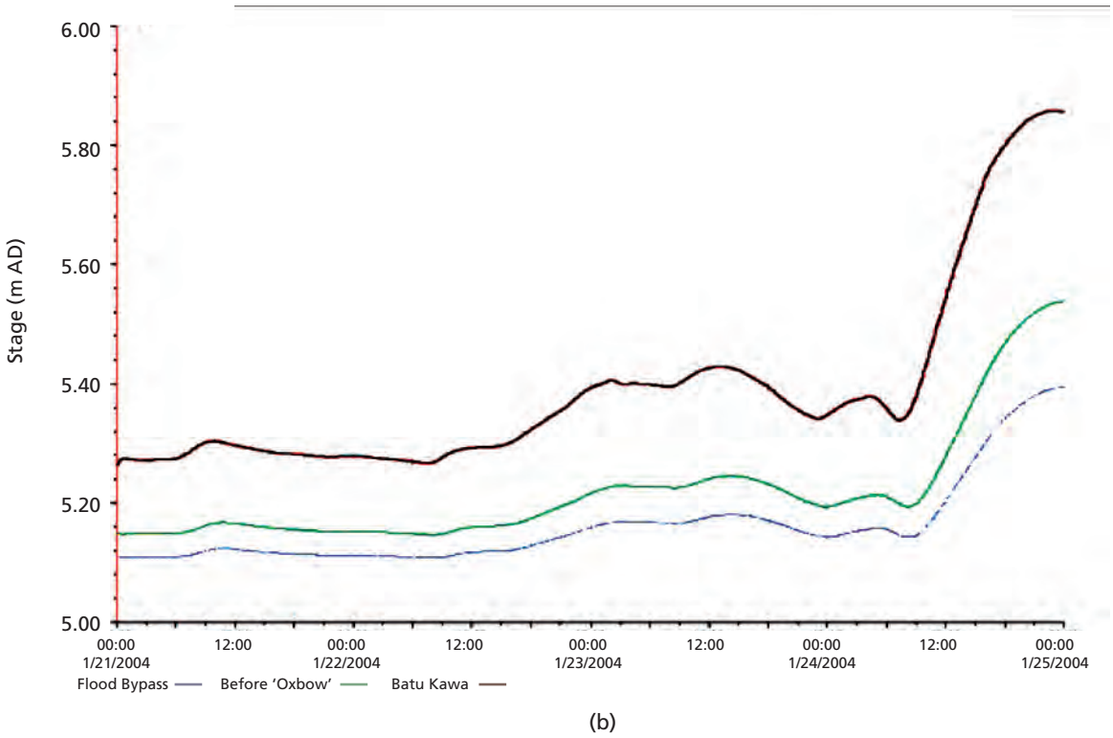
NARRATIVE SUMMARY	VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Ultimate Goal To reduce the excessive flood damages at Batu Kitang and Batu Kawa	1.0 Economic growth increase. 2.0 Property and crops value increase 3.0 Live losses prevented. 4.0 Health and hygiene improved.	1.0 SPU Annual Report. 2.0 DID Sarawak Annual Flood Report.	1.0 Participation of all stakeholders to success integrated Flood Management.
Objectives 1.0 GIS flood map in used by various deparmments. 2.0 Early flood warning and forecasting center in operation. 3.0 Evacuation centers in operation 4.0 Community education.	1.0 Information transmits among the departments become faster and precise. 1.1 Stakeholders able to make decision based reliable information. 2.0 Less complaint from public. 3.0 The flood victims able to be provided stay, food and medical care. 4.0 Public knowledgeable to evacuate using the right path before flood.	1.0 SPU enforce policy that every related department to use the GIS Flood map and to restrict the development on the Floodplain. 2.0 DID Sarawak Annual Flood Report. Electronic notice board at the main road.	**Objectives to Ultimate Goal** 1.0 Effective law enforcement on floodplain. 2.0 Joint operation rules for Early Flood Warning and Forecasting Center and Evacuation Center. 3.0 Integrated Water Resources Management is enhanced.
Outputs 1.0 Thorough ground information survey been collected. 1.1 Single Geographical Information System (GIS) platform for various departments' usage has been developed. 2.0 GIS has been updated from time to time. 3.0 Early flood warning and forecasting center has been setup 4.0 Evacuation centers are completed. 5.0 Public awareness increase	1.0 Mapping using GIS can be carried out. 1.1 Information sharing among the departments can be achieved. 1.2 GIS able to trace the latest changes on the ground. 2.0 Land price increase. 2.1 Population growth increase. 2.2 More housing and commercial center been built up. 3.0 Land price increase. 3.1 Population growth increase 3.2 More housing and commercial center been built up. 4.0 Public able to get information easily, either through mass media or related department webpage.	1.0 Land and survey reports from Land and survey department. 1.1 Coordination among the departments which lead by ICTU. 1.2 Annual report by ICTU 2.0 Annual report from Land and Survey Department. 2.1 More income for MBKS. 3.0 Annual report from Land and Survey Department. 3.1 More income for MBKS 3.2 More housing and commercial center been built up. 4.0 Fewer damages and live losses reported. 4.1 Hygiene during flooding period improved.	**Outputs to Objectives** 1.0 Funds are available. 2.0 Each department sharing the single GIS platform. 3.0 Proper operation of Early Flood Warning System and Evacuation Center. 4.0 All Stakeholders concern and participate in the Integrated Flood Management.
Activities 1.0 Thorough ground information survey on topographical and landuse information. 1.1 Set up Single Geographical Information System (GIS) platform for various departments' usage. 1.2. Continuous effort to ensure the GIS has been updated from time to time. 2.0 Setup an early flood warning and forecasting center. 2.1 Human resources and community development. 3.0 Construction of evacuation centers. 4.0 Community Education programme.	**Inputs** 2.0 Budgets. 3.0 Other Pre-requirements 4.0 Staff and Technicians. 5.0 Researchers. 6.0 Workshops and Coordination meetings.	**Costs** 1.0 Budgets 2.0 Other Pre-requirements	**Activities to Outputs** 1.0 Funds are available. 2.0 Each department has the facilities of GIS. 3.0 Approval for the Early Flood Warning System and Evacuation Center. 4.0 All Stakeholders participate in the programme.

For the purpose of this demonstration, the objective of early flood warning and a forecasting centre in operation from Table 2 was chosen. A sub-logical framework was developed as shown in Table 4. Modeling outputs were set in the second column of the sub-logical framework as indicators.

Modeling outputs helped to identify critical and priority areas of river flooding based on the rate of submergence. It also provided information regarding the time for evacuation based on the time to reach 2 m flood depth from bankfull level. It also included the route for evacuation based on extent or length of the flooded



(a)



(b)

Figure 9. Simulated water level hydrographs of January 2004 Flood Event for the (a) Lower Sarawak River where the blue colour line is for Pending and green colour line is for Kuala Maong; and (b) Upper Sarawak River where the blue colour line (bottom line) is at flood bypass, green colour line (middle line) is for before "Oxbow" and red colour line (top line) is for Batu Kawa.

Table 3. Estimation of rise and spread of floodwater from Sarawak River.

	January 2004 Flood Event Simulation Results Flood Levels from Bankfull												
	1st 0.5 m			2nd 0.5 m			3rd 0.5 m			4th 0.5 m			Remarks
	L	t	L/t	L	t	L/t	L	t	L/t	L	t	L/t	
Lower Sungai Sarawak													
Pending	1.816	0.40	4.541	1.830	0.45	4.068							Rank 2
Kuala Maong	2.005	0.40	5.012	2.032	0.35	5.806	2.069	0.40	5.174	2.091	0.50	4.183	Rank 1
Upper Sungai Sarawak													
Batu Kawa	4.636	2.40	1.932	4.689	4.05	1.155	4.689	6.30	0.744	4.785	3.10	1.542	
Sungai Sarawak Kanan													
Tondong	1.929	7.00	0.275	1.903	4.20	0.451							
Siniawan	2.186	1.20	1.822	2.212	1.55	1.427	2.240	3.05	0.737	2.240	4.40	0.507	
Sungai Sarawak Kiri													
Kpg Landeh	1.531	1.20	1.276	1.613	5.25	0.307							

Table 4. Sub-logical Framework for Sarawak River Basin Integrated Flood Management.

Goal This would relate to the dedication to Flood Disaster Risk Reduction and Emergency Response at the Sarawak River basin level.	**Objectively Verifiable Indicators (OVI)** Similarly, this would relate to the measurement of reducing injuries, deaths and properties damage caused by floods at the basin level.
Purpose • Practicing of an automatic (real-time) flood early warning system • Community-based cooperation	This would relate to the achievement of the impact indicators set out below and the merging realization of strengthening local authorities and communities capacities in flood preparedness. This is an exercise for the stakeholders of the Sarawak River basin management.
Outputs • Timely evacuation of community in the identified areas. • Timely decision to minimize damages to properties.	• Identified area from *modelling outputs* : Priority / Location / Rate of Submergence 1 Kuala Maong 5.8 2 Pending 4.5 3 Batu Kawa 1.9 4 Siniawan 1.8 5 Kpg Landeh 1.3 6 Tondong 0.4 Lower Sarawak River is found to be the most critical to river flooding.
Activities • Test against time to evacuate	• Estimated time factor from *modelling outputs* : Location with more than 2m flood depth / Time to reach 2m flood depth from bankfull Kuala Maong 1 hour 25 min Batu Kawa 16 hours 25 min Siniawan 11 hours Taking the most critical time, evacuation should be carried out within one and half hour.
• Test against route to evacuate	• Estimated effected length of flooded area from river bank from *modelling outputs* : Location with more than 2m flood depth / Length of flooded area reach 2m flood depth Kuala Maong 2.091 km Batu Kawa 4.785 km Siniwan 2.240 km Route to evacuate should be outside the flood zone
• Test against when to warn • Test against mechanism to warn etc.	• Need to link up with Meteorological Department • Need to link up with Rivers Board as authority in Operation Plans

area. This contributed substantially in identifying the priority areas most likely in need of emergency notification, critical time for evacuation and the most effective route for relief.

CONCLUSION

The Logical Framework is an excellent tool for communication between various stakeholders to promote participation in decision making towards Integrated Flood Management. It could also address the issues of accountability and evaluation if the planned activity or project had met its intended objectives. In order to use the Logical Framework effectively, computer simulation such as hydraulics models could aid in providing the necessary information in terms of visualizing the system under study so that it would be understood by all stakeholders. This paper has demonstrated the utilization of a river basin model being incorporated into the development of a sub-logical framework which was part of the bigger Logical Framework. It had been proven that hydraulics modeling when used together with Logical Framework was an excellent tool to support decisions made on flood management measures.

