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ISSN 1823-6782

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AKADEMI SAINS MALAYSIA

ASM Science Journal 5(2) 2011

ASM JOURNAL Science
In Pursuit of Excellence in Science
Vol. 5, No. 2, December 2011 • ISSN : 1823-6782

Price (2 Issues)

Malaysia: RM100 (*Individual*)
RM200 (*Institution*)

Other Countries: USD50 (*Individual*)
USD100 (*Institution*)

ASM Science
JOURNAL

Cover:

Climate changes will have significant major effects on animal production. This is reflected in reduced performance, multifunctionalty and contribution to stable livelihoods. The hardest hit will be an estimated 85% of the 470 million global total of resource-poor small farms, small farmers, landless and agricultural labourers. These individuals are largely illiterate, have little or no access to credit, markets, information, risk-sharing tools, and property rights. The available production resources in the farm are put to maximum use in traditional systems that just enable subsistence living, and with reasonable weather, income from the sale of farm produce. An example is the use of animal manure to fertilise crop land in the face of high prices for inorganic fertilisers (Figure 1, pp. 144). With the many constraints, these farmers have limited ability to adapt to the new technology and farming practices that can mitigate the negative effects of climate change. Adaptation to rising temperatures and changing weather patterns is therefore crucial to the food security of millions of farmers.

Climate change impact therefore further exacerbates the complex interactions with the environment. Type of production system is also an important consideration. While stall feeding arrangements enable some control over stress, ruminants in the more extensive systems are more vulnerable mainly because of feed scarcity. Ability to cope and adapt to climate change will be particularly challenging, and important. Goats for example, prefer and flourish in hot dry environments such as the semi-arid AEZs conditions, rapidly multiply resulting in overstocking, ownership of larger flocks, and possible soil and environmental degradation. Improved soil and agronomic practices are important strategies to promote carbon sequestration in integrate systems with ruminants, and therefore merit urgent development priority (Figure 2, pp. 144).

Cover illustation—from the article entitled *Impact of Climate Change on Animal Production in Asia: Coping with Challenges for Agricultural R&D* (pp. 139–150).

ASM Science Journal is listed and indexed in Scopus.

Published by the Academy of Sciences Malaysia

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- 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
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- To encourage research and development and education and training of the appropriate scientific, engineering and technical man power
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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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Preparation and Characterization of Carboxylic-functionalized Multi-walled Carbon Nanotubes

L.K. Zakiyah[1], M.M. Gui[1], R.S. Foo[1], A.R. Mohamed[2] and S.P. Chai[2]

The functionalization of pristine CNTs is necessary for carbon nanotubes (CNTs) to be fully utilized, with the aim of increasing the nanotube reactivity and solubility in aqueous solutions. In this study, multi-walled carbon nanotubes (MWCNTs) were functionalized with a carboxylic group as this was an important step prior to application. The carboxylic group-functionalization was conducted through acid treatment, using sulphuric and nitric acids mixed at a ratio of 3:1 (v/v) and sonication for 30 min under different temperatures and time durations. The functionalization conditions of 50ºC × 5 h and 60ºC × 3 h were identified to be most suitable for introducing a carboxylic group onto the nanotube surfaces. The percentage of total weight loss due to the carboxylic group on the MWCNTs treated at 50ºC × 5 h and 60ºC × 3 h obtained from the thermogravimetric analysis was 13.26% and 13.76%, respectively. For both samples, peaks corresponding to the carboxylic group were identified in the FT-IR spectra. The changes in the morphology of the treated MWCNTs were also observed under SEM analysis.

Key words: Functionalization; carbon nanotubes; carboxylic groups; scanning electron microscopy; acid treatment; sonication; oxidation; FTIR; TGA

Carbon nanotubes (CNTs) are one of the allotropes of carbon and are members of the fullerene structural family (Daniel *et al*. 2007). CNTs possess many outstanding properties such as superb mechanical strength, excellent electronic properties and chemical inertness apart from having large surface areas and are ultra-light (Yang *et al.* 2007; Feng *et al*. 2008). These properties have inspired researchers to put CNTs into application in various fields, for example as electrode materials, polymer composites, electrochemical biosensors and many more (Feng *et al*. 2007; Wang & Lin 2008). The fact that CNTs are hydrophobic structures, however, has caused quite a problem when it comes to their development. Considering the surface of CNTs as inert also limits certain applications (Chen & Shimizu 2008). Nevertheless, these problems can be easily overcome by functionalizing them with oxygen-containing groups, mainly carboxyl and hydroxyl, to increase their solubility in aqueous or organic solvents as well as to provide some areas where the polymers can anchor themselves to the CNTs (Balasubramanian & Burghard 2005).

Functionalization of CNTs can be done in two ways: covalent attachment and non-covalent attachment (Balasubramanian & Burghard 2005; Daniel *et al.* 2007). Covalent functionalization is based on the chemical bond formation between functional groups and CNTs, whereas non-covalent functionalization is achieved by forming van der Waals bonds between the functional groups and the tube walls using methods such as adsorption, entrapment and wrapping (Goyanes *et al*. 2007; Harris 2009). The two methods of functionalization have their own advantages and disadvantages. Covalent functionalization has been observed to be able to provide higher stability, accessibility and selectivity due to the way functional groups attach themselves to the CNTs (Daniel *et al.* 2007). By undergoing the oxidizing treatment, these carboxylic acids are more likely to attach themselves at the CNTs' caps and defect sites on the sidewalls as they are more reactive compared to the rest of the area due to the presence of the dangling or open bonds (Yang *et al*. 2007; Yun *et al*. 2007). However, the oxidation treatment of CNTs with acids and/or covalently attached biomolecules into the functionalized CNTs may alter their electronic properties since these properties rely heavily on the structure and diameter of CNTs (Daniel *et al*. 2007). In fact, several researchers have reported that chemically oxidized CNTs with carboxylic acids may induce more damage on the sidewalls and increase the defect sites depending on the type of acids and parameters used (Chen *et al*. 2005; Goyanes *et al*. 2007; Shieh *et al.* 2007). Although this will increase the reactivity and solubility of CNTs as more dangling bonds are created and more carboxylic residues can be attached, it is regarded as

[1]School of Engineering, Monash University, Jalan Lagoon Selatan, 46150 Bandar Sunway, Selangor, Malaysia
[2]School of Chemical Engineering, Universiti Sains Malaysia, Engineering Campus, Seri Ampangan, 14300 Nibong Tebal, SPS Pulau Pinang, Malaysia
*Corresponding author (e-mail: chai.siang.piao@monash.edu)

disadvantageous situation for the development of certain applications such as electrochemical biosensors (Daniel *et al*. 2007).

In comparison, non-covalent functionalization is much less damaging since it is capable of attaching desired molecules to CNTs without forming any chemical bonds, thus the CNTs can retain their original properties (Harris 2009). The problem with this type of functionalization is most of the methods used require high skills and rare equipment thus limiting the commercialization potential of these methods. Since the bonding depends on the van der Waals forces alone, these methods may provide lesser stability than the covalent functionalization methods (Goyanes *et al*. 2007). It is well documented that although covalent methods are much cheaper and easier to apply, they can be tricky as well. On the other hand, non-covalent methods may be suitable for applications such as biosensors but they are not exactly cost effective and simple to do. Therefore, it is critical to develop a better way to conduct covalent functionalization without damaging the CNT structures as they are more advantageous in term of commercial production and manufacturing cost.

In this present study, a procedure combining the sonication and oxidation methods was utilized to develop the carboxylic-functionalized CNTs. The purpose of sonication was mainly to increase the dispersibility of CNTs in the solutions which in turn reduced the agglomeration of CNTs. Various conditions of temperature and time were set as parameters in order to study the effect of these two factors on the functionalization process. The developed carboxylic-functionalized CNTs were characterized by Fourier Transform infrared spectroscope (FT-IR), thermogravimetric analyzer (TGA), and scanning electron microscope (SEM).

MATERIALS AND METHODS

MWCNTs used for this study were synthesized from Co-Mo/MgO catalyst in a horizontal rotary reactor. An amount of 30 mg of MWCNTs were added into a mixture of 30 ml sulphuric acid (98% purity) and 10 ml of nitric acid (70% purity). The mixture was sonicated in a water bath at room temperature (25ºC) for 30 min and then heated and stirred under a reflux condition. Table 1 shows the conditions for which the MWCNTs were treated. Once the acid treatment was completed, the mixture was cooled down to room temperature and diluted with distilled water. The diluted mixture of acid and MWCNTs were filtered with 0.2 µm nylon membrane filter. When all the diluted mixture was filtered, the residue was washed with distilled water until the pH became neutral. The washed residue was then scraped off the nylon membrane filter and dried in an oven at a temperature of 105ºC. The characterizations of the treated MWCNTs were done by FT-IR (Nicolet iS10), SEM (FEI Qunta 200) and TGA (TA Q50). For preparing the samples for the FT-IR analysis, the dried samples of MWCNTs were mixed with KBr powder at a ratio of 1:20 (v/v), ground and compressed at 8 tons by a manual hydraulic jet to form a transparent, thin pellet. TGA was then performed on the samples to quantitatively analyze the weight loss due to the functional groups attached on the MWCNTs upon heating (Kim *et al.* 2010; Mamba *et al*. 2010). For TGA, the treated MWCNTs were flushed with purified air or nitrogen gas at a heating rate of 10ºC/min from ambient temperature up to 900ºC. The TGA thermogram was analyzed for the presence of functional groups such as carboxylic and hydroxyl groups on the MWCNTs by calculating the weight loss at the specific temperature range.

Table 1. Acid treatment conditions.

Sample	Temperature (ºC)	Time (hr)
1	50	1
2	50	3
3	50	5
4	60	1
5	60	3
6	70	1
7	70	3
8	70	5

RESULTS AND DISCUSSION

Characterization of Pristine MWCNTs

FT-IR analysis was performed on the pristine MWCNTs so as to analyze the functional groups attached to the surface prior to any acid treatment. Figure 1 shows the FT-IR spectrum of the pristine MWCNTs. The spectrum of the pristine MWCNTs displayed in Figure 1 shows the peaks for the OH and C=O groups. The relatively broad and strong OH peak at 3440 cm^{-1} attributed to the inherent moisture of the KBr powder and for the atmospheric moisture present on the MWCNTs (Kim *et al*. 2007; Datsyuk *et al*. 2008; Men *et al.* 2008; Chokoli *et al*. 2009). In addition, the weak peak of C=C at the wavenumber of 1570 cm^{-1} shows the characteristic of CNT skeleton (Jiang *et al*. 2009; Mamba *et al*. 2010), whereas the C-H peaks which appeared in between 2980 cm^{-1} and 2840 cm^{-1} indicate that the pristine MWCNTs contain defects which may have been formed when they were produced (Chokoli *et al.* 2009; Rosario-Castro *et al.* 2009).

To analyze the carbon content and purity of the pristine MWCNTs, TGA was conducted under purified air. Figure 2 shows the TGA thermogram for the pristine MWCNTs. It was shown that 0.96% of the total weight of the pristine MWCNTs was the moisture content. It is well accepted that

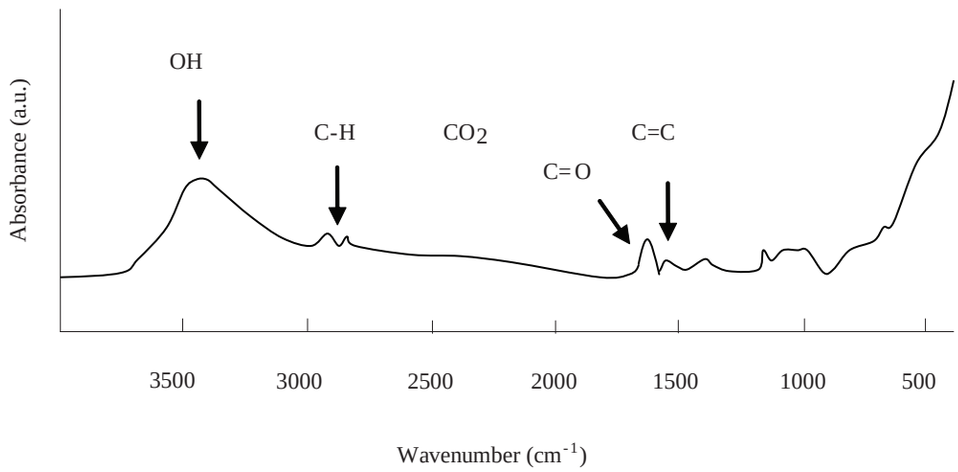

Figure 1. FT-IR spectrum of pristine MWCNTs.

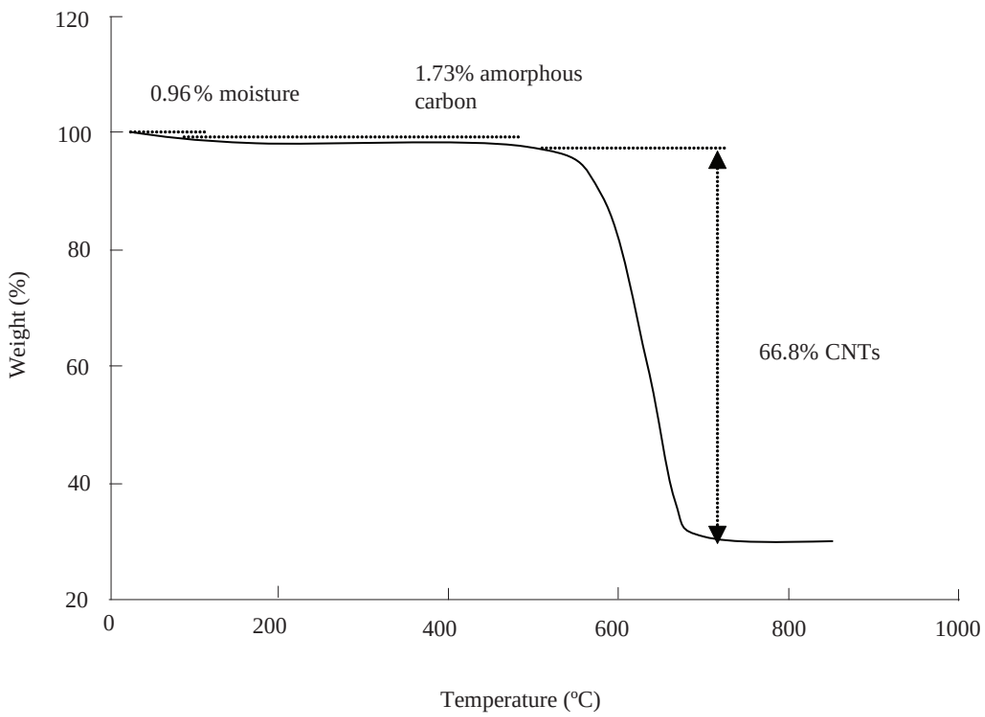

Figure 2. TG curve of pristine MWCNTs.

amorphous carbon oxidizes in the temperature range of 100ºC – 500ºC. From the TG curve, the amorphous carbon content in the pristine MWCNTs was found to be 1.73%. The weight loss in the temperature range of 500ºC – 700ºC, corresponding to the MWCNTs content, was determined to be 66.8%.

The SEM images of the pristine MWCNTs are shown in Figure 3. The SEM micrograph of the pristine MWCNTs at low magnification showed bulky rock-like pristine MWCNTs and at higher magnification, the pristine MWCNTs were shown to be similar to bundles of unaligned and highly coiled ropes.

Characterization of Treated MWCNTs

Fourier transform infrared spectroscopy. The spectra of the treated MWCNT samples based on the temperature are shown in Figures 4–6. From Figure 4, both the FT-IR spectra for the MWCNTs treated at 50ºC × 3 h and 50ºC × 5 hr show quite similar peaks albeit with different intensity. The peak at 3440 cm^{-1} indicate the presence of the OH stretching mode of water molecules present in the MWCNTs and/or KBr powder during the analysis (Yu *et al*. 2008; Jiang *et al*. 2009). If the carboxylic group was present, there should be a C=O stretching vibration band at 1630 cm^{-1} and OH bending vibrations between 1390 cm^{-1} and 1280 cm^{-1} (Rosario-Castro *et al*. 2009). As shown in Figure 4, these two bands were present, indicating that the OH stretching band was indeed assigned to the COOH group. In addition, the band at around 1100 cm^{-1} is contributed by the C-O stretching vibrations of the COOH group (Kim *et al*. 2010). It is also noted that these peaks increase as the functionalization duration increases.

Furthermore, the FT-IR spectra also showed that the C=C and C-H stretching modes increased after functionalization. The C=C stretching mode is reported to be assigned to the MWCNT graphitic layers near the defect sites (Yu *et al.* 2008) whereas the increase in the C-H stretching may be explained by the attachment of alkyl groups onto the surface of MWCNTs and the increase in defect sites can be due to oxidation of the acid mixture (Men *et al*. 2008). Therefore, the weak absorption intensity of these two modes in the 3-hour spectrum indicated that at 3 h, the functionalization effect was marginal. The characteristics as mentioned previously were typically observed in the oxidized MWCNTs as reported in many papers and therefore confirming the attachment of hydroxyl and carboxyl groups on the surface of MWCNTs (Daniel *et al*. 2007; Shieh *et al*. 2007; Men *et al.* 2008; Yu *et al*. 2008; Jiang *et al*. 2009; Kim *et al.* 2010).

Figure 5 shows the FT-IR spectra for the MWCNTs treated at 60ºC for 1 h and 3 h. The main peaks corresponding to the carboxylic group can also be observed in Figure 5. As the treatment time increased, the intensity of these peaks became sharper. Among the MWCNTs treated under 60ºC, the best sample was observed to be the one treated for 3 hours. For treatment at 70ºC, it was discovered that along with the appearance of carboxylic group peaks, a strong and sharp peak appeared at the wavenumber of 1390 cm^{-1} as shown in Figure 6. This particular peak, however, only started to appear when the MWCNTs underwent the treatment for both 3 h and 5 h. This peak was reported to be the S=O stretching vibrations of the grafted sulphonic acid group (-SO3H) (Peng *et al*. 2005; Zhao *et al*. 2010). Since the sulphonic group was not one of the desired groups for this study, further characterization on the samples treated at 70ºC was not considered. From Figures 4 and 5, it was clear that the best samples were MWCNTs treated at the temperatures of 50ºC for 5 h and 60ºC for 3 h. These samples were further analyzed using SEM and TGA.

Thermogravimetric analysis. The functional groups attached on the MWCNTs were determined quantitatively by performing TGA under a nitrogen atmosphere. The TGA thermograms for the MWCNTs treated at 50ºC × 5 h and 60ºC × 3 h are shown in Figures 7 and 8, respectively. From Figure 7, it is observed that the major weight loss occurred in stage 1 (9.41%) at temperatures up to 100ºC, signifying a high content of moisture in the treated MWCNTs (Shieh *et al*. 2007; Chen *et al*. 2008; Yu *et al.* 2008; Chokoli *et al*. 2009). The second stage (temperatures 100ºC – 350ºC) contributed to the second highest weight loss of 8.78% which was reported to be due to the decarboxylation of carboxylic group (Datsyuk *et al*. 2008; Chokoli *et al*. 2009). The weight loss of 4.48% of the third stage was caused by the elimination of the hydroxyl groups, whereas the loss at the last stage (temperatures above 500ºC) was attributed to the degradation of disordered or amorphous carbons (Datsyuk *et al.* 2008). By combining the weight loss in stage 2 and 3, the total weight loss due to carboxylic group on the MWCNTs treated under this condition was calculated to be 13.26%. The thermogram shown in Figure 8 highly resembles the one shown in Figure 7, suggesting a consistency in the oxidation behaviour of the carbon structures. Compared to the MWCNTs treated at 50ºC for 5 h, the amount of carboxylic group undergoing decarboxylation process in this sample was slightly higher at a weight loss of 8.95%.