ACKNOWLEDGEMENT

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Kinetic Modelling of Ethanol Fermentation Process Using Cassava (*Manihot esculenta*) Starch as Carbon Source

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Cassava starch was used as feedstock for production of bioethanol by *Saccharomyces cerevisiae*. The cassava starch was hydrolyzed using commercial α-amylase and glucoamylase enzymes followed by a batch ethanol fermentation process using saccharified starch slurry. By using 110 g/L of reducing sugar from saccharified starch slurry, the ethanol yield was promising with maximum ethanol concentration of 20.6 g/L recorded after 55 hours of cultivation process. Three different models — the Logistic model, Luedeking-Piret-like equation and Gompertz equation — were used to characterize and explain the cell growth, reducing sugar consumption and production formation, respectively. The kinetic parameters were estimated by fitting the experimental data to the proposed models using non-linear regression analysis. The correlation coefficient r^2 values for the Logistic model, Luedeking-Piret-like equation and the Gompertz equation were 0.994, 0.996 and 0.990, respectively. The high correlation coefficient values indicate that the proposed models were able to describe the ethanol fermentation process.

Key words: Cassava, bioethanol, starch hydrolysis, batch fermentation, kinetic model; carbon source; cell growth; *Saccharomyces cerevisiae*; liquefaction; saccharification

Various feedstock such as corn, sugarcane, wheat, barley and sorghum can be used for the production of bioethanol. The feedstock can be categorized into three main types of materials which are sucrose, starch and cellulosic materials. An example of a sucrose containing feedstock is sugarcane. Sugarcane is the primary feedstock for biofuel production in Brazil, which is the world's largest biofuel producer (Drapcho, Nghiem & Walker 2008). However, the drawback of using sugar cane as bioethanol feedstock is that it puts a high demand on the soil due to the heavy machinery used while harvesting the sugarcane, leading to the use of biocides and inorganic fertilizers, which introduce risks of groundwater contamination, eutrophication of surface waters, soil pollution, and acidification (Hartemink 2008). The production of bioethanol from lignocellulosic materials is relatively high based on current technologies and the main challenges faced are low yield and the high cost of the hydrolysis process (Sun & Cheng 2002). Starch materials used as bioethanol feedstock can be hydrolyzed by enzymes from malt and moulds into fermentable sugars (Nadir *et al.* 2009). Cassava can be considered as a potential feedstock for bioethanol because of its high starch content; it can also be grown in the humid and subhumid tropics while not requiring much attention and it can survive drought extremely well (Drapcho, Nghiem & Walker 2008). In tropical countries such as Malaysia, cassava is a popular root crop. Cassava root crop is often used for the production of starch which can be use as a feedstock for bioethanol production (Johnson, Padmaja & Moorthy 2009). The objectives of the present study are (i) to investigate the potential of using cassava starch as a carbon source for bioethanol production and subsequently (ii) to study the kinetics of the fermentation process.

MATERIALS AND METHODS

Cassava Starch

Cassava starch was obtained from a local supermarket and was used throughout the study.

Liquefaction and Saccharification

Cassava starch slurry (30% w/v) was prepared by mixing starch powder with distilled water and gelatinized at 90ºC. Then, liquefaction was performed by adding Termamyl® 120L (Novozymes) into the gelatinized starch slurry at 90ºC for 2 h. The mixture was then cooled to room temperature and pH was adjusted to 4.5 by using 0.1 M HCI and 0.1

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M NaOH. Following that, saccharification was performed by adding Dextrozyme L (Novozyme) into the mixture and incubating at 65ºC for 2.5 h.

Batch Fermentation

Cultivation medium containing yeast extract (10 g/l), peptone (20 g/l) and saccharified medium was diluted to the required level of reducing sugar at a concentration of 110 g/l. The yeast extract peptone medium was autoclaved saparatedly from the saccharified medium, at 121o for 15 min. Batch fermentation process was carried out by mixing both mediums together with 1 g of instant dry yeast (*Saccharom cerevisiae*) in a 250 ml Erlenmeyer flask. The flasks were then placed in an incubator shaker at 30ºC and agitated at 250 r.p.m. Samplings were conducted at every 4 h time intervals.

Analytical Methods

Crude broth (5 ml) were centrifudged at 9000 r.p.m. for 5 min. The supernatant was used for determination of ethanol concentration using gas chromathography (GC), reducing sugar concentration using the 3.5-dinitrosalicylic acid (DNS) method while the cell pellet was used to study the growth of yeast at an optical density of 660 nm. The experiment was conducted in triplicate and the mean values were reported.

RESULTS AND DISCUSSION

Ethanol Fermentation

Figure 1 illustrates the time course profile of ethanol fermentation by *S. cerevisiae* using saccharified cassava starch as carbon source. The ethanol production rate in the early phase of the culture was relatively slow but it rapidly increased after 24 h of cultivation. The fermentation process was completed within 55 h and the final ethanol concentration achieved was 20.6 g/l. As observed, reducing sugar was virtually utilized as the stationary phase was attained and almost 80% of the reducing sugar was converted to ethanol. *S. cerevisiae* requires a portion of the substrate for cell growth and maintenance during the cultivation process (Demirbas 2005).

In the present study, growth of *S. cerevisiae* during the batch ethanol fermentation process exhibited a typical growth trend, in which an initial lag phase was observed (Figure 1). This was followed by the exponential growth phase, stationary phase and death phase, accordingly. Sikyta (1995) reported that the length of the lag phase could be affected by several factors like composition of medium, type and age of the strains, number of cells, and physical factors such as temperature and pH. The cell entered an exponential phase after the lag phase. Figure 1 illustrates that the exponential phase started at 24 h and continued up to 30 h. Eventually, a stationary phase was achieved, after 30 h when the cell concentration was almost constant with time.

Kinetic Modeling of Fermentation Process Cell Growth

The logistic equation (Equation 1) as proposed by Baei, Mahmoudi & Yunesi (2008) was used to describe the yeast growth during batch ethanol fermentation.

$$\frac{dX}{dt} = \mu_m X\left(1 - \frac{X}{X_m}\right) \quad (1)$$

where, μ_m is the maximum specific growth rate (h^{-1}) and X_m is the maximum cell concentration (g/l). The integrated form of Equation 1 using $X = X_0$ (at $t = 0$) gives a sigmoidal variation of (X) as a function of (t), which may present both the exponential and the stationary phases. Equation 2 shows the relationship between biomass and fermentation time, which is used to fit experimental data of biomas concentration:

$$X = \frac{X_0 X_m e^{\mu_m t}}{X_m - X_0 + X_0 e^{\mu_m t}} \quad (2)$$

Taking X_0 = 0.1665 g/l from the experimental data and fitting the experimental data to Logistic equation (Equation 1) by non-linear regression analysis, yields the values of parameters as follows: maximum attainable biomass concentration X_m and the maximum specific growth rate μ_m are 0.37 g/l and 0.108 h^{-1}, respectively. The predicted value of maximum cell concentration, X_m (0.37 g/l) was close to the experimental value of 0.36 g/l.

As observed from Figure 2, the proposed growth model (Equation 2) firs significantly well with the experimental data displaying a high correlation coefficient, r^2 value of 0.994. Gu *et al.* (2006) reported that the Logistic model as a sigmoidal shaped model with its 'goodness of fit' has been widely used in describing the growth of micro-organisms.

Reducing Sugar Consumption

Luedeking-Piret-like equation (Equation 3) proposed by Panilaitis *et al.* (2007) was used to model the utilization of sugar in the medium by S. cerevisiae:

$$\frac{dS}{dt} = \frac{1}{Y_{X/S}}\frac{dX}{dt} + m_s X \quad (3)$$

Integration of Equation 3 and substitution of Equation 2 leads to the final equation for substrate utilization, as shown in Equation 4.

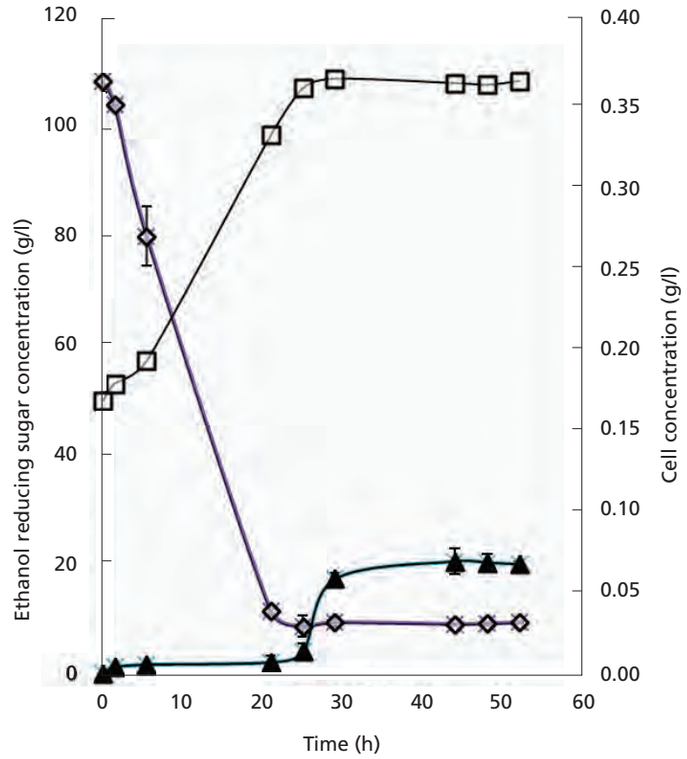

Figure 1. Ethanol fermentation using cassava starch as carbon source. Symbol: Ethanol concentration (△), Reducing sugar concentration (◇) and cell concentration (□). Error bars indicate the mean ± standard deviation of three experiments.

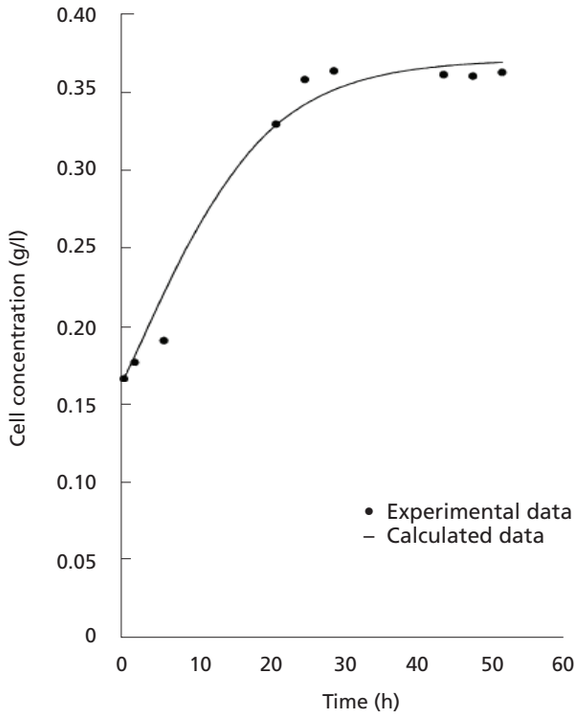

Figure 2. Logistic modelling of cell growth fitted with experimental data.

$$S = S_0 - \frac{X_0 X_m e^{\mu_m t}}{Y_{X/S}(X_m - X_0 + X_0 e^{\mu_m t})} + \frac{X_0}{Y_{X/S}} - \frac{X_m m_s}{\mu_m} \ln \frac{X_m - X_0 + X_0 e^{\mu_m t}}{X_m} \quad S = S_0 - \frac{X_0 X_m e^{\mu_m t}}{Y_{X/S}(X_m - X_0 + X_0 e^{\mu_m t})} + \frac{X_0}{Y_{X/S}} - \frac{X_m m_s}{\mu_m} \ln \frac{X_m - X_0 + X_0 e^{\mu_m t}}{X_m} \quad (4)$$

where, S is the substrate concentration (g reducing sugar/l), $Y_{X/S}$ is the maximum yield coefficient (g cell/g reducing sugar), and ms is the maintenance coefficient [g reducing sugar/(g cell.hr)].