On the other hand, the higher weight loss caused by the disordered carbons in MWCNTs treated at 60ºC × 3 hr also signifies that there were more defect sites in this sample and the defects were most likely caused by the insertions of the functional groups (Osorio *et al*. 2008). By combining the weight loss due to decarboxylation of carboxylic group and the degradation of hydroxyl group, the total weight loss due to the carboxylic group on the MWCNTs treated under this condition was observed to be 13.76%. This result showed that compared with the MWCNTs under the condition of 50ºC × 5 h, MWCNTs treated at 60ºC × 3 h had a marginally higher percentage of attached carboxylic

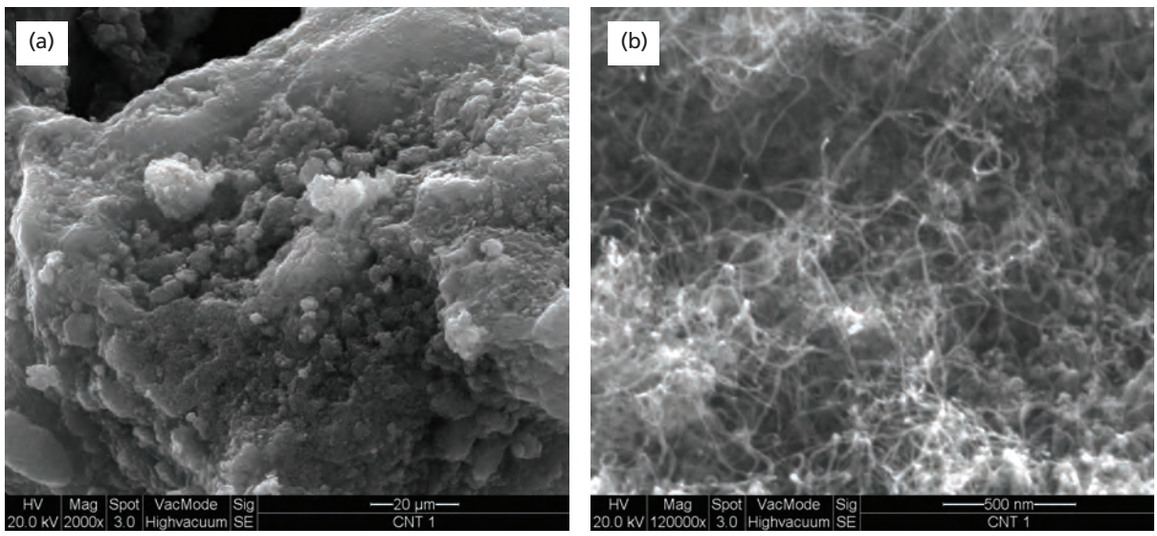

Figure 3. (a) Low-magnified and (b) high-magnified SEM micrographs of pristine MWCNTs.

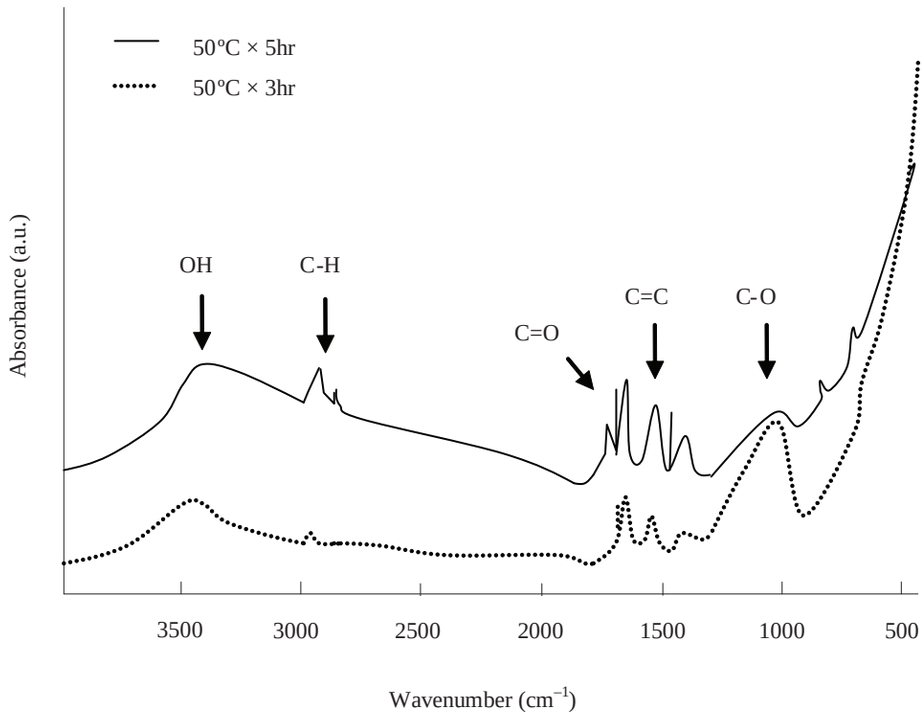

Figure 4. FT-IR spectra of MWCNTs treated at 50°C.

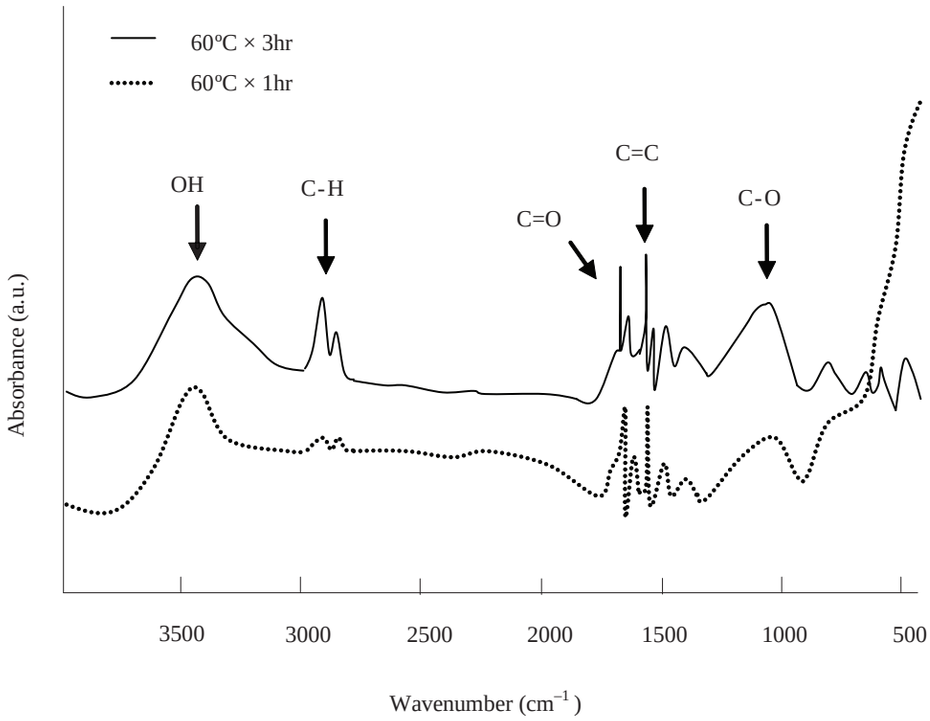

Figure 5. FT-IR spectra of MWCNTs treated at 60°C.

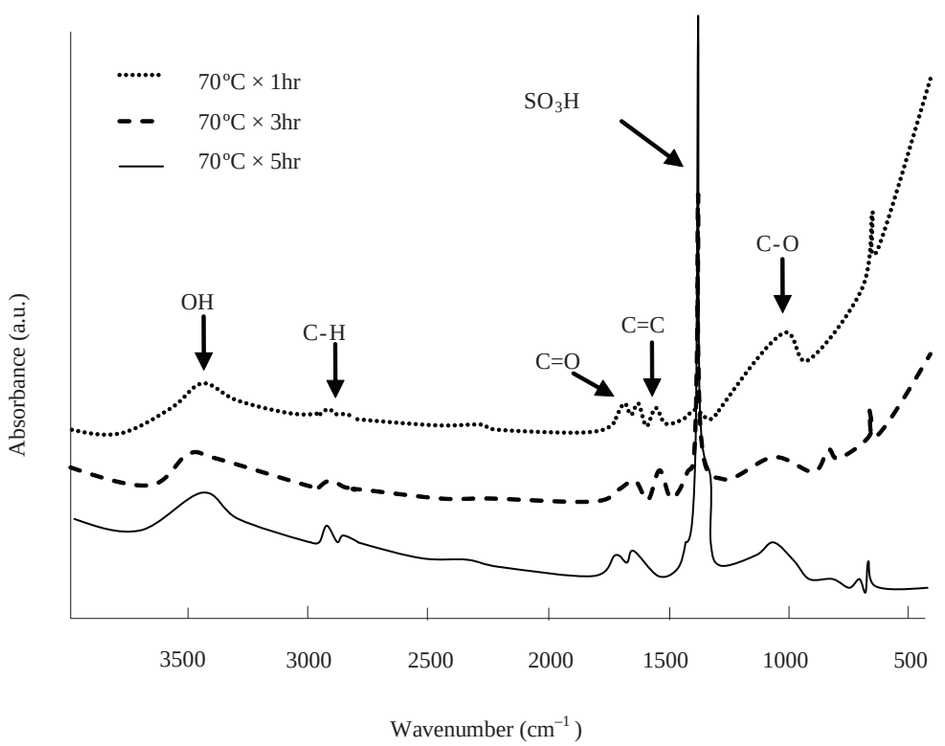

Figure 6. FT-IR spectra of MWCNTs treated at 70°C.

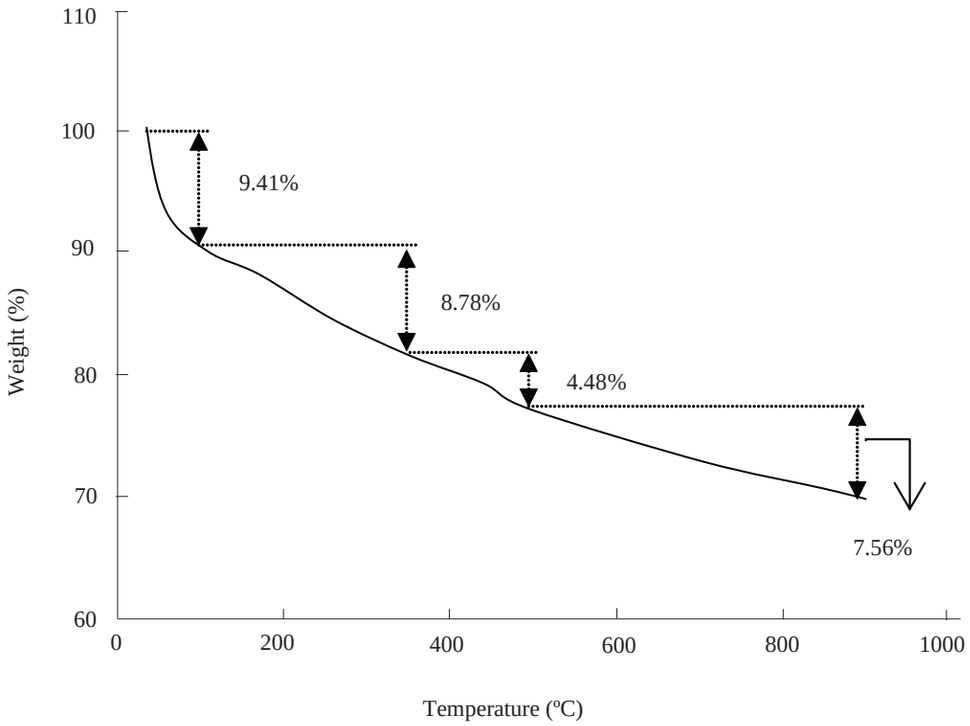

Figure 7. TG curve of MWCNTs treated at the condition 50ºC x 5 h.

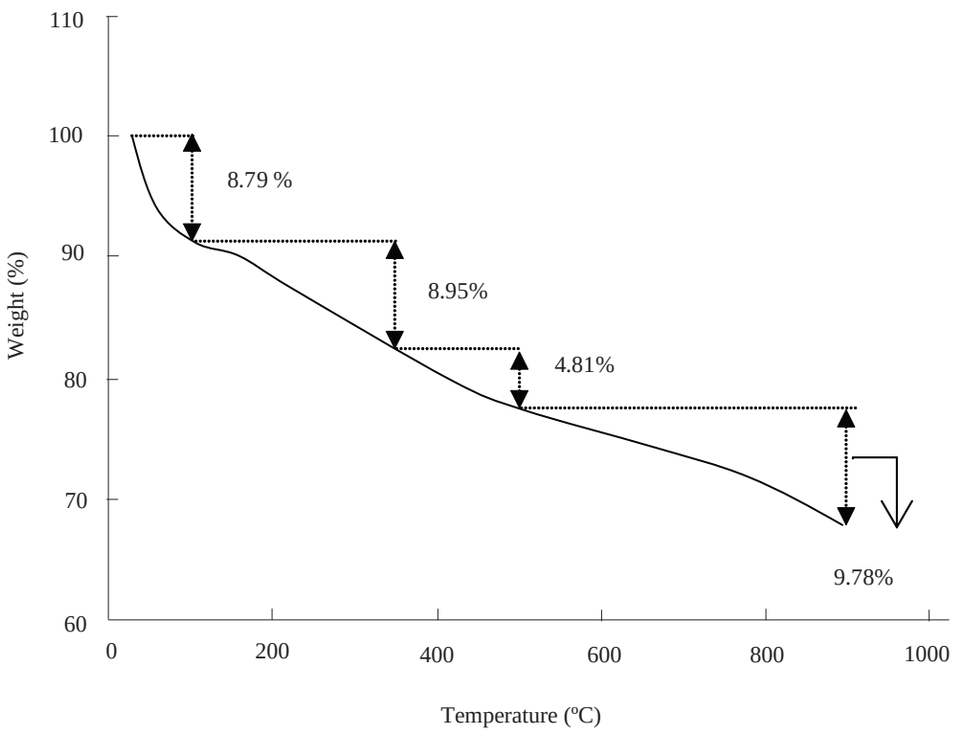

Figure 8. TG curve of MWCNTs treated at the condition 60ºC x 3 h.

group. This showed that temperature had a greater impact on the functionalization compared to the treatment time.

Scanning electron microscopy. Figures 9 and 10 show the SEM micrographs for the samples treated at 50ºC × 5 h and 60ºC × 3 h, respectively. The SEM micrographs of the samples taken at low magnification showed MWCNTs which appeared to stick together to form a shape similar to a collection of rods. This might be caused by the presence of the intermolecular hydrogen bonding of the carboxylic groups attached on the MWCNTs surface (Shieh *et al*. 2007). At higher magnification and compared to the pristine MWCNTs in Figure 3, the treated MWCNTs appear to be more aligned and the bundles are denser (Rosca *et al*. 2005). This observation is in agreement with the findings reported by other groups (Rosca *et al.* 2005; Shieh *et al*. 2007; Jiang *et al*. 2009; Kim *et al*. 2010). It should be noted the micrographs of treated MWCNTs were more blurred than those of the pristine MWCNTs. This observation was reported to be caused by the decrease in the treated

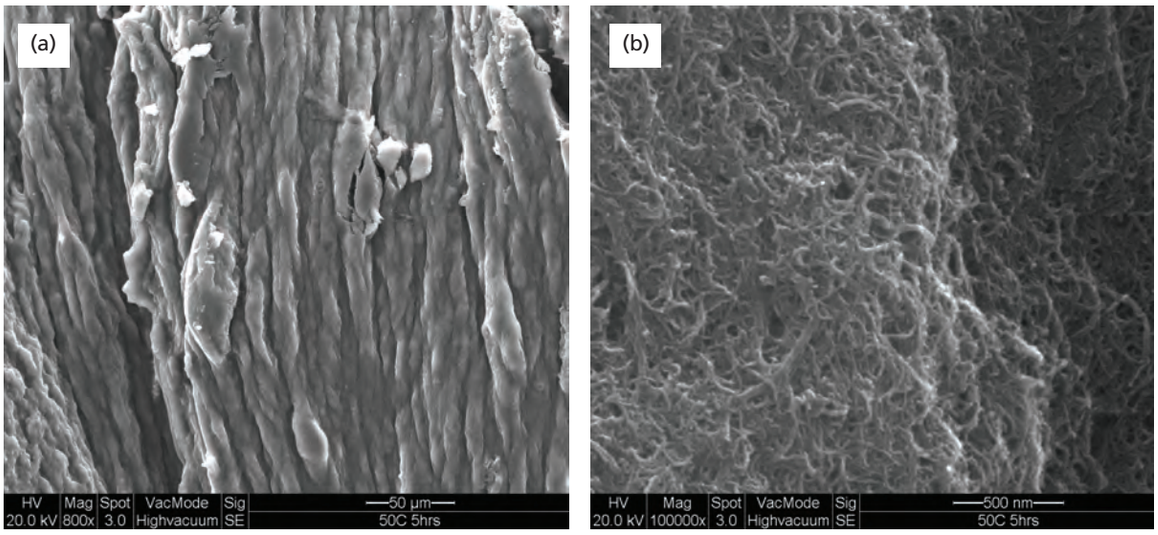

Figure 9. (a) Low-magnification and (b) high-magnification SEM micrographs of MWCNTs treated at condition 50ºC x 5 h.

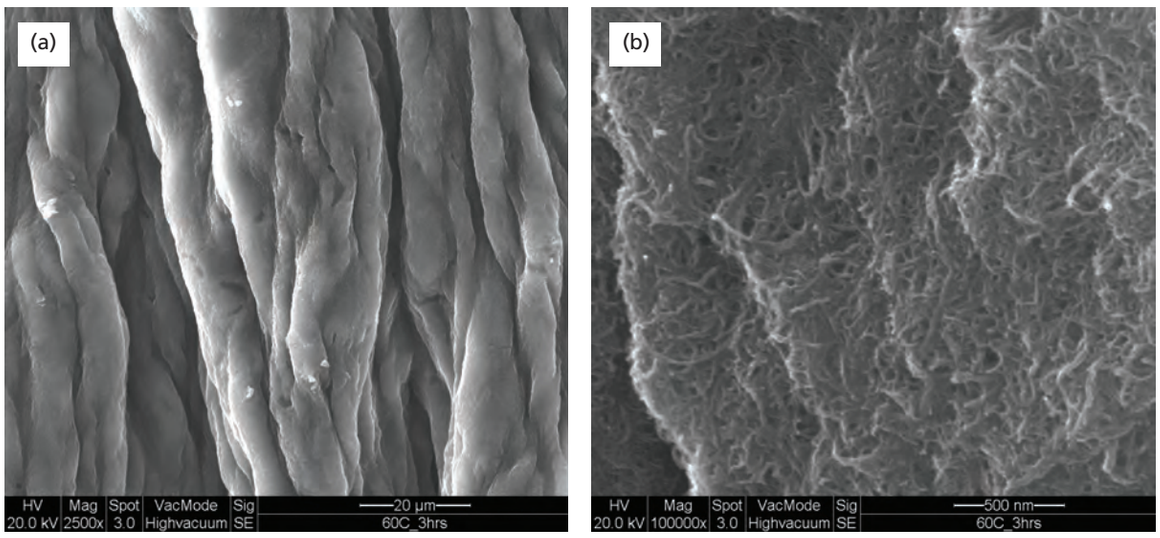

Figure 10. (a) Low-magnification and (b) high-magnification SEM micrographs of MWCNTs treated at condition 60ºC x 3 h.

MWCNTs' electrical conductivity due to the presence of the newly attached carboxylic groups (Daniel *et al*. 2007). Thus, the SEM which works by scanning the electrons emitted from a specimen would display a more blurred image. In both Figures 9 and 10, there were no significant damages identified on the structure of the MWCNTs after the acids functionalization.

CONCLUSIONS

The functionalization of MWCNTs via acid treatment was proven to be simple with minimal chance of error. The results showed that carboxylic group was introduced on the surface of MWCNTs, as evidenced by the FT-IR spectra. From the FT-IR analysis, the two samples of MWCNTs treated at the conditions of 50ºC × 5 h and 60ºC × 3 h were observed to be the best among other acid treatment conditions investigated in this study. The results obtained from the TGA have also confirmed this observation. From TGA, the carboxylic groups attached to the MWCNTs were found to be 13.26% for MWCNTs treated at 50ºC × 5 h and 13.76% for MWCNTs treated at 60ºC × 3 h. The morphology changes in both samples of the treated MWCNTs were also analyzed by SEM and it was concluded that there was no significant damage to the MWCNT structure after the functionalization.

ACKNOWLEDGMENTS

We would like to thank the Monash University through the Monash Internal Seed Fund (A/C no: E-2-09) and the Ministry of Higher Education through the Fundamental Research Grant Scheme (FRGS) (Ref no: FRGS/2/2010/TK/MUSM/03/4) for their financial support.

Date of submission: May 2011
Date of acceptance: December 2011

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ASM Sci. J., **5(2)**, 101–107

Impact of Landfills on Groundwater in Selangor, Malaysia

S. Suratman[1]*, I. Tawnie[1] and A. Sefei[1]

A study to determine the impact of leachate from operating and closed landfills into the surface water and groundwater systems in the state of Selangor was conducted in the year 2009. Groundwater was a major source of water for various uses in Selangor, Malaysia and was especially important for industrial purposes. The presence of high numbers of landfill sites was seen to have increased the risk of groundwater contamination. There were 20 landfill sites in the state of Selangor and seven of them were still operating and 13 closed. The landfills are classified into four categories, which were: (a) landfills operating at critical stages without controls to prevent pollution into the environment; (b) open dumpsites that have the capacity to continue to accept waste but needed to be upgraded to manage leachate and gas; (c) landfills that were closed but no safety closure plan was carried out; and (d) engineered landfills with up to date technologies. As most of the landfills were built prior to 1989, they were not subjected to the Environmental Impact Assessment requirements, hence, they were being poorly managed and were badly sited. The non-engineered sites had no proper pollution controls such as cover materials, liner materials, groundwater monitoring wells, leachate collection ponds and treatment, and methane gas collection pipes. This study revealed that the surface water and groundwater at and nearby the landfill sites were contaminated at various levels due to the landfill sites and operation. A comparison between the current quality of surface water and groundwater with their respective standards and background levels was carried out to survey the trend of the contamination. However, the limited financial resources hindered a very thorough investigation and restricted the number of samples collected and parameters analysed.