Figure 3 indicates that the predicted model for substrate utilisation agreed well with the experimental data. The model was verified with high correlation coefficients, r^2, for model fitting (0.996). As calculated by using the predicted model (Equation 4), the bacterial yield, $Y_{X/S}$ and the maintenance coefficient, m_s, were 0.002 g cell/g reducing sugar and 0.207 g reducing sugar/(g cell. hr), respectively.

Don and Shoparwe (2010) reported that some of the products, such as acetic acid, lactic acid, hydrogen peroxide, and ethanol, were toxic to cell growth. Hence, a maintenance coefficient (m_s) was used to describe the specific rate of substrate uptake for cellular maintenance. Sinclair and Kristiansen (1987) also reported that the values of the maintenance coefficient (m_s) could range from as little as 0.02 g to as high as 4.0 g substrate/per unit cell per hour, depending on the environmental conditions surrounding the cell and on its rate of growth. In the present study, the value of ms obtained from the model was 0.207 g substrate/per unit cell per hour, which was in the range as suggested by Sinclair and Kristiansen (1987) further proving that this model, Leudeking–Piret-like equation, was suitable for describing the consumption of reducing sugar.

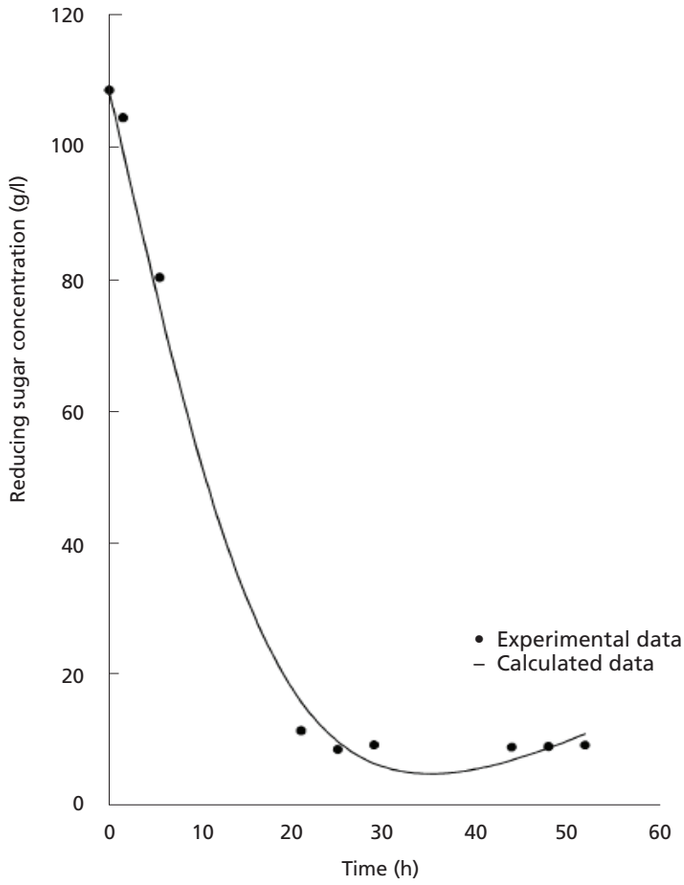

Figure 3. Luedeking-Piret-like modeling of reducing sugar consumption fitted with experimental data.

Production of Ethanol

A modified Gompertz equation (Equation 5) as proposed by Mu, Han-Quing and Wong was used for modeling the ethanol production during the fermentation process:

$$P = P_m \exp\left\{-\exp\left[\frac{r_{p,m}\exp(1)}{P_m}(t_L - t)+1\right]\right\} \quad (5)$$

where P is the ethanol concentration (g ethanol/l), P_m is the potential maximum ethanol concentration (g ethanol/l), $r_{p,m}$ is the maximum ethanol production rate (g ethanol/l.hr) and tL is the lag phase or the time for exponential ethanol production (h).

Figure 4 shows that the modified Gompertz equation fitted well with the experimental data. The correlation coefficient from non-linear analysis was 0.990. The value of maximum ethanol production rate ($r_{p,m}$) obtained from the model was 0.646 g ethanol/(l. h) and the lag phase (t_L) was 9.834 h.

CONCLUSION

The production of bioethanol by a locally available yeast strain, *S. cerevisiae*, showed that cassava starch is a potential carbon source for production of ethanol. The high correlation coefficient (r^2) clearly showed that the proposed Logistic models, Leudeking-Piret-like and Modified

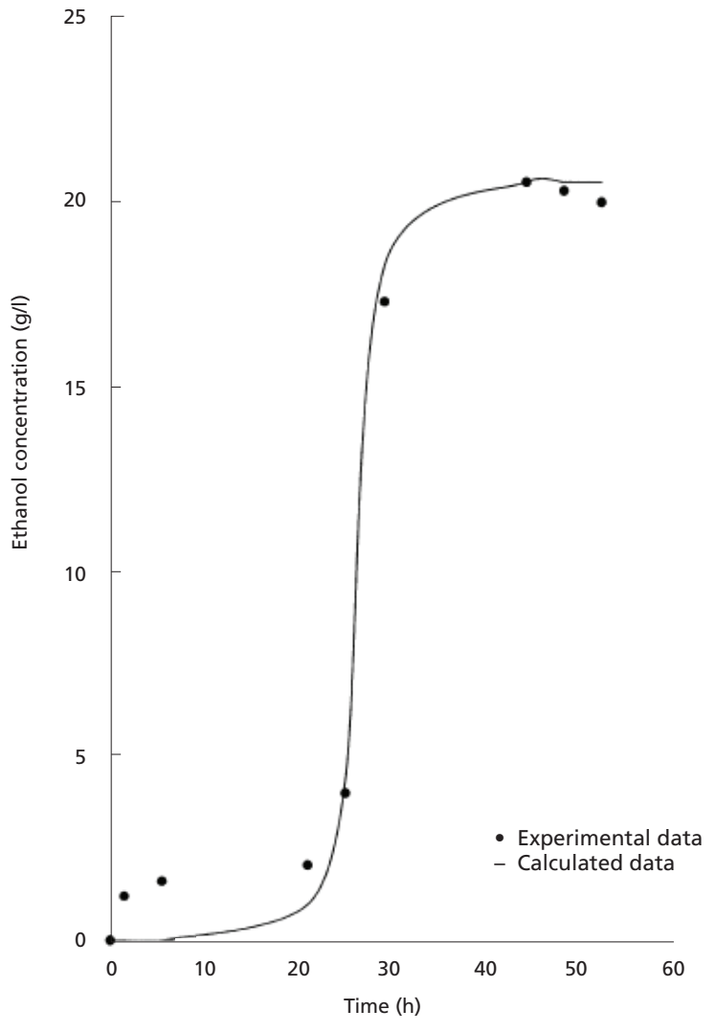

Figure 4. Modified Gompertz modelling of ethanol formation fitted with experimental data.

Table 1. Parameter estimations by non-linear regression.

Parameter Estimation	Value
Cell Growth	
X_m (g/l)	0.370
μ_m (h^{-1})	0.108
r^2 (Correlation coefficient)	0.994
Substrate consumption	
$Y_{X/S}$ (g cell/g reducing sugar)	0.002
m_s (g reducing sugar/g cell.h)	0.207
r^2 (Correlation coefficient)	0.996
Product formation	
t_L (h)	9.834
P_m (g ethanol/l)	20.57
$r_{p,m}$ (g ethanol/l.h)	0.646
r^2 (Correlation coefficient)	0.990

Gompertz were found to be sufficient to describe the growth of *S. cerevisiae*, utilization of saccharified starch and production of ethanol.

ACKNOWLEDGMENT

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The Interplay between the Civil Society and the Private Sector, Especially for Resource Mobilization

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Old School of Thought?

"Few trends could so thoroughly undermine the very foundations of our free society as the acceptance by corporate officials of a social responsibility other than to make as much money for their stockholders as possible." (*Capitalism and Freedom*, Milton Friedman 1962)

New School of Thought?

"There is no conflict between social responsibility and the obligation on companies to use scarce resources efficiently and be profitable — an unprofitable business is a drain on society. The essence of the contract between society and business is that companies shall not pursue their immediate profit objectives at the expense of the longer term interests of the community."
(*Corporate Governance and Chairmanship*, Adrian Cadbury 2002)

INTRODUCTION

The pursuit, initiation and establishment of multi-stakeholder partnerships, including with the private sector, is often a critical component of attaining and achieving the success and sustainability of many projects the world over. However, the soliciting and securing of socially, economically and environmentally constructive engagements between the private sector on the one hand, and the NGOs, CBOs and local communities on the other hand, is in reality much easier said than done. Notably, since most private sector corporations undoubtedly tend to leave behind various "ecological footprints", differing only in their size and depth, stemming from their respective forms and functions, and their ensuing impacts and implications.

It is against the aforesaid backdrop, that NGOs, CBOs and local communities are continuously confronted by the tricky task of finding fail-safe and reliable ways and means of identifying and distinguishing between genuinely motivated private sector corporations from their PR-riddled private sector corporate counterparts. Thus, in addition, the urgent and pressing need for all of us to agree, adopt and apply eligibility criteria and litmus tests to discern between the two categories of private sector corporations — one to be systematically sourced, and the other to be strategically scrutinized.

Some of the Better Known and Utilized "Corporate Social Responsibility" (CSR) Principles and Procedures

From this perspective, there already exist several well-intentioned principles and policies on the behaviour and conduct of private sector corporations, aimed at fostering and harnessing their role and responsibility in promoting sustainable development, be it at the local, national, sub-regional, regional or global level. These include the following three five known ones:

1. "The Global Compact" of the UN. (<www.unglobalcompact.org>)

   The Nine Principles of "The Global Compact" of the United Nations (UN), which reiterate that: (a) "Businesses should support and respect the protection of internationally proclaimed human rights within their sphere, and make sure that they are not in complicit in human rights abuses"; (b) "Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining, the elimination of all forms of forced and compulsory labour, the effective abolition of child labour, and eliminate discrimination in respect of employment and occupation"; and (c) "Business should support a precautionary approach to environmental challenges, undertake initiatives to promote better environmental responsibility, and encourage the development and diffusion of environmentally friendly technologies".

2. The "Business Charter for Sustainable Development" of the International Chamber of Commerce (ICC 1991)

   The 16 Principles of "The Business Charter for Sustainable Development", of the International Chamber of Commerce (ICC), which include elements of "(a) Corporate Priority, (b) Integrated Management, (c) Process of Improvement, (d) Employee Education, (e) Prior Assessment, (f) Products and Services, (g)

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Customer Advice, (h) Facilities and Operations, (i) Research, (j) Precautionary Approach, (k) Contractors and Suppliers, (l) Emergency Preparedness, (m) Transfer of Technology, (n) Contributing to the Common Effect, (o) Openness to Concerns, and (p) Compliance and Reporting", the adoption of or subscription to which comprise the core components of corporations becoming members of the World Business Council for Sustainable Development.

3. The Chapter 30 of "Agenda 21". (UNCED 1992)

The Chapter 30 of "Agenda 21", entitled "Strengthening the Role of Business and Industry", which emerged from the landmark United Nations Conference on Environment and Development (UNCED), held in Rio di Janenario, Brazil, in June 1992, underscores two programme areas, viz. (a) "Promoting Cleaner Production", and (b) "Promoting Responsible Entrepreneurship"; as well as three objectives, viz. (i) "Governments, business and industry, including transnational corporations, should aim to increase the efficiency of resource utilization, including increasing the reuse and recycling of residues, and to reduce the quantity of waste discharge per unit of economic output"; (ii) "The concept of stewardship in the management and utilization of natural resources by entrepreneurs should be encouraged"; and (iii) "The number of entrepreneurs engaged in enterprises that subscribe to and implement sustainable development policies should be increased". The spectrum of activities advocated for addressing the aforesaid two programme areas and three objectives include, inter alia, the following:

a. Business and industry, including transnational corporations, should work towards the development and implementation of concepts and methodologies for the internationalization of environmental costs into accounting and pricing mechanisms.

b. Business and industry, including transnational corporations, should be encouraged to report annually on their environmental records, as well as on their use of energy and natural resources; adopt and report on the implementation of codes of conduct promoting the best practices.

c. Industry should incorporate cleaner production policies in its operations and investments, taking into account its influence on suppliers and consumers.

d. Industry should encourage individual companies to undertake programmes for improved environmental awareness and responsibility at all levels to make the enterprises dedicated to the task of improving environmental performance based on internationally-accepted management practices.

e. Business and industry, including transnational corporations, should be encouraged to establish worldwide corporate policies on sustainable development, arrange for environmentally-sound technologies to be made available to affiliates owned substantially by their parent company in developing countries without extra external charges, encourage overseas affiliates to modify procedures in order to reflect local ecological conditions and share experiences with local authorities, national governments and international organizations.

4. The CERES Principles. (CERES 1989)

The vision of "The Coalition for Environmentally Responsible Economies (CERES)", underscores that "all corporate and transnational reportings on their economical, environmental and social performances, should be as routine and as comparable as that for their financial reportings. And to facilitate such holistic reportings, it had formulated the following set of ten "The Ceres Principles":
(i) "Protection of the Biosphere"; (ii) "Sustainable Use of Natural Resources"; (iii) "Reduction and Disposal of Wastes"; (iv) "Energy Conservation"; (v) "Risk Reduction"; (vi) "Safe Products and Services"; (vii) "Environmental Restoration"; (viii) "Informing the Public"; (ix) "Management Commitment"; and (x) "Audits and Reports".

5. The Global Reporting Initiative (GRI). (<www.globalreporting.org>)

Irrespective of the corporate governance ethics and norms adopted or adhered by a private sector corporation internally, much more importantly is the entity's willingness to publicly report on its, not only on its financial dimensions alone, but also on its "triple-bottom-line" (social, economical and environmental) performance dimensions, as a corner-stone of the fundamentals of community-right-to-know rights and responsibilities. One such comprehensive and consolidated manner of public reporting is the Global Reporting Initiative (GRI).
The GRI was initially convened by the Coalition for Environmentally Responsible Economies (CERES).
The GRI has developed a set of core metrics intended to be applicable to all business enterprises, sets of sector-specific metrics for specific types of enterprises and a uniform format for reporting information integral to a company's sustainability performance.

Since its inception, the GRI has become a worldwide, multi-stakeholder network which includes representatives from business, civil society, labour, investors, accountants and others. Revisions to the framework take place through an exhaustive set of committees and subcommittees, but

the GRI says that its multi-stakeholder approach does ensure the credibility and trust needed to make a global framework successful.

In broad terms, the GRI Sustainability Reporting Guidelines recommend specific information related to environmental, social and economic performance. It is structured around a CEO statement, key environmental, social and economic indicators, a profile of the reporting entity, descriptions of relevant policies and management systems, stakeholder relationships, management performance, operational performance, product performance and a sustainability overview. For further information on the GRI, please visit its website at: <http://www.globalreporting.org>.

The key criteria of the GRI encompasses, inter alia, the following aspects and components at the level of their respective "Reporting Guidelines", and "Application Levels": (i) "Indicator Protocol: Environment"; (ii) "Indicator Protocol: Economic"; (iii) "Indicator Protocol: Human Rights"; (iv) "Indicator Protocol: Labour Practices & Decent Work"; (v) "Indicator Protocol: Product Responsibility"; and (vi) "Indicator Protocol: Society".

ANALYSIS AND RECOMMENDATIONS

In this context, we must first and foremost realize, recognize and reiterate the following three overarching principles in our attempts to define and determine constructive engagements between us and private sector corporations, especially for resource mobilization:

a. Most private sector corporations, particularly those involved in the manufacturing and marketing of products and services, seem to be invariably characterized by some sort of socio-economic or environmental fall-outs or spin-offs or other, varying only in their subjectivity and relativity.

b. Some private sector corporations, like consumer and commercial banks, publishing houses, private foundations, insurance agencies, mass media, etc., tend to come across as being relatively environmentally friendlier, when compared to certain other corporations, like oil cartels; tobacco companies; firms engaged in logging, mining, polluting industrial processes, smelting, natural resource extraction, incineration; land-filling, motor vehicle production, toxic chemicals and hazardous wastes manufacturers and marketers; and propagators of over-consumptive and unsustainable lifestyles and technologies, etc.

c. It is therefore critical to verify that the adoption of or subscription to however lofty or well-intentioned principles and policies by private sector corporations, are indeed meaningfully internalized and corroborated by their actual implementation on the ground. More so, as only then can the true practices and performances of such private sector corporations be properly monitored for systematic auditing and evaluation of their inherent and integral socio-economic and environmental justice and credibility. Further, resource mobilization, financial donations, or any other forms of support, from private sector corporations should not be linked to any strings or conditions attached to them (e.g. dos or don'ts, endorsements, restrictions, etc.), in favour of the private sector corporation concerned per se, as they are bound to impinge or compromise our own mission and mandate, be it potentially, really or in perception, to be enhancing environmentally sound and sustainable development and livelihoods.

Based on the aforesaid three overarching principles, it would be logical and practical for us to earmark that any of our constructive engagements with private sector corporations, particularly for resource mobilization, be reinforced by, inter alia, the following approaches:

1. Welcoming the role of responsible private sector corporations as legitimate partners and stakeholders in our activities and aspirations to forge and foster "win-win-win" symbiotic scenarios in addressing the relevant social, economical and environmental considerations and challenges by implementing and mainstreaming sustainable development and livelihoods among local communities through the mutually beneficial interventions of NGOs and CBOs. However, our relationships and constructive engagements with private sector corporations, especially for resource mobilization, must be eventually determined and dictated on a case-by-case basis, depending on the multitude of local, national or international factors and forces at play.

2. Exercising and exerting prudent care and caution, including in adhering to the precautionary principle, to ensure that our joining hands and nurturing constructive engagements with private sector corporations will not in any way, be it explicitly or implicitly, jeopardize or undermine our own mission and mandate of propelling sustainable development and livelihoods among local communities, both in the short-term or long-term.

3. Refraining from seeking, soliciting or securing resource mobilization or any other forms of support or constructive engagement with private sector corporations whose socio-economic or environmental profiles and scorecards are not at

all consistent or compatible with our own policies, principles, practices, priorities and programmes.

4. Providing credence to the proviso that all our operations would steadfastly remain sincere, honest, transparent, accountable and participatory, besides them being readily open to public review and accountability, and hence we should also be expecting the same from any private sector corporations with which we enter into constructive engagements, even for resource mobilization.

5. Ensuring that the private sector corporations with whom we opt to partner or to forge constructive engagements, will not conduct bad businesses, will not behave unethically, and will not be a party to any socio-economic or environmental malpractices, which would in turn be in conflict with our own objectives, activities and expected outputs. Likewise also checking that, irrespective of any proclaimed or publicized sustainable development policies and principles on the part of the private sector corporations, they too, like us, must be sharing our own convictions and commitments towards the notion that in complying with the obligations of one multilateral environmental agreement (MEA), we should be impinging or compromising on the requirements of another MEA. In this context, we should always reserve the right to disengage ourselves and to nullify constructive engagements that we may have entered into, in good faith, with any private sector corporation, if we subsequently discover that the private sector corporation has been taking undue advantage of or abusing its constructive engagement with us. Additionally, we will also have to contend with the "double standard stigma", especially for private sector transnational corporations (TNCs), which could be adopting different codes of conduct and different patterns of behaviour for their own affiliates or subsidiaries located elsewhere in the world.

In our challenging efforts and endeavours to stimulate and solidify constructive engagements with private sector corporations, be it for resource mobilization, technical assistance and/or any other type of in cash or in kind contribution, we should also be consistently striving to change the prevailing status quo, viz. in making real differences and real changes in terms of awareness, attitude and action on the part of private sector corporations, so that they too, aptly referred to as the "engines of growth, wealth and employment", can be transformed into becoming pivotal movers and shakers for socially just, economically equitable and environmentally sound sustainable development and livelihoods for peoples from all sectors of society.

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Energy Inaction Warning—Rio+20 Report

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Twenty years after the 1992 Rio Summit, the world recently convened another session in Rio to thrash out their differences on how to manage sustainable development. Will things change after this? Or will Rio witness another display of undelivered promises? Judging by the reports unveiled at the pre-Rio meetings, disagreements still persist in some key areas. In fact there have been reports of backtracking by some countrie on earlier agreed protocols. Energy, as expected, took centre stage in the Rio+20 deliberations. A report released by the International Institute for Applied Systems Analysis (IIASA), based in Vienna, concluded that further inaction on the energy issues will cost the world dearly.