Key words: groundwater, landfill, contamination; quality; surface water; leachate; impact; water resources; pollution; remedial measures

Groundwater is a major source of water for various uses in Selangor and it is especially important for industrial purposes. It is also regarded as the potential future water source for public water supply in Selangor. The Kelang and Langat river basins are the locations of the major users of groundwater in Selangor. The presence of high numbers of landfill sites is seen to increase the risk of groundwater contamination. As such a study was performed to assess the landfill sites and their operating status in Selangor. It was also conducted to evaluate the impact of landfills on groundwater and surface water systems. However, due to the limited financial resources, a very thorough investigation was not possible; as such, the number of samples collected and parameters analysed were restricted to a minimum.

In Malaysia, sanitary landfills are generally classified into five levels (Department of Local Government 2006). They are:

Level 0: Open dumping
Level 1: Controlled tipping
Level 2: Sanitary landfill with a bund and daily soil cover
Level 3: Sanitary landfill with leachate recirculation system; and
Level 4: Sanitary landfill with leachate treatment facilities.

This paper presents some of the study findings related to the impact of landfills on water resources, especially on groundwater. Evaluation of the extent of pollution at landfills was made and the immediate remedial measures to be taken have been suggested.

OBJECTIVES OF THE STUDY

Considering the importance of groundwater resources and the presence of a large number of landfills in the state, the state of Selangor was chosen for the study which was carried out in 2009. The study was carried out to assess and evaluate the extent of pollution of groundwater as well as

[1]National Hydraulic Research Institute of Malaysia, Lot 5377, Jalan Putra Permai, 43300 Seri Kembangan, Selangor
*Corresponding author (e-mail: saim@nahrim.gov.my)

surface water at landfills and to select the most critical sites especially in terms of water quality which would require immediate attention for remedial measures to be taken. The three main objectives of the study were:

a. To carry out desktop study on the environmental status of operational and closed landfills (rehabilitated or abandoned);
b. To assess the impact of leachate into the surface and groundwater systems; and
c. To recommend remedial measures for the protection of surface and groundwater systems.

OVERVIEW OF THE LANDFILLS

There were 20 landfill sites in the state, seven of which were still operating and 13 were closed. Most of the landfills could be classified as *Level 0* or *1*. The engineered landfills (*Level 4*) were very few but one more was scheduled to be built in Tanjung Dua Belas, Banting. Figure 1 shows the location of all the landfills in Selangor.

The landfills were either sited on alluvial deposits comprising of unconsolidated coarse grain sand, clays and peat, metasedimentary deposits of Devonian to Carboniferous age (300–400 million years old) or granitic rocks of Triassic age (200–250 million years old). The alluvial deposits were regarded as one of the promising aquifers in Selangor.

The landfills were located in five major river basins: Sg. Selangor (7); Sg. Klang (5); Sg. Langat (6); Sg. Bernam (1) and Sg. Buloh (1). None were located in the Tengi River Basin. Most of the landfills were sited very close (<100 m) to rivers or streams.

Most of the landfills in Selangor were built and being operated without proper monitoring facilities and pollution controls such as liner materials, groundwater monitoring wells, leachate collection and treatment ponds, and methane gas ventilation pipes. They were not subject to the requirements of Environmental Impact Assessment (EIA) because they were built prior to 1989 when the EIA requirement was enacted (Department of Environment 1997). They were not properly managed, resulting in the leachate produced by the landfill being allowed to seep into the ground (no liner materials) as well as flow into the nearby drainage or river (Figure 2) without any treatment. Only 25% were equipped with monitoring wells to monitor groundwater quality.

MATERIALS AND METHODS

Information regarding landfill sites such as construction details, operational status, geological characteristics and water quality were obtained from reports, technical papers, manuals, guidelines and research theses from various government agencies, universities and private organisations (Noraini 2003; Agamuthu 2001; Mohd. Nazan 1994; Bahaa-elDin *et al*. 2003; JICA 2001; Omar *et al*. 1999; Wan Zuhairi 2000; Bahaa-elDin *et al.* 2008; Abdul Rahim S. *et al.* 2006, 2008; Bahaa-elDin 2005; Nasiman and Mohd Nazan 1997; Ahmad Fariz M. *et al*. 2009; Universiti Malaya 2007); the data sources concerning landfill operations in Malaysia included Agamuthu & Fauziah (2011), Choong (2001), Consumers' Association of Penang (2001), Department of Environment (2004), Fauziah and Agamuthu (2005) and Norlailatul, Z. *et al*. (2005). Site reconnaissance was carried out from February to August 2009 to verify and update the existing information and data. During the field investigations, landfill inventories (basic information, environmental impact conditions and landfill utilisation after closure) and sampling of surface water, groundwater and leachate were carried out within the vicinity of selected landfills, depending on availability of facilities. A number of landfills were not equipped with monitoring wells and as a result groundwater samples could not be collected from these sites.

The sampling technique, sample preservation and analytical procedures followed the standard methods recommended (APHA 1995, APHA 2005). Data on the composition of leachate was important to determine its potential impact on the quality of nearby surface water and groundwater. This leachate often contained a high concentration of organic matter and inorganic ions including heavy metals (Chian & DeWalle 1976). In carrying out the landfill inventories, questionnaires were also distributed to 11 local authorities to collect information on the current condition of landfills, environmental impact conditions, land utilisation after closure including landfill closure and monitoring. Interviews with 10 residents living relatively near the landfills were also conducted. In-situ analysis for dissolved oxygen (DO), pH, temperature, salinity and conductivity using YSI multi-parameters to evaluate the current status of water and leachate quality was performed. Heavy metals were analysed using Inductively Coupled Plasma Mass Spectrophotometry (ICPMS) at Universiti Kebangsaan Malaysia. Ammoniacal nitrogen (NH3-N), phosphate, nitrate and sulphate were analysed using a portable spectrophotometry model HACH DR 2800.

Out of 20 landfills, only five sites (Kelana Jaya, Air Hitam, Ampar Tenang, Jeram and Bukit Tagar) were equipped with groundwater monitoring wells and hence sampling activities for groundwater were done only at these landfill sites. Surface water from the nearby streams/rivers and leachate was also collected for chemical analysis to determine the effect of leachate on water resources. Due to limited funding, samples were collected only once. Table 2 shows the quality of leachate, the effect of landfill (leachate) on the groundwater and the surface water quality from those five landfills. Results from the chemical analysis

Table 1. List and status of landfills in Selangor (modified from NAHRIM 2009).

Local authorities*	Site name	Locations	Level	Status	Landfill liner	Distance to river/ stream (m)	Location of water intake
MB Shah Alam	MPSA	3°1'39.40"N; 101°33'3.64"E	0	Closed (waste removed)	Natural clay	10	Downstream
MP Ampang Jaya	Hulu Langat	3° 7'58.87"N; 101°48'20.68"E	0	Closed	None	20	Upstream
MP Kajang	Sg Kembong	2°53'15.49"N; 101°49'34.99"E	0	Closed	None	5 downstream	Upstream and
MP Klang	Teluk Kapas	3°02'47.27"N; 101°23'33.70"E	I	Closed	None	20	None
MB Petaling Jaya	Kelana Jaya	3° 6'34.26"N; 101°35'29.96"E	0	Closed & developed	Natural clay	20	None
MP Selayang	Kundang	3°18'43.91"N; 101°30'24.48"E	0	Closed	None	10	None
MP Subang Jaya	Air Hitam Sanitary Landfill	3°00'07.44"N; 101°39'46.22"E	IV	Closed (post-closure)	Various	5	None
MP Sepang	Ampar Tenang	2°49'07.69"N; 101°40'47.68"E	I	Operating	None	25	Downstream
MD Hulu Selangor	Sg Sabai	3°36'21.00"N; 101°32'25.80"E	0	Operating	None	2 km	None
MD Hulu Selangor	Bukit Beruntung	3°25'32.14"N; 101°32'56.6"E	0	Operating	None	5	None
MD Hulu Selangor	Hulu Yam Bharu	3°25'48.70"N; 101°39'14.71"E	0	Closed	None	No river nearby	None
MD Hulu Selangor	Kalumpang	3°34'07.08"N; 101°34'20.60"E	0	Closed (waste removed)	Not known	No river nearby	None
MD Selayang	Seri Gombak	3°15'07.72"N; 101°42'26.08"E	0	Closed	None	No river nearby	None
MD Kuala Langat	Tanjung Sepat	2°40'23.41"N; 101°31'33.91"E	0	Closed	Not known	No river nearby	None
MD Kuala Langat	Sg Sedu	2°50'38.77"N; 101°30'59.63"E	I	Operating	Natural clay	20	None
MD Kuala Selangor	Kubang Badak/ Kg. Hang Tuah	3°22'59.59"N; 101°24'52.38"E	II	Closed (post closure)	Natural clay	20	None
MD Kuala Selangor	Jeram	3°11'27.63"N; 101°22'02.54"E	IV	Operating	Various	70	None
MD Sabak Bernam	Panchang Bedena	3°41'26.36"N; 100°57'50.06"E	I	Operating	Natural clay	>1 km	None
MD Hulu Selangor	Bukit Tagar	3°29'46.64"N; 101°28'50.35"E	IV	Operating	Various	100	Downstream
MD Kuala Langat	Banting	2°48'24.98"N; 101°30'10.19"E	I	Closed	Natural clay	20	None

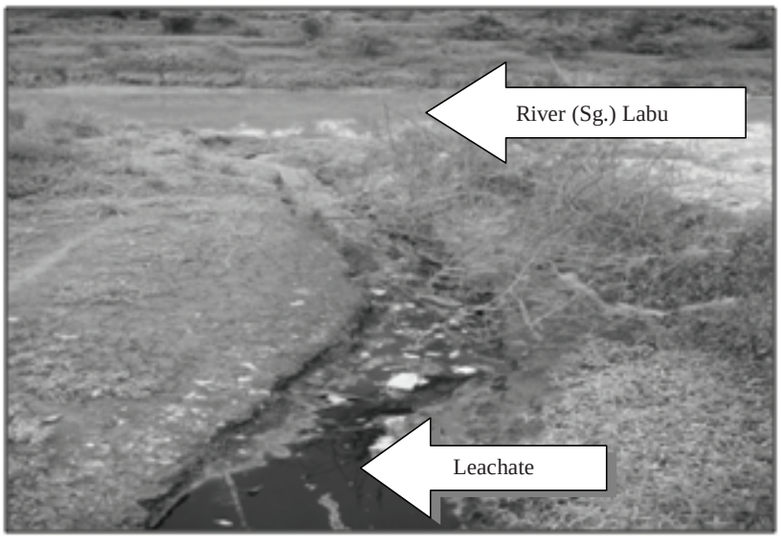
* MD=Majlis Daerah (District Council), MP=Majlis Perbandaran (Town Council), MB=Majlis Bandaraya (City Council)

Table 2. Leachate quality and effect of landfill (leachate) on the groundwater and surface water quality from selected landfill (equipped with groundwater monitoring wells) in Selangor (after NAHRIM 2009).

Landfills	Groundwater	Surface water	Leachate
Kelana Jaya	Slightly contaminated. Cr, Ba, Pb, Fe, As and Hg are slightly higher than the standard.	Class III Coliform exceeds the INWQS Class III limit.	Most parameters are less than the Effluents of Standard B except for BOD, COD and TSS.
Air Hitam	Slightly contaminated. Nitrate, Cr, Cd, Pb, Fe and Se are slightly higher than the standard.	BOD, COD, TSS, Sulphide, Cd, Cr, Pb, Fe, oil and grease are higher than the Effluents of Standard B.	BOD, COD, TSS, Sulphide, Cd, Cr, Pb, Fe, oil and grease are higher than the Effluents of Standard B.
Ampar Tenang	Contaminated. TDS, nitrate, Cr, Cd, Pb, Fe and Se exceeded the standard.	Contaminated (Class III). Increase in BOD, nitrate, As, Mn, Pb, Fe, Cu and Zn.	Most parameters are less than the Effluents of Standard B except for BOD, COD, As, Cr, Fe and Zn.
Jeram	Very slightly contaminated. BOD, COD, Fe, Pb, Cr, Zn, Hg and Ba are above background data.	Not available	Not available
Bukit Tagar	Not contaminated. All parameters below the standard except Fe (natural condition).	Class III	Not available

Location map of Selangor

Figure 1. Operational status of identified landfill sites in Selangor (data from NAHRIM 2009).



(Courtesy of Anuar 2009)

Figure 2. Leachate from Ampar Tenang landfill flows directly to River (Sg.) Labu.

of groundwater, surface water and leachate quality were analysed and evaluated by comparing them using [Leachate] - Effluent Quality (Sewage and Industrial Effluents) Regulations, 1979 in *Environmental Quality Act, 1974*; [Surface water] - Interim National Water Quality Standards for Malaysia (INWQS), (Department of Environment 1995a); and [Groundwater] – Guidelines for Raw Drinking Water Quality Benchmark for Groundwater Quality (Ministry of Health 2000) and Malaysian Environmental Impact Assessment Guidelines for Groundwater and/or Surface Water Supply Project (Department of Environment 1995b). The INWQS was developed by the Department of Environment and it classified inland water quality into 5 classes: domestic water supply, fisheries and aquaculture, irrigation, livestock, and recreation; each with its own set of biological, chemical and physical parameters. Chemical analysis results from Jeram (analytical reports for June and July 2006 obtained from Institute Biological Sciences, Science Faculty, University of Malaya) and Bukit Tagar landfills (KUB-Berjaya Enviro Sdn. Bhd. 2007; 2008) were referred to standard and background data obtained from EIA reports of these landfills (*Kerajaan Negeri Selangor* 2007 and *Perunding Utama* 2004).

RESULTS

The results from chemical analysis showed that the leachate from Kelana Jaya, Air Hitam and Ampar Tenang exceeded the parameter limits for Standard B of Effluent Quality (Sewage and Industrial Effluents) Regulations, 1979 in the *Environmental Quality Act, 1974*. Groundwater quality from selected landfills equipped with monitoring wells indicated chemical oxygen demand (COD), biological oxygen demand (BOD), total dissolved solids (TDS), Cd, Cr, Cu, Pb, Fe, As and Hg slightly exceeded the standards for the raw drinking water quality benchmark for groundwater quality and background data except for the Bukit Tagar landfill. Data of surface water quality for samples taken from streams/rivers adjacent to the landfill sites showed that certain parameters were higher than those of the standards and were thus classified as polluted according to INWQS except for the Bukit Tagar landfill which had a proper leachate drainage system and gas extraction facilities.

DISCUSSION

Groundwater quality from groundwater monitoring wells of the five landfill sites showed that the values for various parameters were higher than that of standard values. This indicated that the groundwater within and surrounding the landfills was contaminated by the leachate. More than 70% of the landfills were located within 100 m from the stream/river. The water quality of the rivers adjacent to the landfill sites was slightly polluted and classified under Class III of INWQS classification. The leachate quality from most of the landfills exceeded Standard B of Effluents Limits by the DOE.

Clean-up measures were recommended to prevent further movement of contaminant into the groundwater and surface water systems as well as to ensure environmental sustainability. Action such as waste removal, construction

of containment walls and pumping of contaminated groundwater might need to be considered. It was also recommended that specific guidelines and standards to address issues related to landfill be established. Several landfill sites such as Sg. Kembong, Ampar Tenang, Sg. Sedu, and Bukit Beruntung were recommended for safe closure since they had surpassed the operation capacity. The Sg. Kembong, Ampar Tenang, Sg. Sedu landfills were also located in areas with high groundwater development potential. Further study on the closed Kelana Jaya landfill was required in order to determine the extent of risk to human health posed by the landfill to know the degree of contamination as the site was already developed into a residential area.

Date of submission: May 2011
Date of acceptance: December 2011

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ASM Sci. J., **5(2)**, 109–114

Effect of Nickel and Platinum Addition on the Thixotopic Behaviour of Lead-free Solder Paste

R. Durairaj*[1], K.C. Leong[1], L. Chia Wea[1] and M.C. Wong[1]

Lead-free solder paste printing processes account for the majority of assembly defects in the electronic manufacturing industry. In the stencil printing process, the solder paste must be able to withstand low and high shear rates which result in continuous structural breakdown and build-up. This study investigated the effect of the addition of nickel and platinum powders to the thixotropic behaviour of lead-free Sn/Ag/Cu solder pastes using the structural kinetic model. A hysteresis loop test and constant shear test were utilized to investigate the thixotropic behaviour of the pastes using parallel plate rheometry at 25ºC. In this study, the shear rates were increased from 0.01 s^{-1} to 10 s^{-1} and the second curve was a result of decreasing the shear rate from 10 s^{-1} to 0.01 s^{-1}. For the constant shear test, the samples were subjected to five different shear rates of 0.01s^{-1}, 0.1s^{-1}, 1s^{-1}, 10s^{-1} and 100s^{-1}. The constant shear rate test was designed to study the structural breakdown and build-up of the paste materials. From this investigation, the hysteresis loop test was shown to be an effective test method to differentiate the extent of structural recovery in the solder pastes. All the pastes showed a high degree of shear thinning behaviour with time. This might be due to the agglomeration of particles in the flux that prohibited paste flow under low shear rate. The action of high shear rate would break the agglomerates into smaller pieces which facilitated the flow of pastes, thus viscosity was reduced at high shear rate.

Key words: Rheology; lead-free; solder paste; thixotropic; hysteresis loop; mechanical properties; shear rates;

Environmentally conscious manufacturing is becoming a very important objective for the electronics industry. It is highly desirable to minimize the environmental impact of electronic manufacturing processes. The electronics industry is being forced to eliminate lead from products, due to the undeniable evidence of lead toxicity. Strict legislation to ban the use of lead-based solders was an inevitable driving force for the development of lead-free solder alloys. Therefore, lead-free solder pastes are perceived as interconnection material for electronic packaging for the next generation (Ifran & Kumar 2008). These lead-free solders are mostly based on Sn-containing binary and ternary alloys. Among them, the Sn–Ag system is one of the earliest commercially available lead-free solders and it has been recommended for general-purpose use as substitutes for Sn–Pb eutectic solder.

The assembly of these devices requires the printing of very small paste deposits consistently from pad to pad, and from board to board. The paste printing process is the paramount process in the electronic manufacturing industry and it does account for some 60% of assembly defects (Mangin 1991), and it is estimated that up to 87% of the reflow soldering defects are caused by stencil printing defects (Okuru *et al*. 1993). As shown in Figure 1, the key sub-processes in the solder paste printing process include the paste roll in front of the squeegee, the aperture filling and aperture emptying stages. During stencil printing, the paste develops a rolling action in front of the squeegee, filling the apertures in the stencil some distance ahead of the squeegee. The squeegee then shears off the paste in the apertures as it moves over the stencil. It is known that during the printing process, the squeegee generates hydrodynamic pressures in the paste roll that injects the paste into the apertures. Once the print stroke is completed, the board is separated mechanically from the stencil. Separation of stencil and printed circuit board (PCB) or substrate occurs after the squeegee move across the stencil and the substrate is then separated mechanically from the stencil.

The paste printing process is known to be controlled by a number of process parameters which can be divided into four groups: printer; stencil; environmental and paste parameters (Haslehurst & Ekere 1996). Some of these parameters are fixed (e.g. stencil) while the paste properties such as viscosity are constantly changing during the print cycle. The key physical sub-processes include: (i) paste pre-print treatment; (ii) squeegee deformation; (iii) paste

[1]Department of Mechanical and Material Engineering,Faculty of Engineering and Science, Universiti Tunku Abdul Rahman, Jalan Genting Kelang, Setapak 53300 Kuala Lumpur, Malaysia

*Corresponding author (e-mail: rajkumar@utar.edu.my)

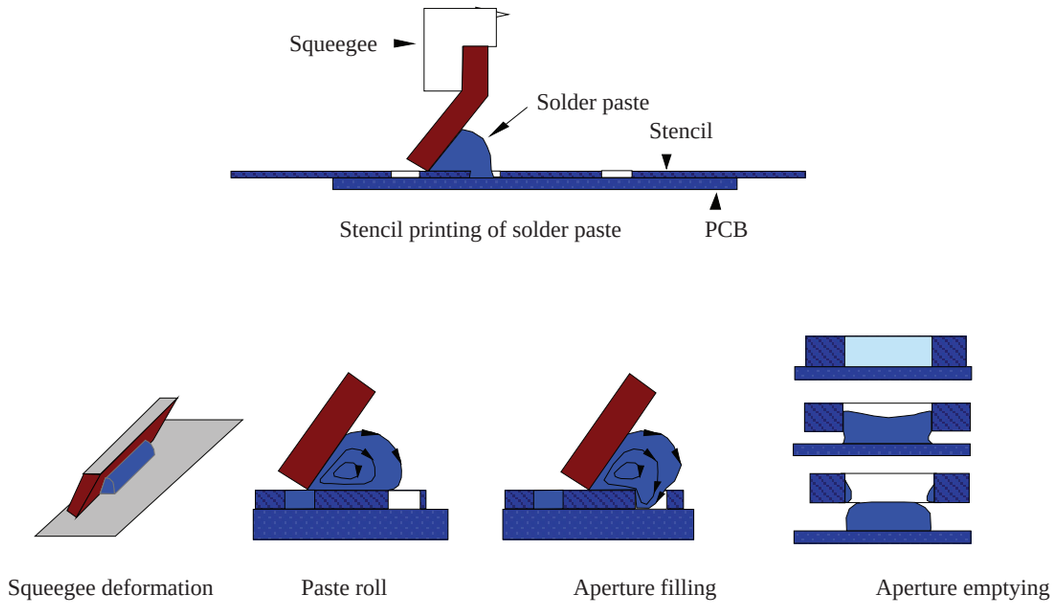

Figure 1. Sub-processes in paste printing (Durairaj *et al.* 2009).

roll (Ekere & He, 1996); (iv) aperture filling (Ekere *et al.* 1994); (v) aperture emptying (Mannan *et al.* 1994a & 1994b) and (vi) past slump. These sub-processes are linked together by the properties of the pastes such as their flow history and its rheology. The pressure in the paste during and after aperture filling helps determine whether the paste will adhere onto the substrate, stencil or squeegee after aperture emptying.