Admittedly, access to clean, reliable and affordable energy is one of the major sustainability and human development challenges of the 21st Century. The authors of the IIASA report on the Global Energy Assessment (GEA) maintain that energy empowers communities, yet reliance on traditional and fossil energy sources has escalated concern about the safety and security of energy supplies in many regions of the world. They also created enormous inequity, reduced life expectancy, and contributed to many environmental issues, including climate change and ecosystem degradation. Action is badly needed to help societies continue to develop in a sustainable way. But what will be the costs and benefits of achieving this new, clean and equitable energy future?

The key findings of the Global Energy Assessment (GEA) were released during the RIO+20 Conference. It is the most comprehensive and first ever fully integrated global assessment of energy systems, involving many of the world's leading energy specialists. The report outlines a range of resources, technologies, policy options and pathways that would facilitate a transformation of energy systems and address these challenges. These necessary changes will require significant investment in new energy infrastructure. They will require major improvements in energy efficiency, particularly in the building and transport sectors. In addition there has to be a scaling down of fossil-fuel based energy systems, and increased investment in the development and use of renewable energy sources.

The GEA analysis puts to rest the concern that such a transformation can be economically retrogressive. Instead it is viable. The authors maintain that the co-benefits to human health and the environment more than balance the up-front investments needed to bring about this transformation. Additionally these investments would enable the delivery of clean, sustainable energy to the 1.4 billion people living without electricity and the 3 billion without access to modern cooking fuels or devices. This could be achieved without additional increases in greenhouse gas emissions.

The GEA analysis further indicates that a rapid transformation to clean energy technologies would require an increase in annual investments from present levels of approximately USD1.3 trillion to USD1.7 trillion, about 2% of the current GDP of the world. The difference corresponds roughly to the current energy subsidies that are often impeding the needed transformational change. A major finding of the GEA is that some energy options provide multiple benefits. This is particularly true of energy efficiency, renewables, and the co-production of synthetic transportation fuels, cooking fuels, and electricity with carbon capture and storage. In addition, they offer advantages in terms of supporting all of the goals related to economic growth, jobs, energy security, local and regional environmental benefits, health, and climate change mitigation.

The GEA explores sixty alternative energy transformation pathways and finds that forty-one of these pathways simultaneously satisfy the following goals:

- Universal access to affordable energy (especially electricity and clean cooking) by 2030;
- Enhanced energy security at regional and national levels;
- Climate change mitigation (limit global mean temperature increase to less than 2°C above pre-industrial levels, with a probability of at least 50%); and
- Improved human and environmental health by controlling household and ambient air pollution, ocean acidification, and deforestation.

It is clear that effective energy management holds the key to sustainable development. Concerns over the costs and the uneconomic nature of change are unfounded. In fact, according to the GEA report, the world should be more concerned over inaction on energy. The repercussions of delayed actions may be disasterous for future generations. It is time to fulfill promises articulated at Rio.

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Population Growth and Unsustainable Consumption— Inter-Academy Panel Warns of Dire Consequences

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The Inter-Academy Panel (IAP) brings together many Academies of Sciences of the world. The Academy of Sciences Malaysia has been an active member for many years now. The IAP provides a platform for members to exchange and articulate views and opinions on the many issues faced by humanity. The intention is to bring to the attention of the world the many issues confronting mankind so that urgent measures are taken to resolve them. A recent media release by the IAP, in conjunction with the July 11 world population day, warns of the unresolved challenges faced by the global community, urging the governments of the world to take action. Top of the list is the increasing population growth and unsustainable consumption. Together the two pose the greatest challenges facing the world.

"The global population is currently around 7 billion and most projections suggest it will probably lie between 8 and 11 billion by 2050. Most of the increase will occur in low-income countries. Global consumption levels are at an all time high, largely because of the high per capita consumption of developed countries. At the same time, 1.3 billion people remain in absolute poverty, unable to meet even their basic needs."

According to the communication release, "population and patterns of consumption should be of major concern to policy makers. This is because they determine the rates at which natural resources are exploited. They also directly impact on the ability of the earth to sustainably provide the food, water, energy and other resources required by its inhabitants. Current patterns of consumption, especially in high-income countries, are eroding natural capital at rates that are severely damaging the interests of future generations."

Population growth can contribute to people migration, another growing global concern. This can be between countries or rural-urban movement. By 2050, 70% of the world's population will live in cities—posing challenges for urban planning and logistics. There may be some economic upside, but can be potentially disruptive if not properly planned.

How can the issues be addressed? Though both issues are politically and ethically sensitive, they should not be neglected by policy makers. The call is for a rational and evidence-based approach. The solution must respect human rights and the legitimate aspirations of countries with low-income to improve their living standards.

The IAP recommends that population and consumption are considered in all policies, including those related to poverty reduction and economic development, global governance, education, health, gender equality, biodiversity and the environment. Action is critically needed in higher-income countries to arrest escalating consumption patterns. The least developed countries should avoid repeating the consumption habits of the advanced nations. Programmes that promote the relevant education should be central to the strategies to slow down unsustainable population growths.

They further recommend embracing the "green economy", designed simultaneously to increase human well-being and reduce environmental impacts. They strongly encourage using existing knowledge more effectively and to make research a priority in the natural and social sciences that will provide innovative solutions to the challenges of sustainability. The bottomline is—there is a need for urgent action.

"The common goal for the IAP remains the improvement of the quality of life for all, for those living now and in the future, and in particular to help build the knowledge base required to achieve these aims. The choices made about population and resource use over the next fifty years will have effects that last for centuries. There are a range of possible futures. If we act now, it is realistic to imagine trajectories where population growth comes to a halt, consumption becomes sustainable, human-induced global

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change is kept within manageable limits, and human well-being increases. A failure to act will put us on track to alternative futures with severe and potentially catastrophic implications for human well-being. The longer the delay, the more radical and difficult measures will be needed. Everyone has a role to play: individuals, non-governmental organisations, and both the public and private sectors. It is critical that national and international policy makers, acting individually and collectively, take immediate action to address these difficult but vitally important issues."

Water Scarcity—A Growing Concern of the Power Sector

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Imagine a day without water. Not many would want to experience that. It is miserable going through a day without electricity. Water and electricity have no doubt become indispensable in modern day living. Life is impossible without water and intolerable without energy. The fact that the world must have both is undeniable. In Malaysia, there is already serious discussions about water scarcity. Selangor, for example, is contemplating bringing water from Pahang through expensive tunnel system. This is despite the fact that we enjoy very high rainfall throughout the year. Not to mention the frequent flooding. And in Kelantan, the public has lamented for years about the quality of their piped water. This still remains unaddressed.

What is the relation between water and electricity? Will reduced water availability impact on energy? There is now growing evidence that as a result of climate change, some supply source of energy will be curtailed because of problems with water. A recent study published in the Nature Climate Change paints grim prospects on the supply of electricity in the USA and Europe as a result of changing water temperatures arising from global warming. Higher water temperatures coupled with reduced river flows in Europe and the USA in recent years have resulted in reduced production, or temporary shutdown, of several thermoelectric plants, both nuclear or fossil-fuelled power plants. This has to some extent pushed up electricity prices, raising concerns about future energy security in a changing climate. Are we in the region spared from this? There have already been reports of reduced water flow negatively impacting hydropower plants.

It is a major issue in the US and Europe. This is because in the US, about 91% of their electricity comes from thermoelectric power. In Europe it is only slightly less at 78%. Any disruption to plant operation is therefore a significant concern for the energy sector in both countries. As there has yet to be a solution to the warming of the world, the study projects further disruption to supply in the coming years. According to their analysis, there is a likelihood of a decrease in thermoelectric generating capacity of between 6%–19% in Europe and 4%–16% in the US for the period 2031–2060, all because of the lack of cooling water.

The thermoelectric power sector is one of the largest water users in the USA. This now stands at 40%. In Europe, 43% of the surface water withdrawals end up being used as cooling water in their thermoelectric power plants. Malaysia is not far different because of the heavy dependence on thermoelectric power based on coal. According to the study, power plants that rely on "once-through cooling" are the most vulnerable. These plants pump water direct from rivers or lakes to cool the turbine condensers. Water is then returned to its source, often at higher temperatures causing problems for downstream users. This can adversely impact on the river ecosystems. For example, the life cycles of aquatic organisms can be disturbed.

It is a real paradox. Fossil fuel driven thermoelectric power plants are known to be a major emitter of greenhouse gases which drive global warming. Global warming also raises the water temperatures of rivers and lakes, making it difficult to supply cooling water needs of the power plants. It is as if the gases emitted return to haunt the power plants. Either we do away completely with thermoelectric power plants or we look for new sources of cooling water or we design power plants which do not require water cooling. The problem is, even renewables such as biomass would require cooling in their power generation system. Whatever it is, the issue warrants serious attention of researchers. One option is to switch to gas-fired power plants that are both efficient and use less water.

It is clear that water is an important component of power plants. If the supply and character of water changes, then the performance of power plants will be affected. The study which looked at 61 coal-fired and nuclear power plants in central and eastern USA and 35 power plants in Europe, reinforced the need for improved climate adaptation strategies in the power sector.

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FORUM OVERVIEW

WORLD INNOVATION FORUM KUALA LUMPUR (WIF-KL)

Malaysia is privileged to host the World Innovation Forum in Kuala Lumpur. WIF-KL is jointly organised by the Ministry of Science, Technology and Innovation Malaysia (MOSTI) and Malaysian Innovation Foundation (YIM), capitalising on the successes of the KL Innovation Forum (KLIF) Series held in 2010 and 2011. WIF-KL provides an avenue to bring thought leaders and creative minds from all over the world to discuss and share their experience.

WIF-KL will comprise four core events, namely KL Innovation Forum 2012; BioMalaysia Conference and Exhibition 2012; Nano Malaysia Summit and Expo 2012 and the National Innovation Conference and Exhibition (NICE) 2012; as well as eight satellite events. An estimated 1,500 international delegates from 50 countries and 10,000 visitors are expected to visit the World Innovation Exposition, which will be held alongside the Forum. The Exposition, one of the main attractions of WIF-KL, will showcase innovations ranging from the grassroots to sectors such as education, research, services and industry.

The global socioeconomic area for sustainable development has changed immensely in the last few years and WIF-KL will, therefore, address some of the key drivers and unique issues surrounding policies, framework strategies and best practices of innovative nations. In line with the National Innovation Movement, WIF-KL is also set to springboard Malaysia's agenda to position herself as a key player in the global innovation movement for socioeconomic growth.