Characterising the degree of thixotropy in pastes such as solder pastes and isotropic conductive adhesives is an important step in understanding the rheological behaviour of the material during stencil printing. The thixotropic effect is a result of aggregation of suspended particles and the aggregation in the system is caused by attractive forces such as van der Waals and repulsive forces due to the steric and electrostatic effect on the particles. The repulsive force prevents the particles from approaching close to one another, and as a result, the particles are held together by weak physical bonds. When no force is exerted on the suspension, the particle aggregation can form a spatial network which creates an internal structure. When the suspension is sheared, these weak forces are broken, causing the network to break down into smaller aggregates. These aggregates can be broken down further into smaller flocs.

In this research work, a composite solder using nickel and platinum particles reinforcement, prepared by mechanically dispersing Ni and Pt particles into eutectic Sn/Ag/Cu solder paste, was developed and it showed improved mechanical properties over the Sn/Ag/Cu. The study investigated the effect of the addition of nickel and platinum on the thixotropic behaviour of lead-free Sn/Ag/Cu solder pastes.

MATERIALS AND METHODS

Apparatus

A controlled stress rheometer (Model: Physica MCR 301) with a parallel plate geometry with a diameter of 25 mm and gap of 1.0 mm was used as a measuring device. Prior to loading a sample onto the rheometer, the solder pastes were hand mixed with a plastic spatula for about 1 min to 2 min and left for half an hour after the stirring. A sample was loaded on the bottom plate and the top plate was then lowered to the desired gap height of 1.0 mm, squeezing the extra paste out from between the plates. The excess paste at the plate edges was neatly trimmed with a plastic spatula. The sample was then allowed to rest for about 1 min before the start of the test. Identical loading procedures were followed for all the tests. All tests were conducted at 25ºC with the temperature being controlled by a Peltier-Plate system.

Material and Sample Preparations

The solder pastes used for this investigation are shown in Table 1. The nickel and platinum powder content was the only variable parameter. The particle size distribution was 20 µm – 25 µm. These samples (P1, P2 and P3) were stored in the fridge at 4ºC, while the room temperature (which

Table 1. Constituents of lead free solder pastes investigated.

Paste samples	Particle size distribution (μm)	Particle shape	Flux medium	Solder alloys/materials	Platinum powder	Nickel powder
P1	20–45	Spherical	Rosin mildly activated (RMA)	96.5% Tin/3% silver/0.5% copper	0.2%	1.8%
P2	20–45	Spherical	RMA	96.5% Tin/3% silver/0.5% copper	0.4%	3.6%
P3	20–45	Spherical	RMA	96.5% Tin/3% silver/0.5% copper	0.6%	5.4%

could not be controlled) was monitored to average 24ºC and 35% humidity. Before each rheological measurement, the samples were taken out and left about 8 h to reach room temperature.

Experimental Test Method

Hysteresis loop test. Thixotropic behaviour can be studied through the hysteresis loop test, also known as the thixotropic loop. In the hysteresis loop test, the shear rate is ramped up to a maximum shear rate, γm and then reversed back to the first (original) shear rate. In the present study, the shear rates were increased from 0.01 s^{-1} to 10 s^{-1} (step-up) and the second curve was a result of decreasing the shear rate 10 s^{-1} to 0.01 s^{-1} (step-down).

Constant shear rate test. The constant shear rate test was used to investigate the paste sample's dependency on time. For a given constant shear rate, the viscosity of the paste sample decreased over time, ultimately reaching a steady value. In the study, the sample was subjected to a constant shear rate of 0.1 s^{-1} for a period of 120 seconds.

RESULTS AND DISCUSSION

Hysteresis Loop

Figure 2 shows the hysteresis loop for all three paste samples. The samples were constantly subjected to a high shear rate, 10 sec^{-1} with time and linearly recovered to their initial shear rate, 0.01 sec^{-1}. The overall time interval was 240 s. The effect of increasing shear rate on the viscosity of the paste samples was investigated. The up-curve resulted from the linear increase of shear rate with time, while the down-curve was due to the linear decrease of shear rate with time. The drop in viscosity for all three samples clearly indicated that the pastes were shear thinning in nature and the structure of the pastes were undergoing changes due to destruction of flocculation in the suspensions (Durairaj *et al*. 2009). All three samples showed a hysteresis area, where an area between the up- and down-curve was observed. The presence of a hysteresis area indicated that the samples showed time dependent rheological behaviour. Therefore, all the three samples studied were thixotropic suspensions. The enclosed area within the curves indicated the extent of the structural breakdown in the sample for the applied shear.

As expected, the viscosity of the pastes dropped with increasing shear rate which indicated the shear thinning behaviour of the pastes. The pastes exhibited thixotropic behavior as the presence of a hysteresis area between the step-up curve (0.01 s^{-1} to 10 s^{-1}) and step-down curve (10 s^{-1} to 0.01 s^{-1}). The region between the up curve and down curve in the hysteresis curve is an indication of the thixotropic behaviour of the pastes. Based on the area between the two curves, the smaller the area between two curves meant that the recovery was better for the sample. Sample P3 showed the largest structural breakdown followed by samples P2 and P1 (Figure 2). Samples P2 and P1 seemed to show good recovery after the gradual drop in shear rates. In addition, the recovery (%) between the step-up (breakdown) and step-down (build-up) was measured using the equation:

$$\text{Recovery (\%)} = \{[\text{viscosity (step-up)} - \text{structural recover}] / [\text{viscosity (step-down)} - \text{structural breakdown}]\} \times 100.$$

The calculated recovery was 55.3%, 49.8% and 48.3% for samples P1, P2 and P3 respectively, as shown in Figure 3. From the results, it was clear that sample P1 showed good recovery compared to P2 and P3. Sample P1 had the lowest percentage of particles added to the solder paste, followed by P2 and P3. It might indicate that the P3 had a higher content of nickel and platinum particles compared to the others; the particles had larger specific surface area which might lead to particle-particle interactions which were relatively weak and broken down at high shear rate. The rheology of solder pastes was dominated by the solid volume fraction and the particle size distribution of particle addition. Based on the results, P1 showed good recovery.

Constant Shear

In the constant shear rate experiment, when we applied a constant shear rate for a period of 120 s to the samples, it showed that the viscosity of the paste gradually increased

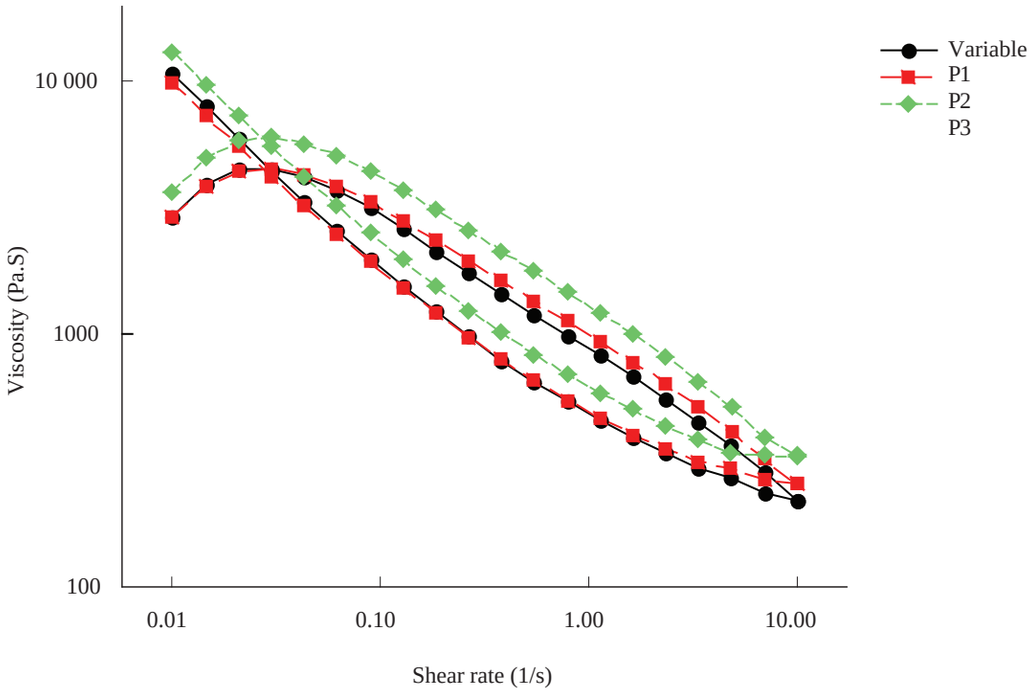

Figure 2. Thixotropic flow curves for sample P1, P2 and P3.

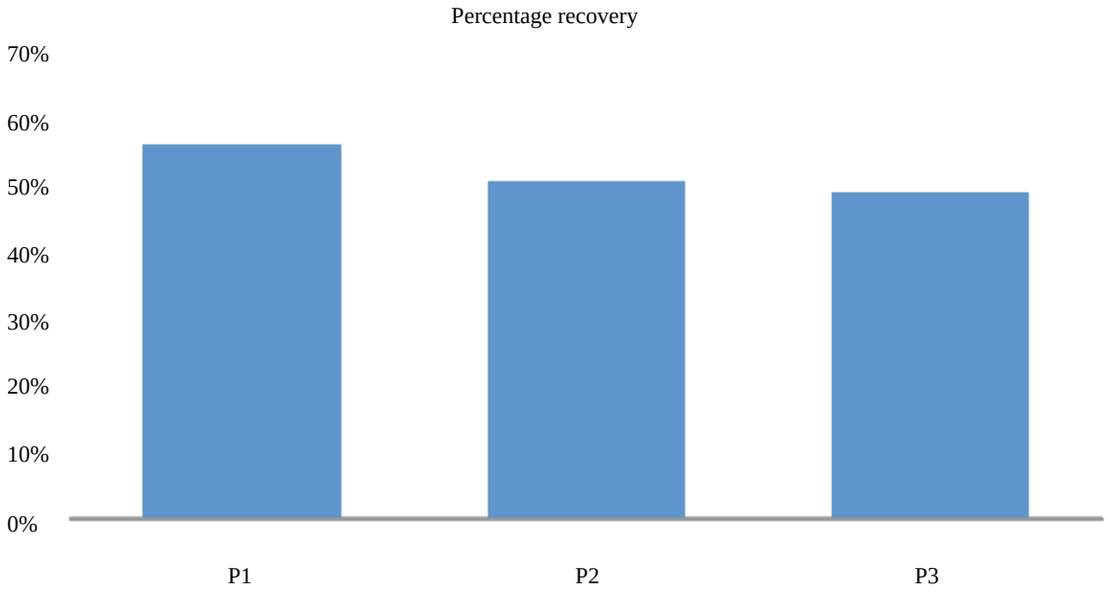

Figure 3. Recovery rate.

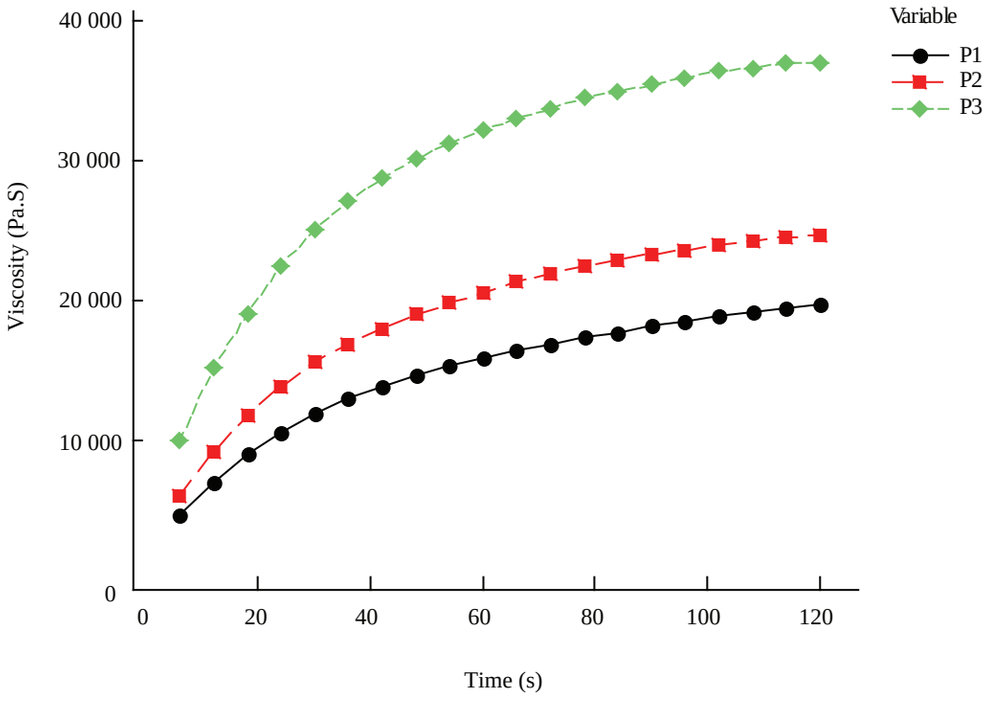

Figure 4. Constant shear rate at 0.1 s^{-1}.

with time. When the sample was sheared, the viscosity rose steeply in the first 50 s; after this period, the paste viscosity continued to increase. The sharp rise in viscosity could be due to the paste resisting flow due to the presence of strong flocculation within the suspension. The strong flocculation is common in concentrated suspensions due to closely packed structure (Nguty & Ekere 2000). As the shear rate was increased in one order of a magnitude, the viscosity reached a steady state after the period of 30 s as shown in Figure 4. When the samples were sheared at 0.1 s^{-1}, P3 had the highest viscosity, followed by P2 and P1. It might be due to sample P3 having the highest content of nickel and platinum particles added in the paste sample; this could cause the paste to be tacky. It might be due to the concentration of the composites, particle-particle interactions resulting in a higher degree of filler agglomeration (Ifran & Kumar 2008).

CONCLUSION

In this study, the effect of adding nickel and platinum to lead-free solder paste was investigated. The presence of an area between the down curve and up curve showed that the paste materials were thixotropic in nature. The results seemed to indicate that as the content of nickel and platinum particles increased in the solder paste, the pastes exhibited a higher degree of structural breakdown. The introduction of nickel and platinum particles in the solder pastes caused the paste rheology to change due to the relatively weak interaction between nickel and platinum particles with the tin/silver/copper-based solder pastes. This study emphasized the importance of thixotropic behaviour in the stencil printing process and that the viscosity of solder paste should be low enough to be forced out from the squeegee yet high enough to be reshaped. The structural breakdown and recovery of the pastes was an important parameter that could be used for the development of new formulations for solder pastes and isotropic conductive adhesives.

ACKNOWLEDGEMENT

The authors wish to thank the UTAR Research Fund for financial support of this work.

Date of submission: May 2011
Date of acceptance: February 2012

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ASM Sci. J., **5(2)**, 115–121

Cortical Spreading Depression during Repeated Stimulation — a Magnetoencephalographic Study

T. Begum[1]*, F. Reza[1] and J.M. Abdullah[1]

Reflex epilepsy is usually induced by external stimulation, photosensitive epilepsy being the most common. Epilepsy induced by auditory stimulation is rarely studied. There are no currently published magnetoencephalographic (MEG) studies demonstrating the initiation of epileptic neuronal discharges by repeated auditory stimulations in temporal lobe epilepsy (TLE) patients. We retrospectively studied one TLE patient who underwent a MEG study to localize her epileptic focus. Auditory, somatosensory, visual and motor evoked potential studies were performed during the MEG recording. A single dipole method calculated equivalent current dipoles to localize the epileptic source. The least-squares minimization method was used to obtain the optimal solution with goodness-of-fit of greater than 80%. Periodic lateralized epileptiform discharges (PLEDs) were recorded in the temporal region when repeated auditory stimulations were done. We postulated that neuronal cortical suppression occurred during repeated stimulations which provoked epileptiform discharges (PLEDs) without any physical symptoms or aura. It was concluded that repeated stimulations could facilitate epileptiform discharges in focal area/areas in certain subjects.

Key words: epilepsy; auditory stimulation; neuronal discharges; somatosensory; motor; epileptiform discharges

Epilepsy is a disorder of the central nervous system characterized by recurrent seizures unprovoked by an acute systemic or neurologic insult. Epilepsy is characterized by a variety of clinical manifestations that reflect a temporary neural dysfunction — abnormal and excessive electric discharges (Bromfield et al., 2006). There are numerous causes of this disorder including prenatal and post-natal infections, traumatic brain injury, parasitic infestations, intoxication, strokes; often the causes are genetic or might even be unknown (Organização Mundial Da Saúde *et al*. 1994). Temporal lobe epilepsy (TLE) is the most common form of epilepsy, and it is often difficult to control, though TLE is not particularly medication resistant.

A seizure trigger is a factor that can cause an epileptic seizure in a person who either has epilepsy or not. There are many known causes of seizures, and in some patients, it is possible to determine the seizure triggers in general or which had led to the onset of a particular seizure. Several researchers have reported that language-related activities such as reading, writing and speech can trigger of seizures (Geschwind *et al.* 1967; Lee *et al*. 1980). Reflex epilepsy is a condition in which seizures can be provoked habitually by an external stimulus or less commonly by internal mental processes, also called environmental epilepsy. Individuals with reflex epilepsy may have seizures exclusively in response to specific stimuli and not suffer spontaneous seizures; alternatively, reflex seizures may coexist with spontaneously occurring seizures. Triggers of reflex seizures include the visual inducement, somatosensory stimulation, auditory stimulation, movement/motor action, complex actions and mental processes. Reflex seizures triggered by auditory stimulation occur in audiogenic epilepsy (AE), which is uncommon. The data, describing the seizure pattern in rats, selected for audiogenic epilepsy, were first published in Russia in 1949 in the *Advances of Contemporary Biology* (vol. 28, pp. 108–133). The data on increased sound sensitivity in audiogenic rats and mice have been known for a long time (Ross *et al*. 2000, Semiokhina *et al*. 2006). However the anomaly in the 'sensory part' of acoustic impulses in the brain pathway, promoting the acoustic seizures, fit/s is/are not the single prerequisite/s for AE development. The abnormal biochemical and physiological status of central auditory (and other) cerebral structures is also an important issue (Garcia-Cairasco *et al.* 2002). Although there are extensive studies and research on experimental animals, there have been no studies on the human brain pertaining to localization of epileptiform discharges after repeated auditory stimulations in TLE patients.

[1]Department of Neurosciences, School of Medical Sciences, University Science Malaysia, 16150 Kubang Kerian, Kota Bharu, Kelantan, Malaysia.

*Correspondence (e-mail: tahaminabegum70@hotmail.com, tahamina@kk.usm.my)

Several methods have been developed for the detection of source localization of epileptic foci in epilepsy. Though MEG/ECoG is not a very common way of recording spikes for the epileptic patients, this procedure had been used for the epileptic foci detection (Mikuni *et al.* 1997). MEG and EEG simultaneous recordings (Yoshinaga *et al.* 2002) are also used for the precise diagnosis of epileptic foci. MEG is particularly useful for studying epileptic disorders, as it provides better spatial and temporal resolution than electroencephalography (EEG) for the localization of pathological brain activity or lesions. MEG and scalp EEG has different sensitivities to epileptic discharges even when they are simultaneously recorded (Stufflebeam *et al.* 2009). Most interictal spikes can be identified on both scalp EEG and MEG in cases of temporal lobe epilepsy but some spikes are visible only on scalp EEG or MEG. Whether MEG has any advantages for spike detection is unclear. Source localization being based upon evoked magnetic responses to repeated stimulation, in accordance with well an established technique for evoked potential. Auditory stimulation is one example of applied stimulation. Previously, we have shown that unifocal PLEDs can localize the ictal onset zone in epilepsy patients as detected by MEG (Begum *et al.* 2011). Retrospective data of one epileptic patient who underwent MEG for epileptic foci detection with repeated auditory, somatosensory, visual and motor stimulation is presented.