REGISTRATION FEE*	On or Before 30 Sep 2012	After 30 Sep 2012
Government, NGO	MYR 500	MYR 1000
Others	MYR 700	MYR 1400
International Participant	USD 500	USD 1000

*Not inclusive of accommodation.

Who should attend?

The WIF-KL is designed for anyone involved or responsible for the socioeconomic growth of communities, companies and nations through innovation. This Forum will be of particular benefit to:

- Policy Makers, Planners and Senior Government Officers
- Chief Company Executives and Directors
- Research Scientists and Inventors
- Academia and Students
- NGOs and Communities

Why Participate?

Some key benefits of attending WIF-KL 2012:

- Understand the key drivers of achieving excellence in science, technology and innovation
- Construct an effective framework of regulations and policy to propel innovation in public and private sector, societal, urban and rural, corporate and industrial, education, healthcare, transportation and branding
- Utilise innovation & technology as catalysts that will lead to creation of high income nation
- Enculture innovation as the new national, regional and global development strategy
- Establish and strengthen networks of organisations and countries of different development levels to fuel future collaboration and cooperation
- Provide a platform for high-level stakeholders (from the public, private and civil society sector) to share experiences, discuss and deliberate on issues and strategies on inclusive innovation
- Provide business opportunities and investments, both locally and globally

JOIN US!

For further information, please contact:

+603 8319 1714 | +603 8319 1715 | klif@yim.my | www.wifkl.com | World Innovation Forum - Kuala Lumpur

Young Scientists Network—Academy of Sciences Malaysia

What seemed miles away and uncertain finally materialised. A network, platform, foundation for the nation's outstanding young scientists. Young Scientists Network—Academy of Sciences Malaysia (YSN-ASM) was the given name. The proposal was presented by Prof Mohd Basyaruddin Abdul Rahman in June 2010 during the Lindau announcement/press conference. The first initiative took place in December 2011 when four young scientists (Prof Basya, Dr Abhimanyu Veerakumarasivam, Dr Azwani Sofia Ahmad Khiar and Dr Normi Mohd Yahaya) under the tutelage of an experienced senior scientist (Prof Abdul Halim Shaari) convened in a meeting room in Universiti Putra Malaysia to lay the foundation of YSN-ASM. More 'bricks' were laid the following year with a more significant involvement of other excellent young scientists across the country who responded to the Academy's call to solidify the establishment of YSN-ASM.

The effort was timely as other nations across the globe have announced the establishment of such chapters in their own respective countries, i.e. Die Junge Akademie in Germany, De Jonge Akademie in The Netherlands, the Royal Society of Edinburgh Young Academy of Scotland, the National Academy of Young Scientists in Pakistan, the Young Academy of Sweden, the South African Young Academy of Science, Young Academy of Japan, Thai Young Academy and Philippine Academy of Young Scientists. All such establishments are the result of or spin-offs from the worldwide organisation for young scientists known as the Global Young Academy (GYA) under the InterAcademy Panel. Malaysia's YSN-ASM will be the latest addition to this growing list.

In line with GYA, YSN-ASM will serve as a strong platform where excellent young, local scientists with diverse background and expertise can interact, co-ordinate, organize and meet both national and international challenges. It will also be a platform for talented young scientists across disciplines to collaborate and create opportunities for career development with any young scientists in the country or abroad. It will serve as the centre where the gap between young and senior scientists is established and consolidated where mentorship, policy consultation by senior scientists with fellow young scientists is highly encouraged for the sustainability of the scientific community. Last but not least, YSN-ASM will be a source of role models for future scientists in training at high schools and universities which is important for expanding the nation's scientific capacity in the near future.

With the impending official launch of YSN-ASM due in December 2012, it would signify the first out of many scientific excellence and contributions by YSN-ASM for the research community and the general public in Malaysia.

The ASM National Nobel Laureate Programme

The National Laureate Programme was initiated by the Government of Malaysia under the 8th Malaysia Plan (year 2001–2005), and was continued into the 9th Malaysia Plan (year 2006–2010) until now, with the support of the Ministry of Science, Technology and Innovation (MOSTI) and implemented by the Academy of Sciences Malaysia. The aim of the National Nobel Laureate Programme is to catalyze the achievement of excellence in science, technology and innovation (STI) in Malaysia for national competitiveness and international recognition.

This Programme was initiated to provide a platform for the Malaysian scientific community, academics, researchers, post-graduates and students to be mentored by and learn from renowned scientists particularly Nobel Laureates and globally recognized centres of excellence to obtain inspiration, ideas, linkages towards achieving excellence in STI, as well as to benchmark their capabilities against the world's best, towards producing high caliber scientists capable of contributing to the advancement of the global scientific community as well as for the benefit of humanity.

To date, 25 Nobel Laureates (Table 1) have conducted various activities in Malaysia under this Programme.

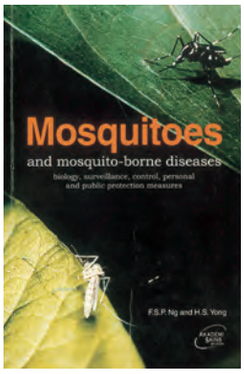
Some of the prominent projects carried out by ASM under the National Nobel Laureate Programme are as follows:

- Public lectures, scientific discourses and science motivation sessions by Nobel Laureates and other eminent scientists.
- The Lindau Programme — National level selection and travel fellowship for outstanding Malaysian young scientists to participate in the annual Lindau Meeting of Nobel Prize Winners with Young Scientists in Lindau, Germany.
- Study Visits to world renowned centres of excellence in scientific research towards establishing scientific exchange and collaboration programmes and facilitating other effective linkages.
- National Science Challenge research mentoring and competition for higher secondary students; and
- Facilitation of collaboration in research and STI human capital development with world renowned centre of excellence and STI institutions.

Table 1. Nobel Laureates Hosted by the Academy of Sciences Malaysia (1996–2012)

No.	Nobel Laureate	Nobel Prize	Year (Hosted)
1	Sir Aaron Klug	Chemistry (1982)	1996
2	Prof David Baltimore	Physiology or Medicine (1975)	1997
3	Prof Lee Yuan Tseh	Chemistry (1986)	1998, 2004 & 2011
4	Prof Werner Arber	Physiology or Medicine (1978)	1999
5	Prof Douglas Osheroff	Physics (1996)	1999, 2004 & 2011
6	Prof Peter Doherty	Physiology or Medicine (1996)	2001, 2003, 2006 & 2012
7	Prof Leland Hartwell	Physiology or Medicine (2001)	2004
8	Prof Arthur Kornberg	Physiology or Medicine (1959)	2002
9	Prof Ahmad Zewail	Chemistry (1999)	2002, 2006 & 2007
10	Sir Harold Kroto	Chemistry (1996)	2004
11	Prof Carl Wieman	Chemistry (2001)	2004
12	Prof Richard Ernst	Chemistry (1991)	2004
13	Prof Gerardus 't Hooft	Physics (1999)	2004 & 2008
14	Prof Ivar Giaver	Physics (1973)	2004
15	Prof Sydney Brenner	Physiology or Medicine (2002)	2005
16	Prof Chen Ning Yang	Physics (1957)	2006
17	Dr Richard Roberts	Physiology or Medicine (1993)	2007
18	Dr Mohamed El Baradei	Peace (2005)	2007
19	Prof Sherwood Rowland	Chemistry (1995)	2007
20	Prof Ryoji Noyori	Chemistry (2001)	2008
21	Prof Roger D. Kornberg	Chemistry (2006)	2008
22	Prof Sir Martin Evans	Medicine (2007)	2009
23	Prof H. Robert Horvitz	Medicine (2002)	2009
24	Prof George F. Smoot	Physics (2006)	2009
25	Prof Ferid Murad	Physiology or Medicine (1998)	2012

ASM Publications



Mosquitoes and Mosquito-borne Diseases: Biology, Surveillance, Control, Personal and Public Protection Measures

F.S.P. Ng **and** *H.S. Yong (Editors)*
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ISBN 983-9445-05-7
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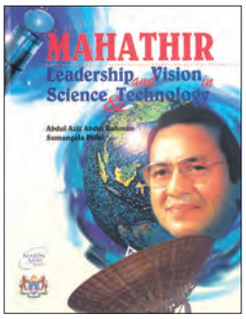

Mahathir: Leadership and Vision in Science and Technology

Abdul Aziz Abdul Rahman **and** *Sumangala Pillai*
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Budaya Kreativiti: Pameran Seratus Tahun Hadiah Nobel

Ulf Larsson (Editor)
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CD Kompilasi *estidotmy*

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dan *Sumangala Pillai*
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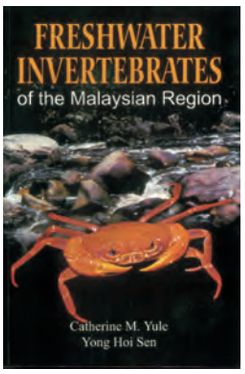

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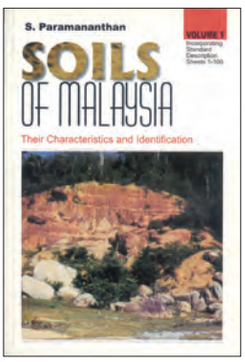

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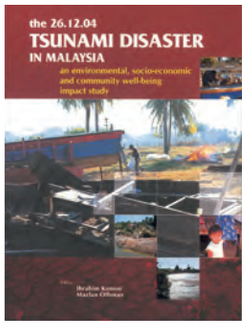

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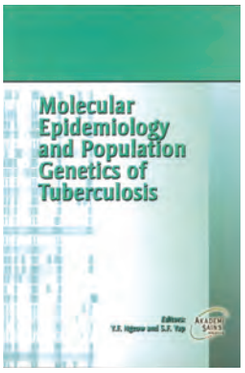

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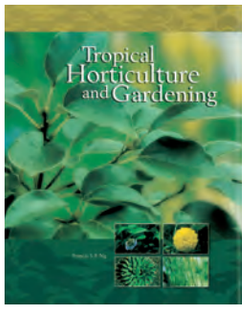

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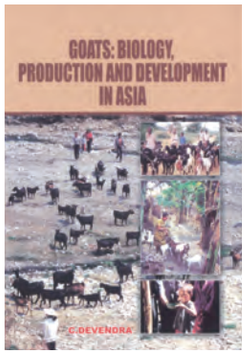

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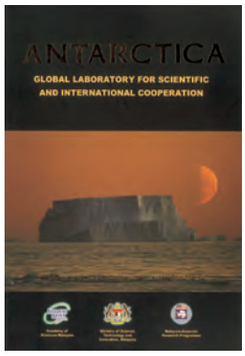

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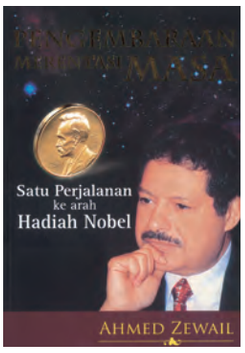

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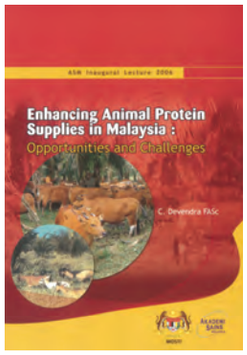

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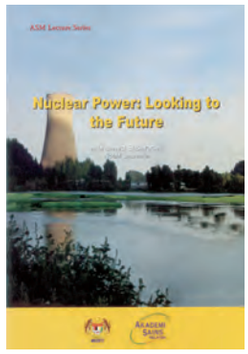

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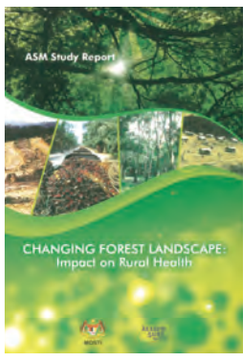

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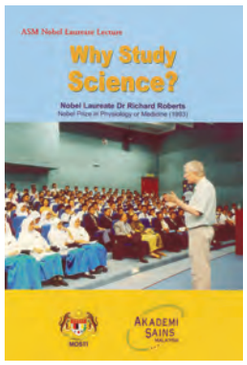

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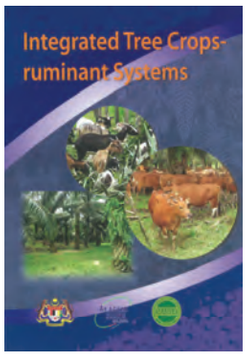

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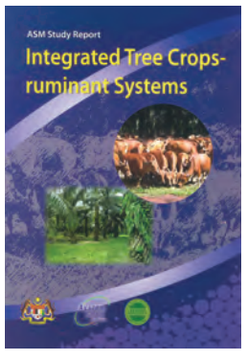

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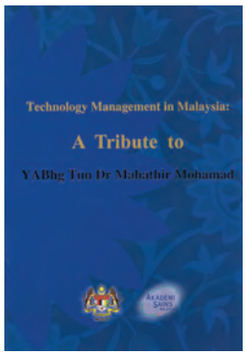

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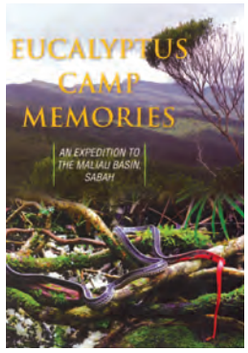

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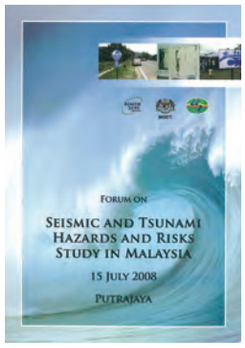

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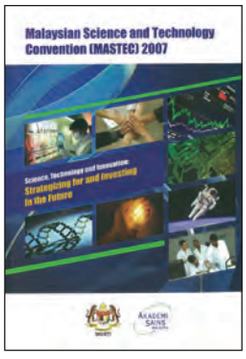

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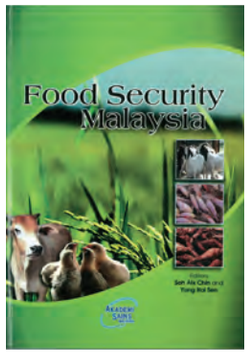

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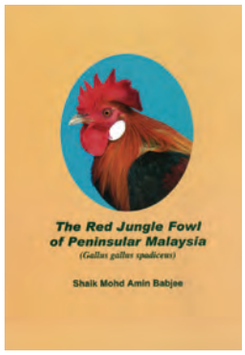

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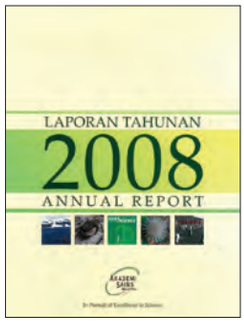

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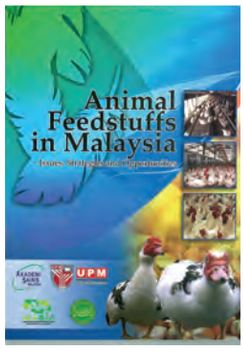

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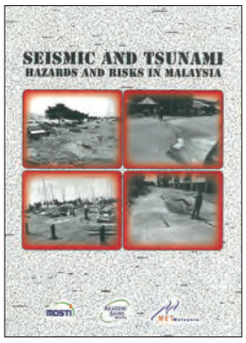

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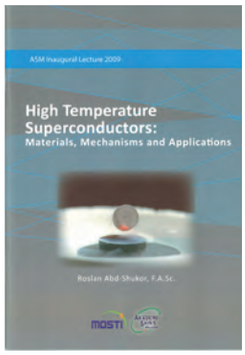

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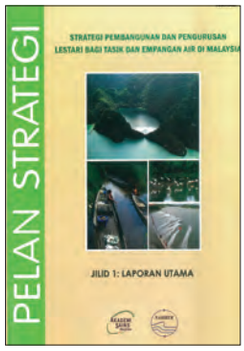

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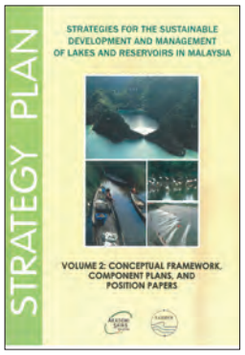

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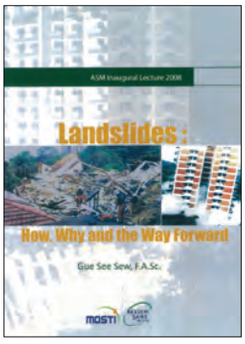

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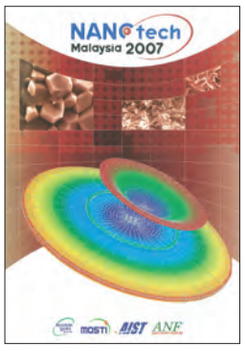

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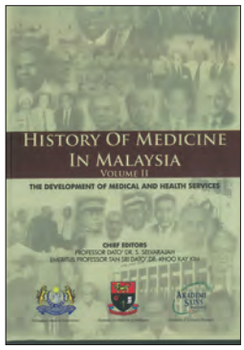

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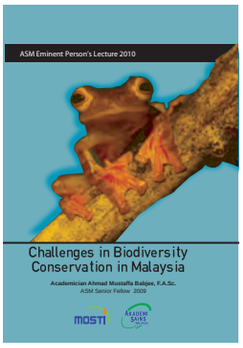

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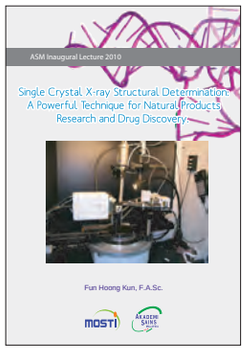

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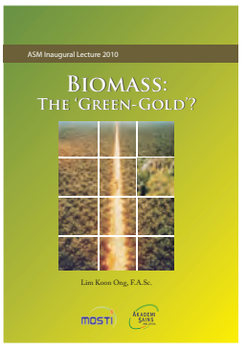

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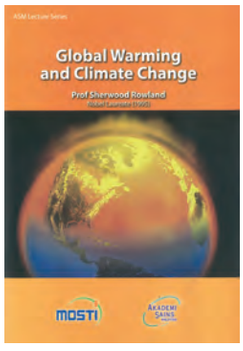

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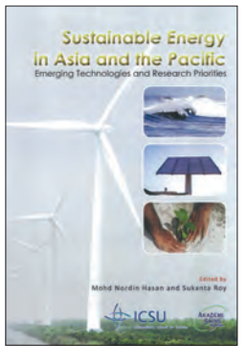

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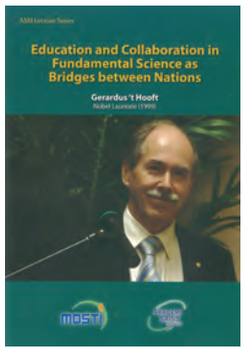

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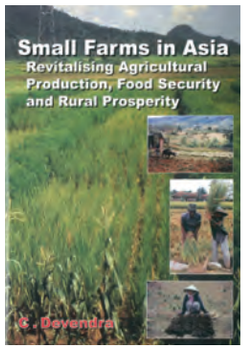

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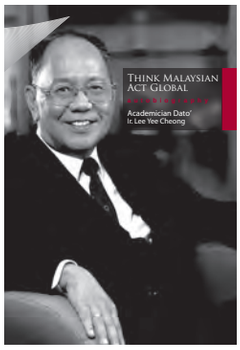

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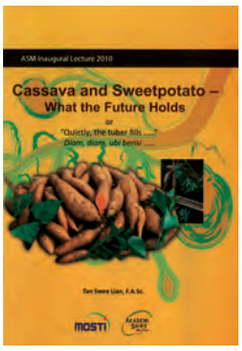

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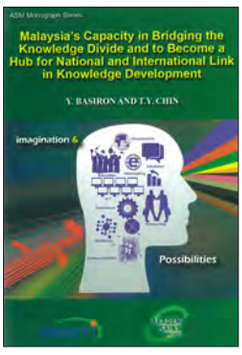

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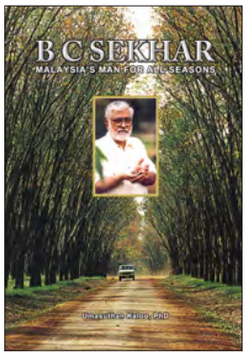

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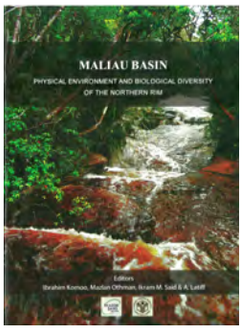

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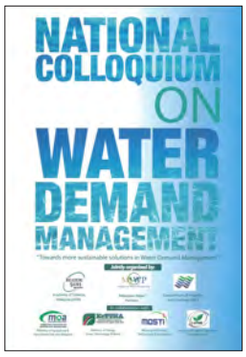

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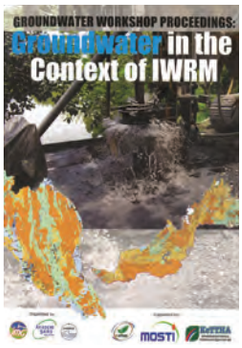

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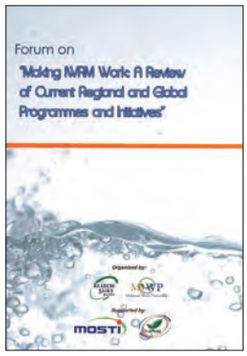