METHODS

Patients' History

A 34-year-old woman with a known history of generalized tonic-clonic seizures (GTCSz) since the age of 20 visited our hospital for evaluation of epileptic focus. The patient had a motor vehicle accident (MVA) when she was 19 years old. After MVA, she had loss of consciousness (LOC) for a few minutes. Laceration over left scalp and bleeding in the left ear were found after MVA. After hospitalization blood clots were removed from the left ear. One year after the accident, she began suffering from seizures which consisted of left eye twitching or déjà-vu. This was followed by loss of contact with surroundings continued with GTCSz with loss of consciousness (LOC) at a frequency of 3–4 times per month. The seizures usually lasted for more than 2 min. More recently, she had experienced 5–6 déjà-vu episodes per month, each lasting 10–15 min. The patient had a subjective perception of diminished hearing in her left ear following the MVA. Routine EEGs were done. Continuous scalp video-EEG monitoring was performed for nine days under reduced antiepileptic medication. She had a total of 13 habitual seizures during the nine days of recording. According to video-EEG monitoring, left temporal lobe epilepsy (LTE) was diagnosed. Neurological examination detected no other abnormalities. MEG-EEG recording was done with spontaneous, auditory, somatosensory, visual and motor stimulation.

Data Acquisition

MEG recordings were performed at the MEG and ERP Centre, Department of Neuroscience, Hospital University Sains Malaysia (HUSM). The location and orientation of the MEG coils relative to each subject's head were determined before recording by digitizing fiducial reference points on the head using a magnetic digitizer (Polhemus 3SPACE, Colchester, VT, USA). After digitizing the reference points, the shape of each subject's head under the recording surface of the MEG system was digitized between 3000 and 5000 points for use when constructing a volume conductor model for MEG source localizations. The MEG data were recorded with a VectorView system (Elekta Neuromag, Helsinki, Finland), 306-channel MEG, consisting of 204 planar gradiometers and 102 magnetometers within a hemispherical array in a light Elekta-Neuromag magnetically shielded room. The position of the head relative to the sensor array was monitored continuously by feeding sinusoidal currents (293–321 Hz) into four head-position indicator (HPI) coils attached to the scalp. The simultaneous EEG (Hamäläinen *et al.* 1993) was recorded by using Ag–AgCl electrodes according to the extended International 10–20 system while using the left earlobe electrode as the recording reference. Vertical and horizontal EOG and ECG were also recorded. All data were digitally filtered and sampled at 600 Hz with a low-pass filter of 0.3 Hz–60 Hz in off-line data analysis. MEG recordings were made to biaural presentations of auditory 1000 Hz pure tone. Output sound level was adjusted 50 dB above patients' hearing threshold. Stimuli were delivered via foam insert earphones (E.A.R., Cabot Safety Co., Indianapolis, IN, USA). In total, 150 discrete stimulus trials with a 2 second inter-stimulus interval were delivered. A single dipole method calculated equivalent current dipoles to localize the epileptic source. The least-squares minimization method was used to obtain the optimal solution with goodness-of-fit (GOF) greater than 80%.

RESULTS

Data were reviewed for spike activities. Periodic lateralized epileptiform discharges (PLEDs) were found in the left temporal region which evolved to rhythmic sharp waves during only auditory stimulation during MEG recording (black arrow, upper panel; Figure 1). There were no epileptiform discharges from the right temporal region (middle panel; Figure 1). No epileptiform discharges were found in the simultaneous EEG recording during the same period of study (lower panel; Figure 1). Electroencephalography (ECG) was also recorded with simultaneous EEG to exclude possible ECG artifacts from PLEDs (Figure 1). These PLEDs were located at the mid-

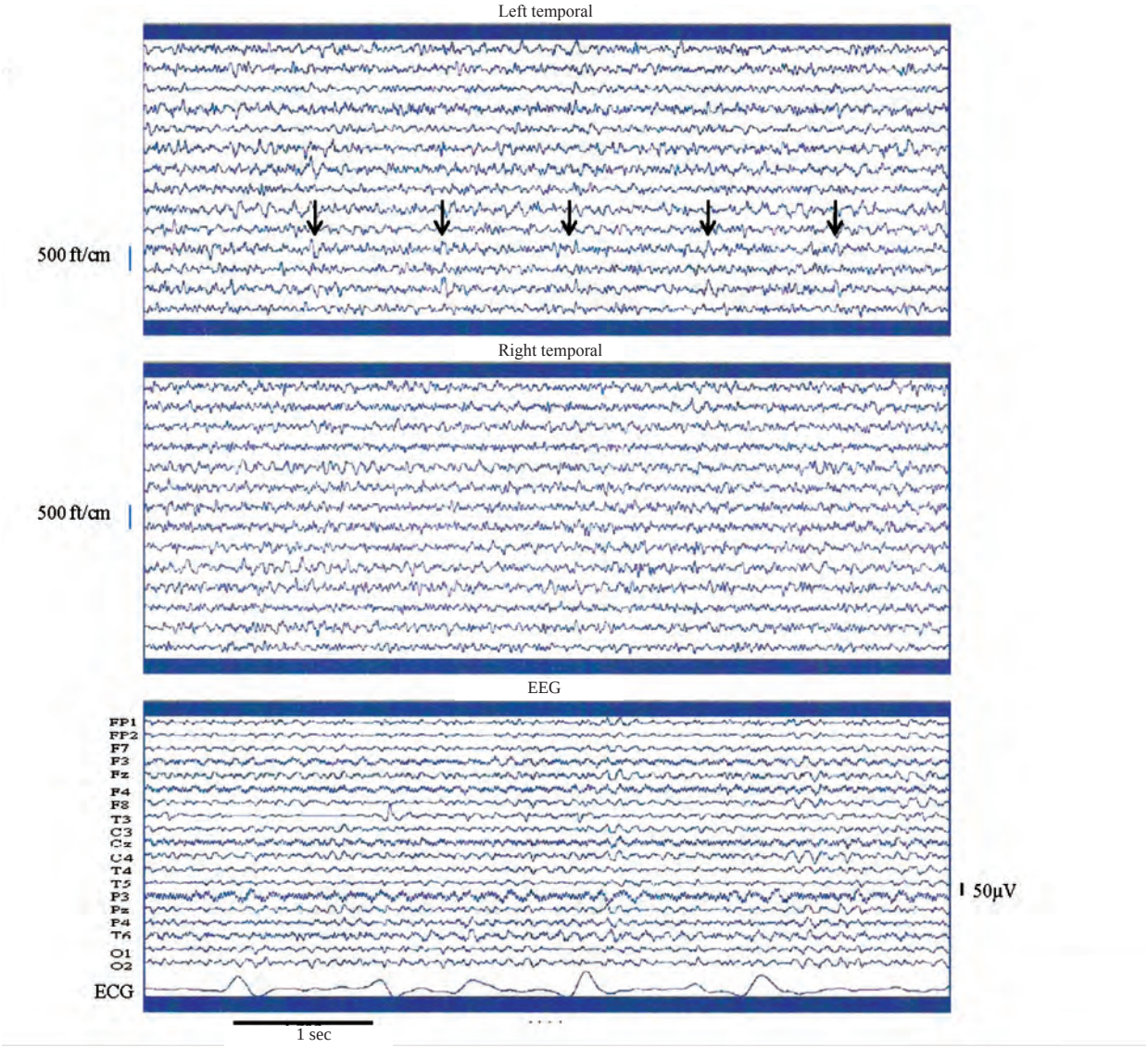

Figure 1. MEG recording during repeated auditory stimulation. Patient was diagnosed with left temporal lobe epilepsy (LTE). Black arrows show auditory evoked 1 Hz PLEDs during MEG recordings at left mid-temporal regions (upper panel). Recordings at the right temporal regions with comparison of left temporal regions (middle panel) are shown. No spikes or epileptiform discharges were recorded during simultaneous EEG recording. ECG did not show any consistency with PLEDs (lower panel).

posterior part of the left temporal region in MEG (Figure 3a); GOF was 98.2%. Equivalent current dipole (ECD) was located at the left temporal region shown by an arrow (Figure 3b). In routine EEGs no interictal spikes were seen. Continuous scalp video-EEG monitoring demonstrated the onset of the seizure from the left mid temporal area/areas (T3/T5) (Figure 2). The location of auditory evoked PLEDs during MEG was retrospectively confirmed from the data of video-EEG monitoring.

DISCUSSION

The present study showed auditory evoked epileptiform discharges (PLEDs) which were localized at the left mid-temporal regions that was consistent with video-EEG monitoring and recorded by MEG.

In this patient, no epileptiform discharges were found in the spontaneous MEG or EEG recording during the auditory evoked potential study. Hyperventilation and intermittent photic stimulation commonly aggravate epileptiform discharges during EEG recording (Aarts *et al.* 1984, Kasteleijn-Nolst *et al.* 1995). Kleiser *et al.* 1995 used methohexital (MHT) anaesthesia to provoke epileptiform activity during their MEG study. Here we found that repeated auditory stimulation could also facilitate epileptiform discharges, in the form of periodic lateralized epileptiform discharges (PLEDs) without any aura.

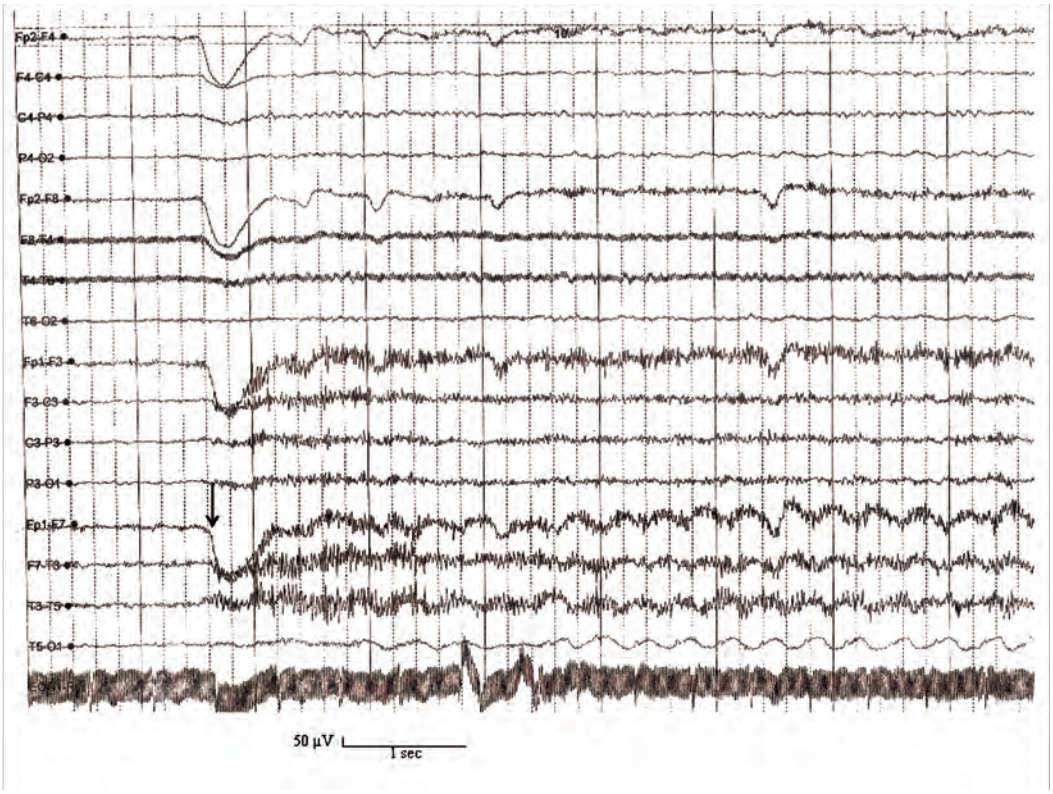

Figure 2. One example of the ictal onset zone, which started from the left mid-temporal regions (T3/T5) was recorded during 9 days of video-EEG monitoring. Ictal onset zone was indicated as a black arrow.

The term PLEDs was first established by Chatrian *et al*. (1964). PLEDs are an electroencephalographic (EEG) phenomenon consisting of high voltage stereotyped periodic transients distributed over one hemisphere, mostly associated with acute or subacute structural brain lesions. The most typical form of PLEDs consist of sharply contoured discharges repeating periodically or quasi-periodically at rates generally close to 1/sec and separated by intervals of apparent quiescence (Chatrian *et al.* 1964). In several studies of audiogenic epilepsy performed on DBA/2J models, cortical EEG has demonstrated the epileptic activity focus (Takao *et al.* 2006). Morphologically the epileptiform discharges were PLEDs (Figure 1: upper panel; black arrow) and their locations were similarly in the epileptic zone (Figure 3a) identified by video-EEG monitoring (Figure 2). We should be careful about possible ECG artifacts when PLEDs occur during MEG recording.

Bellis (1996) described about sound location as a function of biaural interaction, which reflected the way through which the information coming from each ear interacted, in other words, how they were processed together. Alterations in this capability would be justified by an asymmetrical peripheral hearing loss or alterations in the hearing processing that took place in the brain stem (Bellis *et al.* 1996). The temporal lobe is the centre that processes auditory inputs and is primarily involved in speech and vision semantics. Therefore individuals with this disorder experienced a loss in the analysis of their verbal and non-verbal sounds received through hearing, when compared to subjects without cortical alterations (Meneguello *et al.* 2006). In our study, after MVA, the patient's left hearing function decreased (focal epileptic area), where we found PLEDs after repeated auditory stimulation (Figures 1, 3a and 3b). This phenomenon could be explained by the condition of cortical spreading depression (CSD).

Spreading depression (SD) is a slowly propagating wave of cellular depolarization associated with a striking negative potential shift and transient depression of neuronal activity (Leao *et al.* 1944). It is known that sustained depolarization of some critical volume of neuronal tissue is necessary to ignite SD (Bures *et al.* 1974). The mechanism of the wave propagation in CSD remains poorly understood (Martin *et al.* 2000). However direct local stimulation of the cerebral cortex (chemical, mechanical or electrical) is traditionally used to elicit CSD in experimental animals. Vinogradova *et al.* 2009, suggested that sensory-induced brainstem excitation could be a potent trigger of CSD in the hyperexcitable cortex (Vinogradova *et al.* 2009). Cortical SD may be triggered by repeated sound stimulation of rats with innate hypersensitivity to sound (Vinogradova *et al.* 2005, 2006). Thus CSD can occur as a reliable cortical response to repeated acoustic stimulation in the human subject being studied (Figure 4) which was

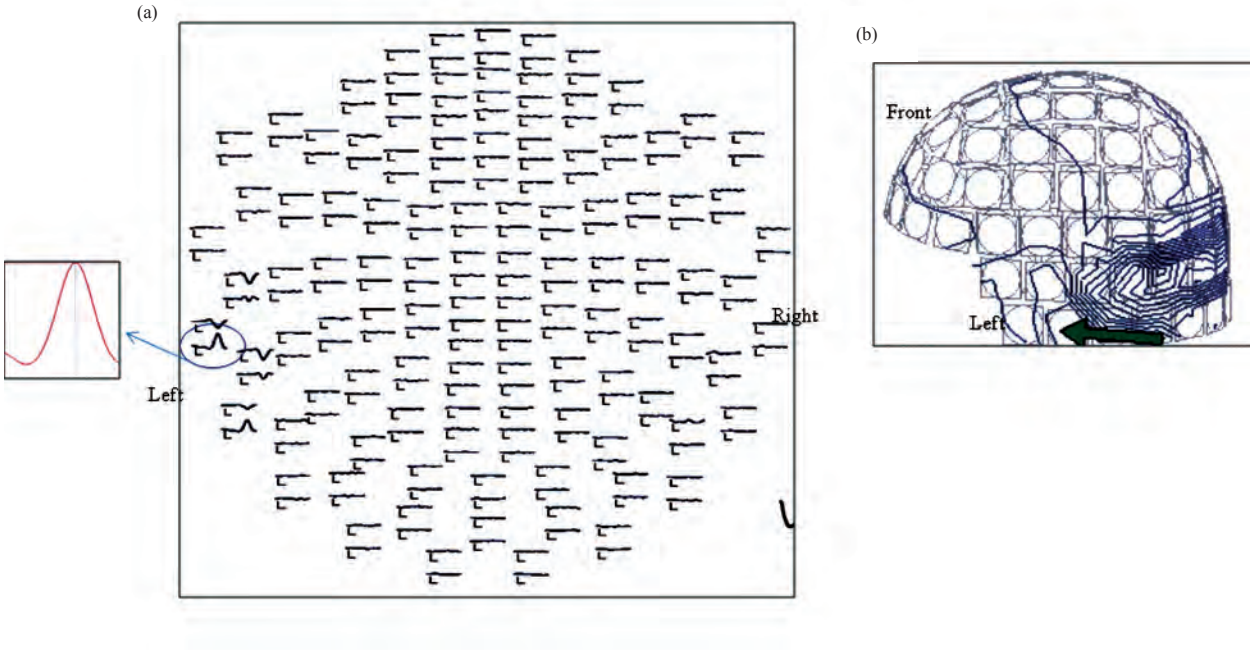

Figure 3. (a) 204-channel gradiometers showed auditory evoked epileptiform discharges at left mid-temporal area. Inset is the enlarged view of circle trace. (b) An equivalent current dipole (ECD) was computed at the peak of the epileptiform discharges (PLEDs) at the left temporal area (the corresponding isocontour map of the MEG data, with the ECD as a green arrow).

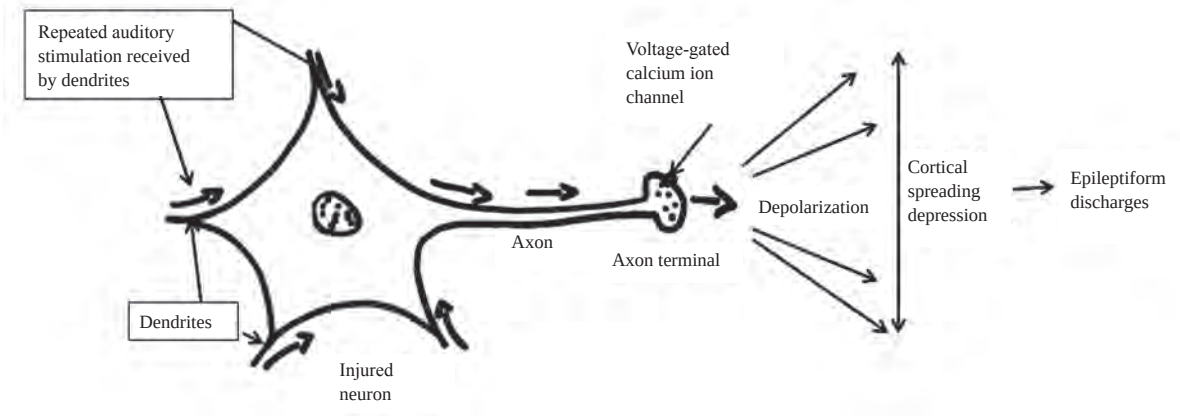

Figure 4. Possible schema of cortical spreading depression (CSD) in case of injured neuron, which can produce depression causing epileptiform discharges after receiving repeated auditory stimulation.

explained previously in awake Wistar and WAG/Rij rats with a hypersensitivity to sound (Vinogradova *et al.* 2009). Figure 4 shows the possible schema of CSD, starting from depolarization of injured neurons. Dendrites of injured neurons received repeated auditory stimulation in our case to make the neurons depolarize and action potentials were generated by special types of voltage-gated ion channels embedded in a cell's plasma membrane (Barnett *et al*. 2007) which transmitted through axon to axon terminals. At the axon terminal, voltage gated calcium ion channels opened that caused an influx of calcium ions from outside to inside of the axon terminal, leading to depolarization of neurons. This depolarization transmitted to postsynaptic neurons and spread to focal areas as depression caused epileptiform discharges.

CONCLUSION

We postulate that epileptiform discharges were induced by repeated auditory stimulation which localized the epileptic zone in certain epilepsy patients mainly TLE patients during

MEG recording. CSD explained the possible mechanism of auditory evoked epileptiform discharges. The localization approach described in this study also offered a new method to detect focal areas in epilepsies.

ACKNOWLEDGMENT

This study was partially presented in poster form at the *Human Brain Mapping Conference*, *2011*. This work was partially supported by the Universiti Sains Malaysia Incentive Grant Scheme for T.B. and F.R. We thank Hazim Omar and Alwani Liyana Ahmed for their technical support. We also thank Prof John Tharakan KJ, Dr Shalini Bhaskar, the clinical staff and fellow researchers from the Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia for their assistance during video-EEG monitoring of the patients.

Date of submission: October 2011
Date of acceptance: February 2012

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Manufacturing Process Variability: A Review

M.A. Djauhari[1]

Almost a half century after it was introduced, Wilks' statistic has come into application in industrial manufacturing process variability monitoring. This is an important breakthrough in the way experts monitor the variability of manufacturing processes which is vital in modern industry. It leaves behind the traditional practice characterized by the use of sample size n which equals 1, if the process variability monitoring is based on individual observations and is greater than the number of variables p if one works with subgroup observations. The use of Wilks' statistic allows us to work with $n < p$. This paper contains a review on process variability monitoring based on individual observations. First, some historical backgrounds of process variability monitoring in the general scheme was reviewed before it was revealed where the philosophy of Wilks' statistic could be further interpreted. Subsequently it was indicated that the way to monitor the process variability depended on how the variability itself was measured. Finally, a new statistic for detecting the shift in variability based on individual observations was introduced and then a new control chart was proposed. The performance of the proposed chart as compared with Wilks chart, was quite promising. Therefore, some recommendations were given to better understand the history of manufacturing process variability.