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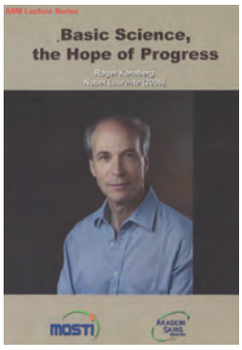

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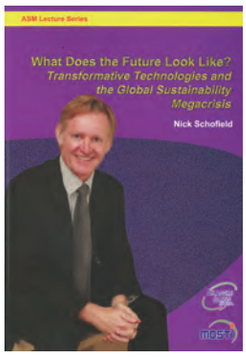

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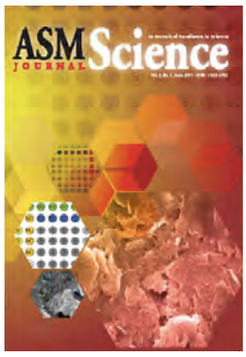

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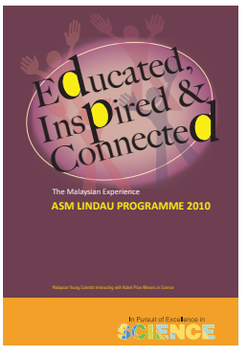

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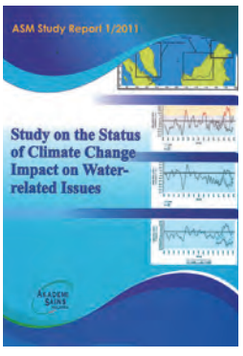

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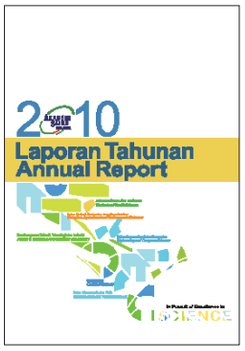

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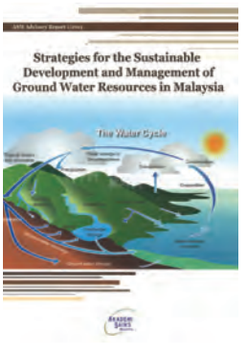

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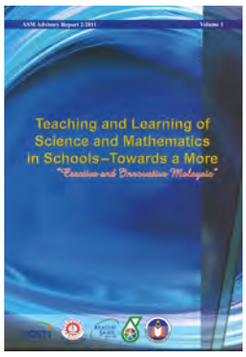

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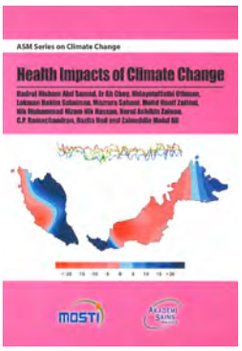

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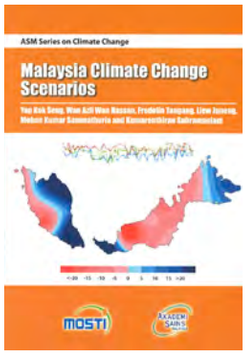

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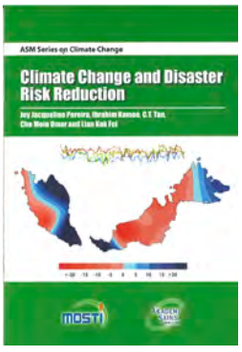

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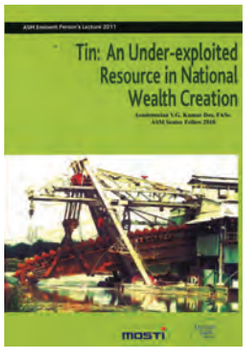

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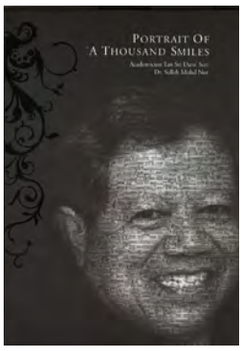

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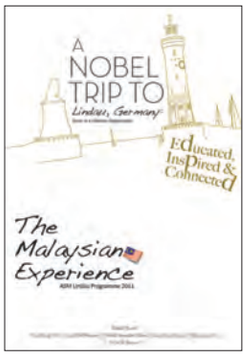

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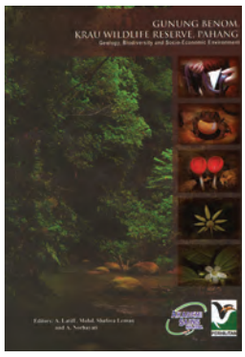

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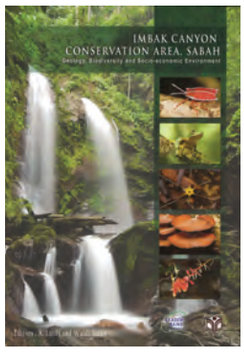

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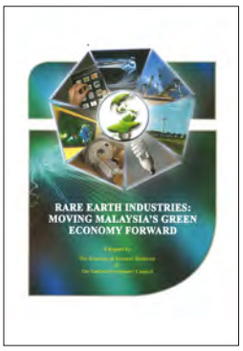

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Individuals who make the news with breakthrough research or those involved in outstanding scientific endeavours or those conferred with internationally recognised awards will be featured in this section. Policy promulgations, funding, science education developments, patents from research, commercial products from research, and significant scientific events will be disseminated through this section of the journal. The following will be the categories of news:

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Kumar, P & Garde, RJ 1989, 'Potentials of water hyacinth for sewage treatment', *Research Journal of Water Pollution Control Federation*, vol. 30, no. 10, pp. 291–294.

Monograph

Hyem, T & Kvale, O (eds) 1977, *Physical, chemical and biological changes in food caused by thermal processing*, 2nd edn, Applied Science Publishers, London, UK.

Chapter in a monograph

Biale, JB 1975, 'Synthetic and degradative processes in fruit ripening', eds NF Hard & DK Salunkhe, in *Post-harvest biology and handling of fruits and vegetables*, AVI, Westport, CT, pp. 5–18.

Conference proceedings

Common, M 2001, 'The role of economics in natural heritage decision making', in *Heritage economics: challenges for heritage conservation and sustainable development in the 21st century: Proceedings of the International Society for Ecological Economics Conference, Canberra, 4th July 2000*, Australian Heritage Commission, Canberra.

Website reference

Thomas, S 1997, *Guide to personal efficiency*, Adelaide University, viewed 6 January 2004, <http://library.adelaide.edu.au/~sthomas/papers/perseff.html>.

Report

McColloch, LP, Cook, HT & Wright, WR 1968, *Market diseases of tomatoes, peppers and egg-plants*, Agriculture Handbook no. 28, United States Department of Agriculture, Washington, DC.

Thesis

Cairns, RB 1965, 'Infrared spectroscopic studies of solid oxygen', PhD thesis, University of California, Berkeley, CA.

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Acknowledgements. Appropriate acknowledgements may be included.

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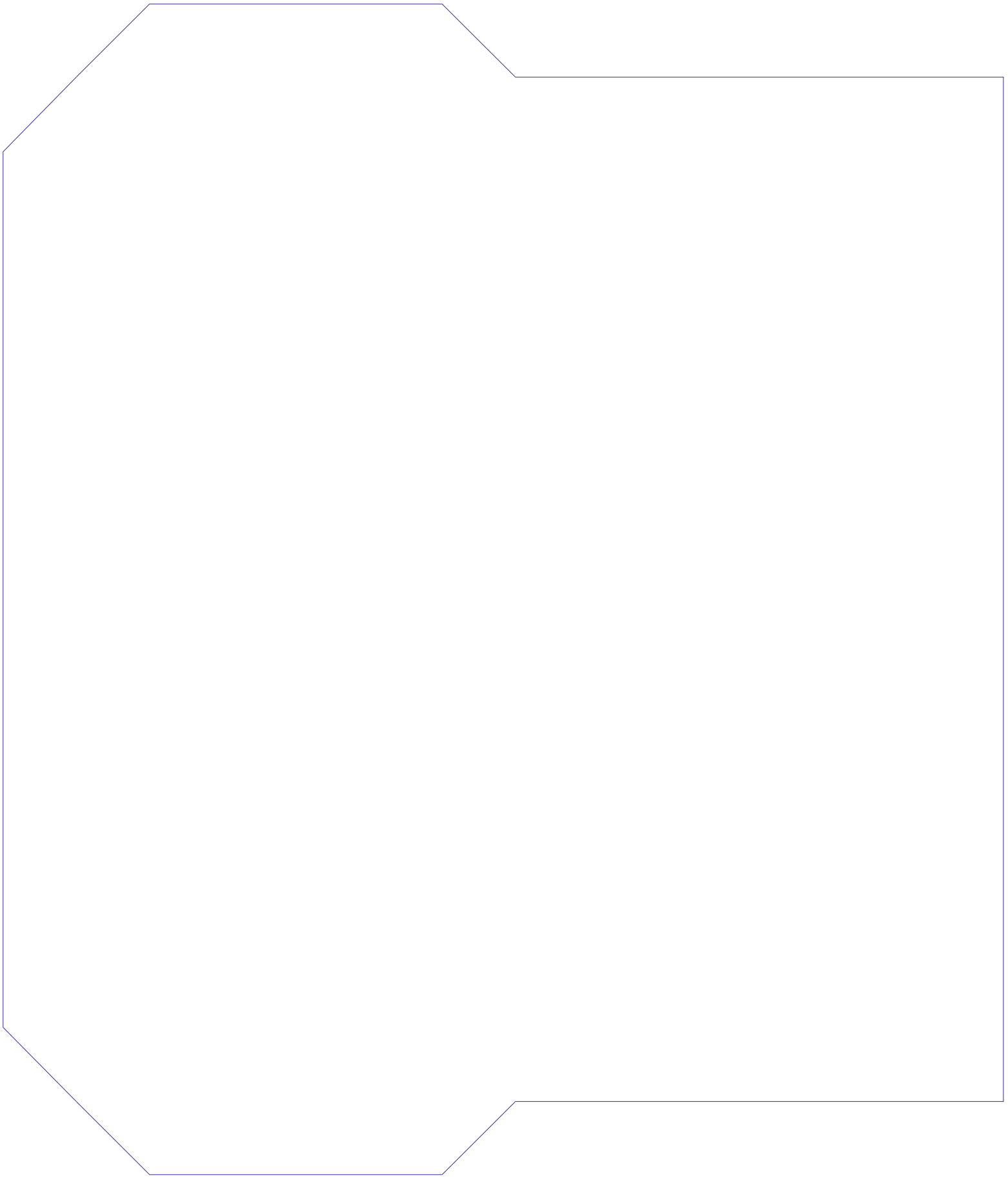

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