Key words: Industrial process capability; multivariate normal process; statistical process control; multivariate variability measure; sensitivity analysis

"Reduce the process variability" is the basic philosophy used in any manufacturing industry to improve the quality of the process and products. It is common, in practice, to materialize that philosophy and to visualize the history of process variability by using control charts. This chart is one of the "magnificent seven" tools in all quality improvement initiatives besides histogram, check sheet, cause-and-effect diagram, Pareto chart, scatter plot, and stratification. See, for example, Rooney *et al.* (2009) for further discussion on these tools. All these tools can also be found in any standard book of statistical quality control. Nowadays, among these tools, only control charting becomes a very dynamic research area especially in a multivariate setting. Multivariate process is meant where (i) quality is determined by more than one quality characteristics and (ii) the correlations among those quality characteristics must be taken into consideration.

In manufacturing industries, the quality of the production process is often determined by several quality characteristics, of which some are correlated. In these circumstances, it is not permissable to monitor the characteristics one by one. They must be monitored simultaneously (e.g. Montgomery 2005). In other words, a multivariate analysis approach must be applied.

In multivariate setting, one of the most widely used control charts to monitor those characteristics, taking their correlations into consideration, is one based on Hotelling's T^2 statistic. Mason and Young (2001) state that this statistic is a powerful tool useful in detecting subtle system changes. Another advantage of the T^2 statistic is that it is relatively easy to use. This method is appealing to practitioners because of its similarity to Shewhart type charts (Prins & Mader 1997). Furthermore, for individual observations, Sullivan and Woodall (1996) have mentioned that it is a seemingly reasonable approach and more specifically Mason *et al.* (1995, p. 99) have pointed out that T^2 is the optimal test statistic for detecting a general shift in the process mean vector.

In recent years, multivariate control charting methods focusing on detecting shifts in the mean vector based on the T^2 statistic, have received considerable attention. For example, Wierda (1994), Sullivan and Woodall (1996), Nedumaran and Pignatiello (1999), Woodall and Montgomery (1999), Mason and Young (1999, 2001), and Mason *et al.* (1995, 1996, 1997, 2001, 2003, 2011). On the other hand, multivariate process variability monitoring had received far less attention in the literature. Among those who mentioned the importance of controlling the process

[1]Department of Mathematics, Faculty of Science, Universiti Teknologi Malaysia
*Correspondence (e-mail: maman@utm.my)

variability were Wierda (1994), Mason *et al.* (1997), Woodall and Montgomery (1999), Montgomery (2005), and Djauhari (2005).

Monitoring process variability is an important part of any control procedure. In this regards, Montgomery (2001, p. 532) points out that "just as it is important to monitor the process mean vector, it is also important to monitor process variability". A similar remark is made by Alt and Smith (1988, p. 341). Events that need to take place for a successful implementation of statistical process control include an initial examination of stability and a capability analysis. Once this stage is satisfactorily completed, ongoing monitoring of key process parameters is necessary and one vital parameter is process variability.

There are three scenarios in multivariate process variability monitoring. The first one, is when the monitoring operation is based on subgroup observations characterized by the use of subgroup size n greater than the number of variables p. The second one, is based on individual observations; in this case, $n = 1$. The third scenario is when $1 < n < p$. It was developed very recently by Mason *et al.* (2009). It is important to note that all these scenarios have the same basis. They are developed based on the concept of multivariate variability measure. This phenomenon will be exploited in the rest of the paper.

To make the presentation clear, this paper is organized as follows. Section 2 reviews the three scenarios mentioned earlier. In Section 3, my discussion will be focused on the second scenario followed by a proposed control chart in Section 4. Quite promising results of a sensitivity analysis of the proposed chart, compared with Wilks' chart, is presented in Section 5 and then in Section 6 a new procedure of process variability monitoring based on individual observations is proposed. Additional remarks in the last section will close this presentation.

Discussion on the Recent Development in All Scenarios (Section 2)

I reviewed some important developments in each scenario of process variability monitoring. Monitoring the stability of multivariate process variability is equivalent to testing repeatedly the following hypothesis (Montgomery 2005),

$$H_0 : = \Sigma_m = \Sigma_0 \text{ versus } H_1 : \Sigma_m \neq \Sigma_0 \quad (1)$$

where, Σ_m and Σ_0 were the covariance matrix of the process and the hypothesized one, respectively, and $m = 1, 2, \ldots$. After I explored some historical background and understood that the way to monitor the process variability depended on how I measured the variability itself, I developed the interpretation of that philosophy of Wilks' statistic. In the second scenario, the philosophy was about measuring the effect of an additional observation on the covariance structure among variables. That philosophy would guide us to propose a new statistic for detecting the shift in variability based on individual observations ($n = 1$).

First Scenario

This scenario is about one of the most widely used methods in practice, that is the generalized variance (GV) chart or its square root chart. See for example: Alt and Smith (1988); Jaupi (2002); Montgomery (2001, 2005); Djauhari (2005) and Mason *et al.* (2009). This motivates us to focus on the GV based chart. Other methods can be seen, for example, in Yeh *et al.* (2004), Yeh *et al.* (2006) and Mason *et al.* (2009).

Let Σ be a positive definite covariance matrix. Its determinant $|\Sigma|$ is called GV. Therefore, if S is a sample covariance matrix, $|S|$ is called sample GV. Under the assumption of multivariate normality, the asymptotic distribution of $|S|$ is univariate normal (Djauhari 2009). This asymptotic distribution is usually used as the basis for constructing a $|S|$ chart or a $\sqrt{|S|}$ chart for monitoring multivariate process variability based on subgroup observations.

Suppose that m independent multivariate samples of the same size are assumed to be available. A $|S|$ chart, as presented in Montgomery (2001, p. 533–534) and Jaupi (2002, p. 119–123) was constructed by using, in a particular manner, the determinant of the average of sample covariance matrices as an estimate of the true generalized variance and its square root. A similar approach had been adopted by Alt and Smith (1988) in the construction of a $\sqrt{|S|}$ chart, by which they estimated the true generalized variance and its square root.

The use of $|S|$ chart or $\sqrt{|S|}$ chart implicitly indicate that either $|S|$ or $\sqrt{|S|}$ is being used as a multivariate variability measures. Unfortunately, these measures possess some serious limitations (Alt & Smith, 1988). In general, changes in the covariance structure do not always change the generalized variance and thus can not be detected by using $|S|$ and $\sqrt{|S|}$ charts. It is also well known that the charts are only sensitive to the large shifts in covariance structure. Other control charts developed for monitoring multivariate process variability can be found, for example, in Tang and Barnett (1996a, 1996b), Alt and Smith (1988, p. 344), Montgomery (2001, p. 532) & Yeh *et al.* (2004, 2006). Due to their practical popularity, the construction of $|S|$ and $\sqrt{|S|}$ charts were the focus of attention in Djauhari (2005) which we also examined in our attempts to make them more effective. We refer to these charts as the standard $|S|$ chart and the standard $\sqrt{|S|}$ chart.

The standard $|S|$ chart, Alt and Smith (1988), Jaupi (2002), and Montgomery (2001, 2005), is to consider that

an out-of-control signal occurs for sample k with a 0.27% probability of false alarm if $|S_k|$ is outside the interval [LCL(1), UCL(1)] :

$$\text{LCL}(1) = max\left[0, |\bar{S}|\left(1-3\frac{\sqrt{b_2}}{b_1}\right)\right]$$

$$\text{and UCL}(1) = |\bar{S}|\left(1+3\frac{\sqrt{b_2}}{b_1}\right), \quad (2)$$

where, $\bar{S}$ is the average of S_1, S_2, …, S_m and S_k is the covariance matrix issued from sample k, and b_1 and b_2 as given in Montgomery (2005, p. 511–512). On the other hand, the control limits of the standard chart are:

$$\text{LCL}(2) = max\left[0, \bar{W}\left(1-3\frac{\sqrt{b_1-b_5^2}}{b_5}\right)\right]$$

$$\text{and UCL}(2) = \bar{W}\left(1+3\frac{\sqrt{b_1-b_5^2}}{b_5}\right), \quad (3)$$

where $\bar{W}$ is the average of W_1, W_2, …, W_m, $W_k = \sqrt{|S_k|}$ and b_5 as given in Alt and Smith (1988, p. 349) or can be seen in Djauhari (2005, p. 33).

The statistics $|S|$ and $\sqrt{|S|}$ measure the same thing. However, in terms of their asymptotic distributions, a simulation study shows that the latter converges more rapidly to normality than the former. That is why some authors prefer to use a $\sqrt{|S|}$ chart instead of a $|S|$ chart.

In Djauhari (2005), I showed that all those control limits were biased. Then, in that paper I improved on their effectiveness by correcting the bias. I derived that the following control limits for $|S|$ chart were unbiased [Djauhari 2005, Equation (10)],

$$\text{LCL}(3) = max\left[0, |\bar{S}|\left(\frac{b_1}{b_3}-3\sqrt{\frac{b_2}{b_3^2+b_4}}\right)\right]$$

$$\text{and UCL}(3) = |\bar{S}|\left(\frac{b_1}{b_3}+3\sqrt{\frac{b_2}{b_3^2+b_4}}\right), \ldots \quad (4)$$

where, b_3 and b_4 were given by Djauhari (2005, p. 34). Furthermore, the unbiased control limits for $\sqrt{|S|}$ chart, see Equation 10 in Djauhari (2005), were:

$$\text{LCL}(4) = max\left[0, \sqrt{|\bar{S}|}\left(\frac{b_5}{b_6}+3\sqrt{\frac{b_1-b_5^2}{b_3}}\right)\right]$$

$$\text{and UCL}(4) = \sqrt{|\bar{S}|}\left(\frac{b_5}{b_6}+3\sqrt{\frac{b_1-b_5^2}{b_3}}\right) \quad (5)$$

where, b_6 was given in Djauhari (2005, p. 34). These are the improved version of $|S|$ and $\sqrt{|S|}$ charts. They are as simple to use as the standard ones. However, as we have mentioned earlier, the GV based charts were only sensitive to the larger shifts in covariance structure. They were not apt to detect the small shifts. To overcome this problem, in Djauhari *et al.* (2008) we introduced a new control chart, called vector variance (VV) chart, which could detect the situation that might not be detected by GV chart. See also Escoufier (1973) for the original idea of VV and Djauhari (2007) for its use as a multivariate variability measure. If GV was the determinant of covariance matrix, $|\Sigma|$, VV were the sum of squares of all elements of that matrix, i.e. $Tr(\Sigma^2)$. It was the squared Frobenius norm of Σ. A geometric interpretation of sample VV was discussed in Djauhari (2011a).

The VV chart consisted of plotting $Tr(S^2_k)$; k = 1, 2, …, m, and the control limits:

$$\text{LCL}(5) = max\left(0, \theta_0 - 3\frac{\eta_0}{\sqrt{n-1}}\right)$$

$$\text{and UCL}(5) = \theta_0 + 3\frac{\eta_0}{\sqrt{n-1}}, \quad (6)$$

where, $\theta_0 = \frac{n+1}{n-1}Tr\left(\Sigma_0^2\right)$, $\eta_0^2 = \frac{8n}{n-1}Tr\left(\Sigma_0^4\right)$. If Σ_0 was unknown, then it was customary to use:

$$\text{LCL}(6) = max\left(0, \hat{\theta}_0 - 3\frac{\hat{\eta}_0}{\sqrt{n-1}}\right)$$

$$\text{and UCL}(6) = \hat{\theta}_0 + 3\frac{\hat{\eta}_0}{\sqrt{n-1}}, \quad (7)$$

where, $\hat{\theta}_0$ and $\hat{\eta}_0^2$ were unbiased estimates of θ_0 and η_0^2, respectively, and $\hat{\eta}_0$ was the square root of $\hat{\eta}_0^2$. We considered that an out-of-control signal occured at sample k with a 0.27% probability of false alarm if $Tr(S^2_k)$ is outside the interval [LCL(6), UCL(6)].

GV and VV are two different measures of multivariate variability. Therefore, they measure different things. Due to these complementary properties, in Djauhari and Mohamad (2010) we proposed to use the GV chart and VV chart together one after another and show the advantage of this procedure. In Djauhari (2011b), we showed that the VV chart was more powerful than the GV chart to detect a true alarm.

The results presented above are some recent developments in the first scenario. We close this sub-section with an important problem in the use of VV for terms of computational efficiency. Since the covariance matrix is

symmetric, VV contains $p(p-1)/2$ doubly counted terms. If we eliminate these terms, the computational efficiency of VV will significantly increase, especially for high dimensions (p is large). The main problem to overcome before it can be practically used, is to identify its sampling distribution. This is the first open problem that we offer here.

Second scenario

Since the last two decades, the notion of quality regards to manufacturing processes has become more and more complex. This is the main reason why quality experts have been considering process quality in a multivariate setting which includes the case $n = 1$. For further discussions and proposals, see, Tracy *et al*. (1992); Sullivan and Woodall (1996); Khoo and Quah (2003), Huwang *et al.* (2007), Memar and Niaki (2009), and very recently Mason *et al.* (2009, 2010, 2011). The idea developed in Mason *et al.* (2009) was very interesting for the following reasons. First, this was a breakthrough in control charting technique which covered the second and third scenarios. Second, they used Wilks' statistic which was introduced almost a half century ago in Wilks (1963) where, unlike other methods such as those used by Khoo and Quah (2003) who needed to know Σ_0, Mason *et al*. (2009) did not need to know it. They just only need a reference sample issued from a Phase I operation. The monitoring procedure was developed further in Mason *et al*. (2010) in order to identify the quality characteristics that contributed to an out-of-control signal.

The philosophy behind Wilks' statistic was about measuring the effect of an additional observation on the covariance structure. What made Wilks's statistic important in the area of industrial application is that it has direct and simple geometrical interpretation and it was easy to implement in practice, especially when p was not too large. Based on Wilks' statistic, the effect of an additional observation on the covariance structure was measured as the ratio of the scatter matrix determinant issued from a reference sample or, equivalently, clean historical data set (HDS) and that issued from the augmented data set (ADS). In the second scenario, the latter data set consisted of HDS and an additional observation. It was thus proportional to the ratio of the GV of HDS and that of ADS. Geometrically, see Anderson (2003), it was the ratio of the volume of the p-dimensional parallelotope related to HDS and that related to ADS.

Let $X_1, X_2, \ldots, X_n$ be a random sample of size n issued from Phase I and X_{n+1} be a random sample of size 1 in Phase II. A realization of $X_1, X_2, \ldots, X_n$ will be considered as a HDS and that of $X_1, X_2, \ldots, X_n, X_{n+1}$ as an ADS (Mason *et al*. 2009). Let also,

$$SS_k = \sum_{i=1}^{k} (X_i - \bar{X}_k)(X_i - \bar{X}_k)^t \text{ with}$$

$$\bar{X}_k = \frac{1}{k}\sum_{i=1}^{k} X_i;\ k = n, n+1. \quad (8)$$

To monitor the stability of covariance structure in Phase II operation, Mason *et al.* (2009) introduced the use of Wilks' statistic in the form of W chart. This chart consisted of plotting the value of W and the LCL where $W = \frac{|SS_n|}{|SS_{n+1}|}$ and $|SS_k|$ was the determinant of SS_k; $k = n, n+1$. We could equivalently write $W = \left(\frac{n-1}{n}\right)^p \frac{|S_n|}{|S_{n+1}|}$ where $|S_k|$ was the GV of HDS and ADS was $k = n, n+1$, respectively. Under the assumption of multivariate normality, LCL was given by Wilks, 1963; and Mason *et al.* 2009 as:

$$\text{LCL} = Beta\left(\alpha, \frac{n-p}{2}, \frac{p}{2}\right) \quad (9)$$

The right hand side of Equation 9 is the α-th quantile of Beta distribution with degrees of freedom $\frac{n-p}{2}$ and $\frac{p}{2}$. We declare that an out-of-control signal occured at sample k if the value of W at sample k was less than LCL.

The W chart was unique in the sense that there existed no comparable chart technique for the case where n < p. That was why Mason *et al.* (2009) stated that the W chart certainly had the advantage of being flexible in that it could be used during the Phase II (monitoring) process when $n < p$. However, the main disadvantage of W chart came from the use of GV. As a GV-based chart, as we had mentioned in the previous paragraph, the use of W chart must be with caution because GV was only a scalar simplification of the complex structure contained in the covariance matrix (Alt & Smith 1988). GV is a numerical representation of that structure in the form of the determinant of covariance matrix. The popularity of GV-based chart was due, for example, to the easiness of its geometrical interpretation. GV was equivalent to the volume of p dimensional parallelotope defined by p quality characteristics under study (Anderson 2003; Mason *et al.* 2009). When the volume of the parallelotope was larger the process variability was larger and when the volume the smaller the variability in a subspace of variable space was smaller. Therefore, in general, the GV-based chart was not able to detect the change in covariance structure if there was no change in the determinant of covariance matrix. This indicated that the use of a W chart to detect the effect of an additional observation on the covariance structure might be misleading. It might happen that the Wilks' statistic failed to detect that effect whereas actually the covariance structure had changed.

To illustrate that situation, it is sufficient to consider two different covariance matrices having the same GV.

Let us consider the following two hypothetical covariance matrices Σ_1 and Σ_2,

$$\Sigma_1 = \begin{pmatrix} 4 & 3 \\ 3 & 9 \end{pmatrix} \text{ and } \Sigma_1 = \begin{pmatrix} 26 & 5 \\ 5 & 2 \end{pmatrix}$$

These covariance matrices represent two different covariance structures. The variance of the first and the second variables and also the correlation coefficient between them represented by Σ_1 is totally different from those represented by Σ_2. Both matrices have different set of eigenvalues. They have different VV, i.e., 115 for Σ_1 and 730 for Σ_2. However, they have the same GV which is equal to 27.

The above illustration indicates that the use of the *W* chart alone might not be sufficient to describe the effect of an additional observation on covariance structure. This was a logical consequence of the use of GV as a multivariate variability measure. Therefore, another statistic was needed to construct an alternative chart in order to have a better understanding about that effect. This is what we intend to discuss in the next sections. See also Djauhari (2010) for preliminary results and Djauhari (2011c) for sensitivity analysis.

Third Scenario

This was the most recent scenario introduced in Mason *et al.* (2009). It was developed based on subgroup observations where $1 < n < p$. See also Mason *et al.* (2011) for an analysis of out-of-control signal. This was an unprecedented scenario in the development of process variability monitoring technique.

Let $X_1, X_2, \ldots, X_n$ be a random sample of size *n* issued from Phase I and $X_{n+1}, X_{n+2}, \ldots, X_{n+m}$ be a random sample of size m in Phase II. As previously, a realization of $X_1, X_2, \ldots, X_n$ will be considered as a HDS and that of $X_1, X_2, \ldots, X_n, \ldots, X_{n+1}, X_{n+2}, \ldots, X_{n+m}$ as an ADS. We write:

$$SS_k = \sum_{i=1}^{k} (X_i - \bar{X}_k)(X_i - \bar{X}_k)^t \text{ with}$$
$$X_k = \frac{1}{k}\sum_{i=1}^{k} X_i ; \text{ k} = n, n+m. \quad (10)$$

For Phase II operation, Mason *et al.* (2009) proposed to use the W_m chart which ploted the value of W_m and LCL where $W_m = \dfrac{|SS_n|}{|SS_{n+m}|}$ and LCL was the solution of:

$$P(W_m < \text{LCL}) = \alpha. \quad (11)$$

LCL WAS thus the α-th quantile of the distribution of W_m. Since it WAS difficult to identify that distribution, Mason *et al.* (2009) gave two approximation solutions. The first, was based on chi-square approximation and the second was based on F distribution. Those approximations gave, respectively:

$$\text{LCL} \approx \exp\left\{-\frac{1}{f}\chi^2_{(1-\alpha);\,pm}\right\} \quad \text{and}$$
$$\text{LCL} \approx \left\{\frac{K}{K + F_{(1-\alpha);\,pm,\,ft-g}}\right\}^t \quad (12)$$

where, $\chi^2_{(1-\alpha)}$; pm and $F_{(1-\alpha);pm,ft-g}$ were the (1–α)-th quantile of chi-square with *pm* degrees of freedom and *F* distributions with *pm* and (*ft–g*) degrees of freedom, respectively. In Equation12,

$$K = \frac{ft-g}{pm}, f = \frac{2n+m-p-3}{2},$$
$$t = \sqrt{\frac{p^2m^2-4}{p^2+m^2-5}}, \text{ and } g = \frac{pm-2}{2}. \quad (13)$$

In their study, Mason *et al.* (2009) chose the second approximation.

As in the second scenario, the W_m chart must also be used with caution here because it was a GV-based chart. An alternative chart to improve the procedure of the monitoring operation was part of our ongoing research. Some preliminary results have been obtained but they are not sufficient to be reported here. This was also another open problem.

Construction of an Alternative Chart for the Second Scenario (Section 3)

In statistics, measuring multivariate variability is a challenging problem (see, for example, Alt & Smith 1988). If multivariate variability is commonly summarized numerically in the form of a covariance matrix, there is no unique measure that can be commonly used to represent it in a single number. One single measure is not enough to represent the complex structure summarized in that matrix. Consequently, many different measures are available in the literature. But, each of them only provides partial information about that structure. This indicates that being able to measure the variability of multivariate distributions in a proper manner is important in practical application.

A measure of multivariate variability can be defined as a non negative real-valued function of covariance matrix such that the more dispersed the population, the larger the value of that function (Djauhari *et al.* 2008). Total variance (Chatterjee & Hadi 1988; Mardia *et al.* 2000), volume of an ellipsoid (Rousseeuw 1985; Grambow & Stromberg 1998;

Croux & Haesbroeck 1999), and generalized variance (Alt & Smith 1988; Anderson 2003) are examples of that function. Other measures such as effective variance (Serfling 1980; Pena & Rodrigues 2005), square root of the generalized variance (Alt & Smith 1988), and relative generalized variance (Tang & Barnett 1996a,b) are variants of GV. A newer measure, totally different from GV, is VV (Djauhari *et al.* 2008). See also Mason *et al*. (2010) for further remarks about this measure. In this section we exploit the concept of VV to construct a new statistic that could be used to measure the effect of an additional observation on covariance structure.

A Motivating Example in Bivariate Case

We had used a *W* chart to control the process variability of beltline moulding in the automotive industry in Malaysia. The HDS consisted of $n = 40$ and $p = 2$. From HDS we obtained the covariance matrix:

$$S_n = \begin{pmatrix} 0.0534 & -0.0169 \\ -0.0169 & 0.0776 \end{pmatrix}$$

Due to its confidentiality, the two quality characteristics and the name of the industry was kept undeliverable. During a Phase II operation, for the first seventeenth subgroups of size 1, the covariance matrix of each ADS is presented in Table 1.

To construct the *W* chart, we first calculated Wilks' statistic W for each ADS in Table 1. The results are presented in Table 2.

Table 1. Covariance matrix of each ADS.

ADS	Covariance matrix		ADS	Covariance matrix	
1	0.0521	–0.0173	10	0.0552	–0.0167
	–0.0173	0.0764		–0.0167	0.0756
2	0.0521	–0.0178	11	0.0527	–0.0167
	–0.0178	0.0775		–0.0167	0.0757
3	0.0584	–0.0130	12	0.0531	–0.0186
	–0.0130	0.0775		–0.0186	0.0799
4	0.0527	–0.0148	13	0.0524	–0.0163
	–0.0148	0.0801		–0.0163	0.0758
5	0.0544	–0.0140	14	0.0521	–0.0165
	–0.0140	0.0782		–0.0165	0.0758
6	0.0524	–0.0163	15	0.0531	–0.0166
	–0.0163	0.0758		–0.0166	0.0756
7	0.0527	–0.0152	16	0.0680	–0.0248
	–0.0152	0.0782		–0.0248	0.0799
8	0.0524	–0.0152	17	0.0611	–0.0175
	–0.0152	0.0812		–0.0175	0.0757
9	0.0544	–0.0151			
	–0.0151	0.0764			

Table 2. The value of *W* for each ADS.

ADS	*W*	ADS	*W*
1	0.9783	10	0.9409
2	0.9673	11	0.9884
3	0.8421	12	0.9399
4	0.9166	13	0.9903
5	0.9032	14	0.9977
6	0.9903	15	0.9796
7	0.9423	16	0.7605
8	0.9120	17	0.8489
9	0.9340		

For α = 0.0027, we get LCL = 0.7325. Therefore, according to *W* chart, in Figure 1 we can see the history of the process variability from sample to sample and the LCL.

In this figure the horizontal axis represents the sample numbers and the vertical axis represents the value of *W*. This figure shows that all samples are in the control region meaning that no out-of-control signal occurs. Thus, according to *W* chart, the process variability is statistically stable.

Is it really true that the process variability is stable? This question is motivated by the result of data analysis on the covariance matrices in Table 1. In Table 3 we present the correlation coefficient (r) and total variance (TV) in each ADS.

The numerical results in Table 3 are visualized in Figures 2 and 3 in the form of run charts. The green line is the average and the red lines are three standard deviation from the average line.

Figure 3 gives a serious warning as TV of sample 16 is beyond the upper red line indicating that the earlier question is reasonable to be clarified. This is the topic of the next section where a new control chart is proposed. We show that this chart might detect the anomaly in the process that cannot be detected by W chart. But, first of all, we propose a new statistic to measure the effect of additional observation on the covariance structure.

Proposed Statistic

In what follows we propose a new statistic that can be used, like Wilks' statistic, to monitor process variability based on individual observations. That statistic will be constructed by using the concept of VV, i.e. as the squared Frobenius norm applied to the matrix defined as the scatter matrix issued from ADS subtracted by that from HDS. Its distribution will be derived and, for practical purpose a chi-square approximation will be presented.

First, I introduce the following theorem on an alternative way to measure the effect of an additional observation on the covariance structure.

Theorem. Let $X_1, X_2, \ldots, X_n, X_{n+1}$ be a random sample of a p-variate normal distribution $N_p(\mu,\Sigma)$ with covariance matrix Σ positive definite. Let also,

$$SS_k = \sum_{i=1}^{k}(X_i - \bar{X}_k)(X_i - \bar{X}_k)^t \text{ where,}$$

$$\bar{X}_k = \frac{1}{k}\sum_{i=1}^{k} X_i;\ k = n,\ n+1. \qquad (14)$$

If $E = SS_{n+1} - SS_n$, then $D = \sqrt{Tr(E^2)}$ has the same distribution as $\sum_{k=1}^{p}\omega_k z_k^2$ where $Z_1, Z_2, \ldots, Z_k$ are i.i.d. $N(0,1)$ and ω_k is the k-th eigenvalue of Σ.

To prove this theorem I need the following lemma.

Lemma. $E = \left(\frac{n}{n+1}\right)(X_{n+1} - \bar{X}_n)(X_{n+1} - \bar{X}_n)^t \qquad (15)$

Proof.
I write as follows:

$$SS_{n+1} = \sum_{i=1}^{n}(X_i - \bar{X}_{n+1})(X_i - \bar{X}_{n+1})^t + (X_{n+1} - \bar{X}_{n+1})(X_{n+1} - \bar{X}_{n+1})^t$$

The first term on the right hand side is equal to:

$$\sum_{i=1}^{n}(X_i - \bar{X}_n + \bar{X}_n - \bar{X}_{n+1})(X_i - \bar{X}_n + \bar{X}_n - \bar{X}_{n+1})^t =$$

$$\sum_{i=1}^{n}(X_i - \bar{X}_n)(X_i - \bar{X}_n)^t + n(\bar{X}_n - \bar{X}_{n+1})(\bar{X}_n - \bar{X}_{n+1})^t.$$

Thus,

$$SS_{n+1} = SS_n + n(\bar{X}_n - \bar{X}_{n+1})(\bar{X}_n - \bar{X}_{n+1})^t + (X_{n+1} - \bar{X}_{n+1})(X_{n+1} - \bar{X}_{n+1}).$$ But,

$$1)\ \bar{X}_n - \bar{X}_{n+1} = \bar{X}_n - \frac{1}{n+1}\sum_{i=1}^{n+1} X_i = \bar{X}_n - \frac{1}{n+1}\left(\sum_{i=1}^{n} X_i + X_{n+1}\right)$$

$$= \left(1 - \frac{n}{n+1}\right)\bar{X}_n - \frac{1}{n+1}X_{n+1}$$

$$= \frac{-1}{n+1}(X_{n+1} - \bar{X}_n) \text{ and}$$

$$2)\ X_{n+1} - \bar{X}_{n+1} = X_{n+1} - \frac{1}{n+1}\left(\sum_{i=1}^{n} X_i + X_{n+1}\right) = \frac{n}{n+1}(X_{n+1} - \bar{X}_n).$$

Consequently,

$$SS_{n+1} = SS_n + n\left(\frac{1}{n+1}\right)^2(X_{n+1} - \bar{X}_n)(X_{n+1} - \bar{X}_n)^t + \left(\frac{n}{n+1}\right)^2(X_{n+1} - \bar{X}_n)(X_{n+1} - \bar{X}_n)^t$$

$$= SS_n + \left(\frac{n}{n+1}\right)(X_{n+1} - \bar{X}_n)(X_{n+1} - \bar{X}_n)^t.$$

The second term on the right hand side of this equation is equal to E. Thus, we get the lemma.

Proof of the theorem.
Now we use the above lemma to prove the theorem. Let $Y_n = X_{n+1} - X_n$. Then,

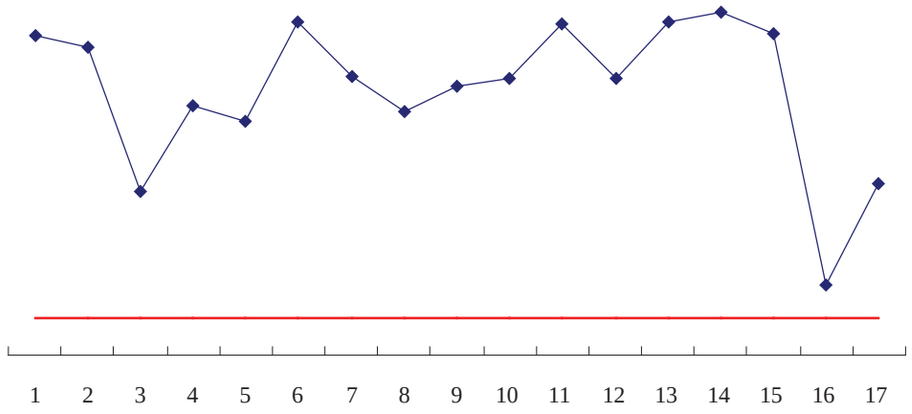

Figure 1. *W* chart.

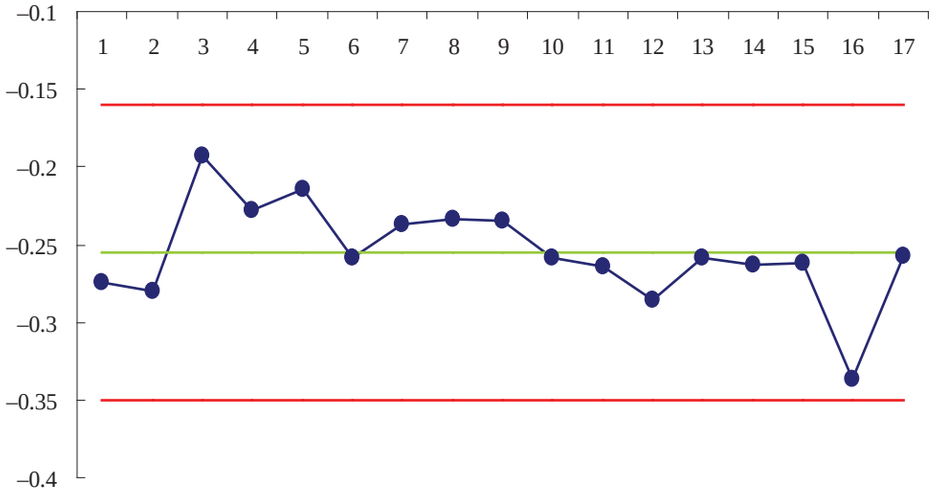

Figure 2. Run chart of *r*.

$$E = \left(\frac{n}{n+1}\right) Y_n Y_n^t \text{ and}$$

$$D = \sqrt{Tr\left(E^2\right)} = \left(\frac{n}{n+1}\right)\sqrt{Tr\left(Y_n Y_n^t Y_n Y_n^t\right)}$$

$$= \left(\frac{n}{n+1}\right)\left(Y_n^t Y_n\right). \quad (16)$$

We write $\left(\frac{n}{n+1}\right)\left(Y_n^t Y_n\right) = \left(\sqrt{\frac{n}{n+1}}Y_n\right)^t\left(\sqrt{\frac{n}{n+1}}Y_n\right)$ and let M be a $(p \times p)$ non-singular matrix such that $\Sigma = MM^t$ and $U_n = M^{-1}\left(\sqrt{\frac{n}{n+1}}Y_n\right)$. Then,

$$\left(\frac{n}{n+1}\right)\left(Y_n^t Y_n\right) = (MU_n)^t(MU_n) = Tr\left(U_n^t M^t M U_n\right) =$$

$$Tr\left(U_n^t C^t \Omega C U_n\right), \quad (17)$$

where, C is an orthogonal matrix and Ω is a diagonal matrix such that $M^t M = C^t \Omega C$. This equality means that if c_k is the k-th row of C, then it is the eigenvector of $M^t M$ associated with the eigenvalue ω_k; the k-th diagonal element of Ω. Thus, we have this equation,

$$M^t M c_k = \omega_k c_k;\ k = 1, 2, \ldots, p. \quad (18)$$

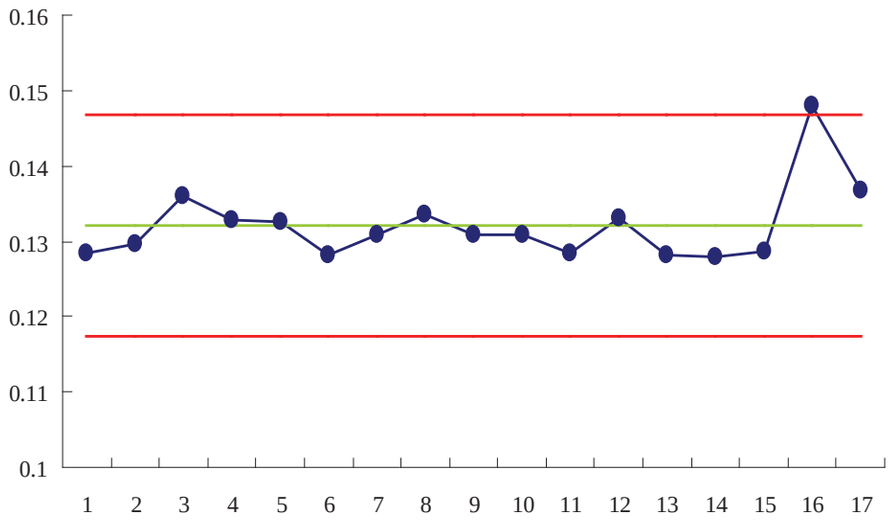

Figure 3. Run chart of TV.

If both sides of this equation is multiplied from the left by M, then $MM^t\ Mc_k = \omega_k Mc_k$ or, equivalently, $\Sigma(Mc_k) = \omega_k(Mc_k)$. This implies that ω_k is also the k-th eigenvalue of Σ. Furthermore, if $Z = CU_n$, then, $T_r(U^t{}_n C^t \Omega C U_n) = T_r(Z^t \Omega Z) = \sum_{k=1}^{p} \omega_k Z_k^2$ where the random variable Z_k is the k-th component of Z. We see that the statistic D has the same distribution as $\sum_{k=1}^{p} \omega_k Z_k^2$.

Now I derive the distribution of Z. Since $\overline{X_n}$ and X_{n+1} are independent and distributed as $N_p\left(\mu, \frac{1}{n}\Sigma\right)$ and $N_p(\mu,\Sigma)$, respectively, the distribution of Y_n is $N_p\left(0, \frac{n+1}{n}\Sigma\right)$. Therefore, $\left(\sqrt{\frac{n}{n+1}}Y_n\right)$ is distributed as $N_p(0,\Sigma)$. Consequently, $U_n = M^{-1}\left(\sqrt{\frac{n}{n+1}}Y_n\right)$ follows $N_p(0,I_p)$ where I_p is the identity matrix of size $(p \times p)$. Since C is orthogonal, the distribution of Z is $N_p(0,I_p)$ which implies that $Z_1, Z_2, \ldots, Z_k$ are i.i.d. $N(0,1)$. This proves the theorem.

The statistic D in that theorem is a new statistic where its value like Wilks' statistic, represents how large an additional observation has changed the covariance structure. Therefore, based on that theorem, in the next section we will propose a new control charting technique as an alternative of W chart. The example discussed previously will be reanalyzed and the results will be reported to illustrate the advantage of the proposed chart.

A New Control Chart (Section 4)

Approximation distribution. The statistic D in the above theorem has the following property; the larger the value of D, the larger the effect of an additional observation on the covariance structure and the smaller the value, the smaller the effect. However, for practical purposes, D is still difficult to use because its distribution cannot be formulated in a closed form. To make it more practical, its distribution will have to be approximated.

It is common, see Solomon and Stephens (1977), to approximate the distribution of the linear combination of a set of i.i.d. chi-square variables $\sum_{k=1}^{p} \omega_k Z_k^2$ by $L\chi_d^2$ for a positive constant L and degree of freedom d. Those scalars L and d are determined such that $E\left(L\chi_d^2\right) = E\left(\sum_{k=1}^{p} \omega_k Z_k^2\right)$ and $Var\left(L\chi_d^2\right) = Var\left(\sum_{k=1}^{p} \omega_k Z_k^2\right)$. The solution of these two equalities is given by:

$$L = \frac{Tr\left(\Sigma^2\right)}{Tr\left(\Sigma\right)} \text{ and } d = \frac{1}{L}Tr\left(\Sigma\right). \quad (19)$$

In the case where Σ is unknown, it is customary to approximate Σ by S_n issued from HDS. Thus, the distribution of D can be further approximated by $L\chi^2{}_d$ where,

$$L = \frac{Tr\left(S_n^2\right)}{Tr\left(S_n\right)} \text{ and } d = \frac{1}{L}Tr\left(S_n\right). \quad (20)$$

Table 3. Correlation and total variance.

ADS	*r*	TV	ADS	*r*	TV
1	0.0521	–0.0173	10	0.0552	–0.0167
2	0.0521	–0.0178	11	0.0527	–0.0167
3	0.0584	–0.0130	12	0.0531	–0.0186
4	0.0527	–0.0148	13	0.0524	–0.0163
5	0.0544	–0.0140	14	0.0521	–0.0165
6	0.0524	–0.0163	15	0.0531	–0.0166
7	0.0527	–0.0152	16	0.0680	–0.0248
8	0.0524	–0.0152	17	0.0611	–0.0175
9	0.0544	–0.0151			

To illustrate the goodness of fit for this approximation approach, we would report some simulation results. The simulation experiment consisted of two data generations:

(i) Generate p random numbers in an interval (a, b); $0 < a < b < \infty$, sorted in descending order, that will be used as $\omega_1, \omega_2, \ldots, \omega_p$;
(ii) Generate n random data from p-variate normal distribution with vector mean zero and covariance matrix I_p.

In this experiment we used $p = 2$ and 5, $n = 100$, $a = 1$ and $b = 20$. Figure 4 shows the QQ plot between the experimental value of $\sum_{k=1}^{p} \omega_k Z_k^2$ in vertical axis and that of $L\chi^2_d$ in horizontal axis for $p = 2$ and $n = 100$. Figure 5 presents the same plot for $p = 5$ and $n = 100$. These figures indicate that the approximation was quite satisfactory.

Proposed Control Chart

Based on the above approximation distribution of D, we propose the following D chart. This chart consists of plotting the value of D for each sample and the upper control limit UCL = $L\chi^2_{(1-\alpha);d}$ where $\chi^2_{(1-\alpha);d}$ is the (1–α)-th quantile of chi-square distribution with d degrees of freedom. I declare that an out-of-control signal which occured for a given sample if the value of D at that sample was greater than UCL.

Now, let us look again at the result of our experience in controlling the process variability of beltline molding in Section 3. From $n = 40$ observations in the HDS we got the sample mean vector:

$$\overline{X_n} = \begin{pmatrix} 0.00750 \\ 0.57875 \end{pmatrix}$$

To construct the F chart, I first calculated the value of the statistic D for each sample. The results are in Table 4.

Now I calculated its upper control limit UCL. For $\alpha = 0.0027$, we got UCL = 4.41167. This UCL together with the value of D in Table 4 are presented in Figure 6 which visualizes the history of process variability based on D chart.

According to this chart, an out-of-control signal occured at sample 16 which was not detected by W-chart.

A Sensitivity Analysis (Section 5)

In the previous sections I saw a real example where the W chart could not give any out-of-control signal while the D chart could do it. This indicated that further study was needed to see the general performance of the proposed chart. In this section the sensitivity of both charts would be analyzed and compared in terms of their power in detecting the true alarm. For that purpose, a simulation experiment was conducted using the same approach as in Mason *et al*. (2009).

First, we generated n random data from a p-variate normal distribution with zero mean vector and covariance matrix I_p. Secondly, I adopted one type of shift, i.e. all p standard deviations $\sigma_1, \sigma_2, \ldots, \sigma_p$ were increase by the same amount when all variables had the same correlation ρ with $\rho = 0$, 0.5, and 0.9. These values of ρ represented no correlation, moderate correlation, and high correlation. The number of data generated was $n = 50\,000$ and $p = 2$, 3, and 5. That experiment indicated that:

(i) In general, the percentage of true alarms detected by D was larger than that detected by W for $p = 2$ and all values of ρ. Furthermore, D was far better than

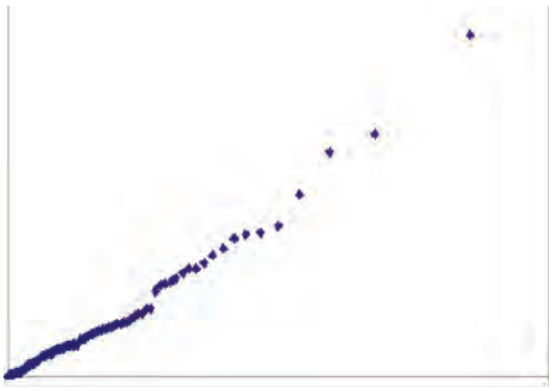

Figure 4. QQ plot for $p = 2$.

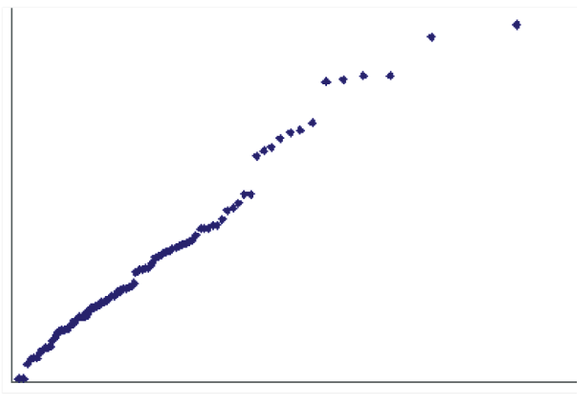

Figure 5. QQ plot for $p = 5$.

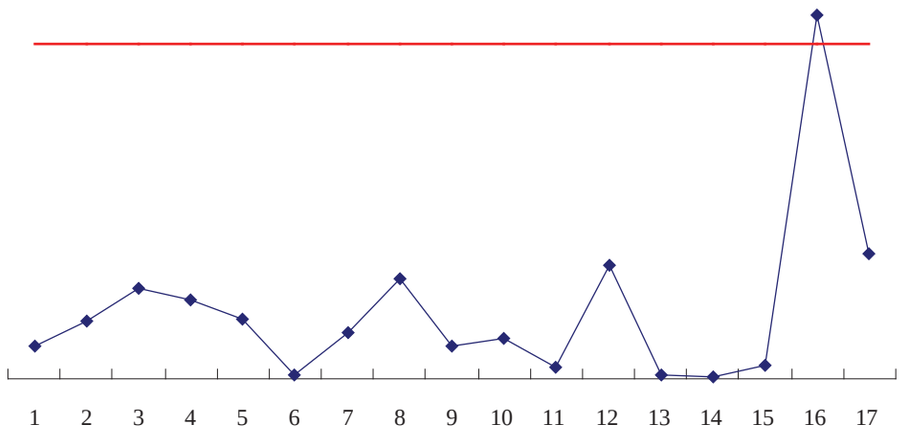

Figure 6. *D* chart.

Table 4. The values of *D* statistic for each ADS.

ADS	D	ADS	D
1	0.43078	10	0.54130
2	0.75825	11	0.15986
3	1.18389	12	1.49131
4	1.05290	13	0.06197
5	0.79260	14	0.03535
6	0.06197	15	0.18897
7	0.62173	16	4.81151
8	1.32232	17	1.64137
9	0.43806		

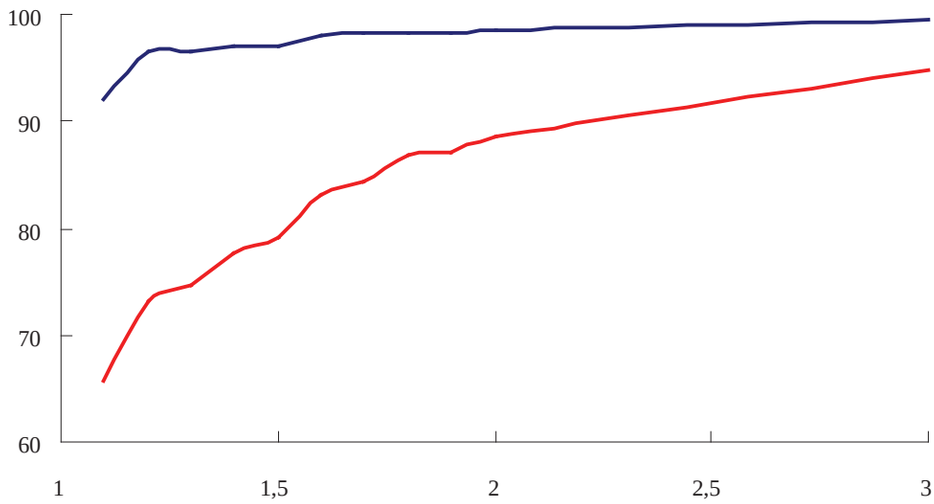

Figure 7. Percentage of detected outliers, ρ = 0.

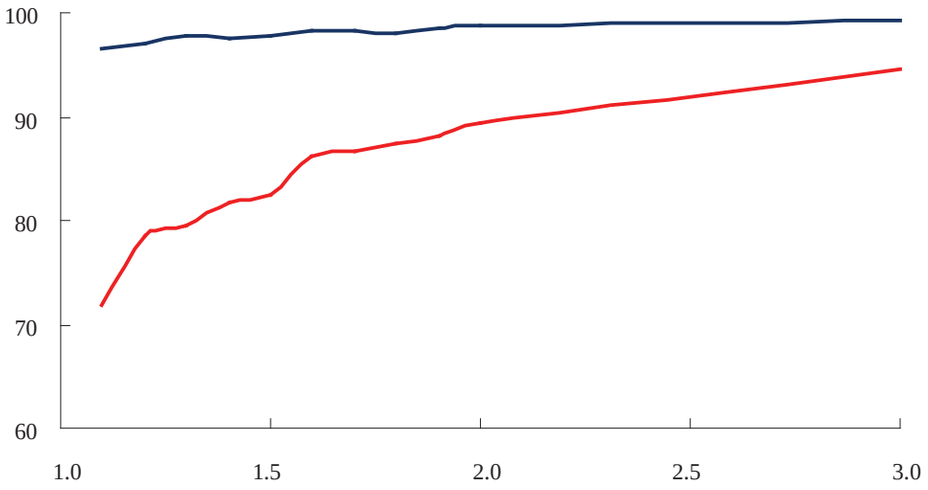

Figure 8. Percentage of detected outliers, ρ = 0.5.

W for small shifts. For $p = 5$ and all, 100 % of true alarms were detected by *W* but less than 100% by *D*. However, the difference was small, i.e. no more than 5 %. For $p = 3$ and $\rho = 0$, their performances were similar to those when $p = 5$, but, when $p = 3$ and $\rho \neq 0$, they were similar to those of the case when $p = 2$ and $\rho \neq 0$. Figures 7 – 9 illustrate those percentages for $p = 2$ at $\rho = 0$, 0.5 and 0.9, respectively. The vertical axis is the percentage of true alarms detected by *D* (blue curve) and *W* (red curve) and the horizontal axis is the amount of the shift.

(ii) In terms of the percentage of false negatives, for $\rho = 0$, *W* does not show any false negatives except for $p = 2$. On the other hand, *D* gives false negatives for all *p* and all ρ with magnitudes no more than 10% for small shifts. For $\rho = 0.5$ and 0.9, *W* produces false negatives except for $p = 5$ while *D* produces it for all *p*. Interestingly, if *W* produces false negatives, their percentages are always greater than that of *D* especially for small shifts.

(iii) In terms of false positives, *D* does not produce any false positives for all *p* and ρ while *W* shows it for all

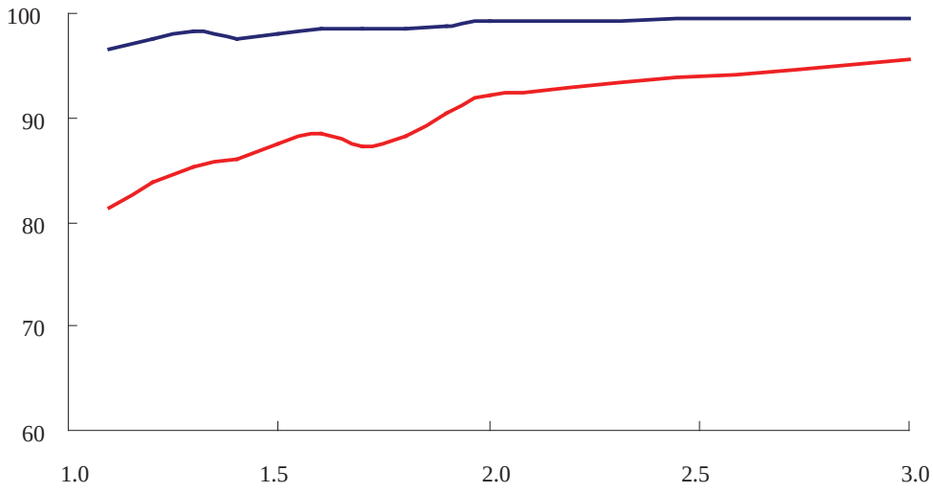

Figure 9. Percentage of detected outliers, $\rho = 0.9$.

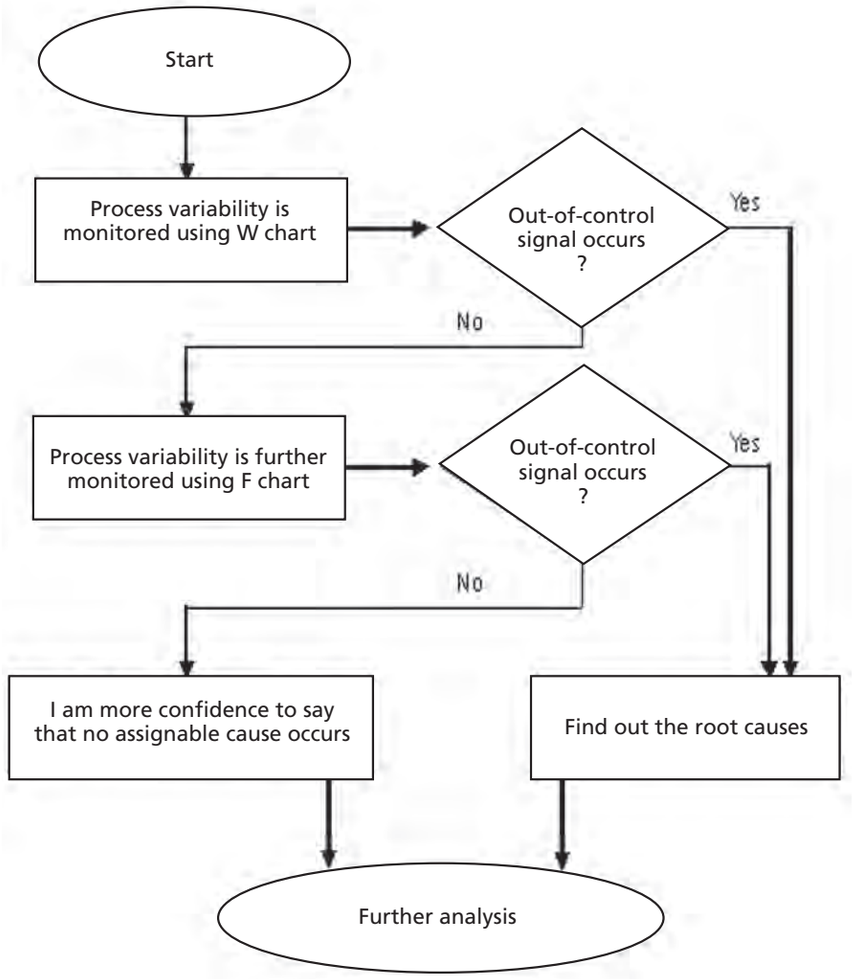

Figure 10. Flow chart of the proposed procedure.

at $p = 5$ and $\rho = 0$ at $p = 3$. The larger the shift the larger the percentage of false positives given by W.
(See Djauhari 2011c)

We could see that the performance of the D chart was quite promising. Therefore, in the next section I proposed a new monitoring procedure which would give a better understanding about the effect of an additional observation on the covariance structure.

Proposed Procedure

Both W and D charts were constructed based on different statistics and they showed different signals.

According to the performance analysis discussed in the previous paragraph and in order to have a better understanding about the history of process variability, the use of both charts simultaneously would be helpful. Therefore, we propose to use both charts together one after another such as described in Figure 10.

Additional Remarks

Several experiences in the manufacturing industry have shown that, in practice, the following situations might occur:

(i) W and D charts give different out-of-control signals
(ii) The same signals occur in both charts; and
(iii) No signal occurs in both charts.

An industrial example presented and discussed in the previous Sections 3 and 4 was one of our experiences. The situations (i) and (iii) are clearly present in Figures 1 and 6. In that example, the situation (ii) would also occur if I use larger α.

In this paper I showed that, in terms of the percentage of true alarms detected, the D chart dominated the W chart, especially for small shifts in process variability. However, the use of both charts is necessary since they provided additional information about the history of process variability. One important thing had to be mentioned here. As indicated in (iii), the proposed procedure in Figure 6 was still not sufficient to understand the actual process. There was a certain situation where both charts did not signal any change in covariance structure but actually it had actually changed. Therefore, a better procedure that would be able to detect that situation was needed. That was the third open question.

ACKNOWLEDGEMENT

The author is very grateful to the Ministry of Higher Education and the Ministry of Science, Technology and Innovation, Government of Malaysia, for financially supporting this research under FRGS vote numbers 78484 and 4F013, and RUG vote number Q.J1300.7126.02H18. He specially thanks Universiti Teknologi Malaysia for facilitating this research. His thanks also goes to the Editor and the anonymous referees whose comments and suggestions have improved the presentation of this work and to Dr Talib Bon, Universiti Tun Hussen Onn Malaysia, for providing beltline moulding data.

Date of submission: September 2011
Date of acceptance: December 2011

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Review

Impact of Climate Change on Animal Production in Asia: Coping with Challenges for Agricultural R&D

C. Devendra[1]

The effects of anticipated climate change and the potential impact on animal production are discussed in the context of varying biophysical features, agro-ecological zones (AEZs), ecosystems, land use, and responses in animal genetic diversity and production. The AEZs in Asia have great diversity in their links to food production in crop-animal small farm systems, the poverty complex and livelihoods of the poor. In these environments. climate change effects on animals were mediated through heat stress, water availability, quantity and quality of the available feed resources, type of production system and productivity. The responses to heat stress are tabulated and they vary according to species, breeds within-species, AEZs, physiological and nutritional status, genetic potential and multifunctionality. Among ruminant production systems, dairy production was especially vulnerable to heat stress. Interestingly in India, buffalo numbers owned largely by the landless and small farmers in the semi-arid and arid regions have grown twice as fast as the buffalo population in the irrigated areas. The implications and strategies to cope with climate change involve mitigation, adaptation and policy. The principal strategy is targetting to the reduce on in greenhouse gas (GHG) emission from the agricultural sector from enteric fermentation and manure, and ways to intensify C sequestration. An important link is that of breeding and conserving indigenous animal genetic resources as a means to mitigate climate change, with associated benefits to the trade of live animals and animal products. Improved integrated tree crops-ruminant systems are an important pathway to enhance C sequestration. The opportunities for research and development (R&D) are enormous and they would need policy support and large investments to provide improved understanding of ways to ensure sustainable animal production systems. Coping with the totality of the effects and impact of climate change constitutes the challenges for agricultural R&D and the improved livelihood of the resource-poor in the future.

Key words: Climate change; animal agriculture; food security; rainfed; dryland agriculture; genetic diversity; conservation; strategies; policy;impacts; agricultural R&D

There is no doubt that the anticipated climate change will have very serious consequences on food security, livelihood of the poor and economic growth. Of the potential impacts, the hardest hit will be the resource-poor small farmers who produces the food. It is conceivable that climate change will accentuate constraints, their survival and capacity to improve and sustain agricultural production. About 2.6 billion farmers produce the majority of food as well as all other products and services in agriculture throughout the world on small farms of less than two hectares. More than 70% of people suffering from hunger live in rural areas (IAASTD 2008)

These circumstances are very compelling for the following reasons:

- The livestock sector constitutes about 30% of the agricultural gross domestic product (GDP) in the developing world, and about 40% of the global GDP. More importantly, it is one of the fastest growing sub-sectors in agriculture (World Bank 2009). However, animal protein supplies are inadequate to meet current and projected hman requirements.

- The demand for food of animal origin is particularly acute, driven by population growth, increasing affluence and changing consumer preferences. Consumers have been showing preference in South Asia for milk and East and South east Asia for meat while a large majority of countries have recorded structural changes in food consumption patterns (Pica-Ciamarra & Otte 2011).

- Reduced productivity will exacerbate food and nutritional insecurity. IFAD (2009) has reported

[1]Consulting Tropical Animal Production Systems Specialist, 130A Jalan Awan Jawa, 58200 Kuala Lumpur, Malaysia)
*Correspondence (e-mail: cdev@pc.jaring.my)

that climate change is expected to put 49 million additional people at risk of hunger by 2020, and 132 million by 2050

- The capacity and capability of the animal industries was to ensure cost-effective production, efficiency of use of production resources, ways to increase productivity to meet spiralling demands and sustain potential contributions from the totality of animal genetic resources (Devendra 2004).

The purpose of this article is four-fold. Firstly, to provide an understanding of what we know about the potential impacts of climate change and the implications for agricultural R&D. Secondly, to emphasise the urgency to address current, continuing and emerging problems concerning the efficient use of the natural resources. Thirdly, to identify ways to mitigate and respond to the potential harmful effects and impact on animal production, and fourthly, to ensure that the capacity of the multifunctional contribution of animals is not reduced for food security, stable livelihood systems and environmental sustainability.

THE BIOPHYSICAL ENVIRONMENT

Agro-ecological Zones

The AEZs in Asia are very variable and show great diversity in biophysical features, land use patterns in which crops and animals play a very important role in food production, as well as contribute towards income generation, food security and livelihoods of the poor. Crop-animal or mixed farming systems form the backbone of Asian agriculture (Devendra & Thomas 2003; Devendra 2010a).

For Asia, the AEZs of relevance are as follows:

- Rainfed temperate and tropical highland systems — mainly the Hindu Kush/Himalayan region
- Rainfed humid/sub-humid tropical systems — mainly countries in Indo-China, South East Asia and the South Pacific islands, South India, Bangladesh and Sri Lanka
- Irrigated humid/sub-humid tropical systems — mainly countries in Indo-China, South East Asia and South China, and
- Irrigated and non-irrigated arid/semi-arid tropical and sub-tropical systems — mainly Pakistan and India.

South Asia is characterised by dry climates where total rainfall and its distribution could limit crop growth. Arid/semi-arid (warm arid and semi-arid tropics consolidated with warm arid and semi-arid tropics with summer rainfall) and sub-humid climates predominate. The length of growing period (LGP) for the arid/semi-arid zones varies from 0–74 days (arid) to 75–179 days (semi-arid), respectively. Annual rainfall in the semi-arid zone ranges from about 500–1000 mm to <500 mm in the arid zones. In contrast in South East Asia, humid (warm humid tropics consolidated with warm-cool humid sub-tropics with summer rainfall) and sub-humid (warm sub-humid tropics consolidated with warm/cool sub-humid sub-tropics with summer rainfall) system predominate. Humid zones are characterised by an LGP of 180–270 days and a rainfall regime ranging from 1000–1500 mm annually.

Land Use Systems

A major constraint for increased agricultural development is the availability of arable land in the future. This is due to the increased use of land for industrial, recreational needs and also urbanisation. A matter of concern was the loss of about 5.7 million hectares of arable land annually through soil degradation, and a further 1.5 million hectares as a result of water logging, salinisation and alcanisation (FAO 1999).

Increasing food production in the future is linked to three possible ways:

(1) Increase in the existing arable land and include crop-animal systems
(2) Intensifying the use of existing land; and
(3) Expanding production in the rainfed or less-rain favoured areas.

Of these options, it is doubtful that dramatic increases are going to be available from existing arable land. Maximum production has already been achieved and the output is levelling off. Intensifying agriculture on existing land will give increased production. The expansion of production in the rainfed areas is an important development frontier, has great potential and merits priority attention (Devendra 2010a; 2012).

The justification for the urgent development attention is linked to the presence in Asia and the Pacific of the areas under rainfed agriculture which account for about 223 million hectares which represents some 67% of the total arable land (ADB 1989). The six countries in South Asia alone accounted for 52% of the land area. Alexandratos (1995) has estimated that rainfed lands suitable for cropping in South Asia and currently not utilised was 81 million hectares in South East Asia and 37 million hectares in South Asia.

Using the definitions and consolidation of the classifications of the Technical Advisory Committee (TAC) (1994), the rainfed AEZs of relevance are as follows:

- Rainfed temperate and tropical highlands — mainly the Hindu-Kush / Himalayan region
- Rainfed humid/ sub-humid tropical systems — mainly countries in Indo-China, South East and East Asia, and the Pacific Islands, parts of South Asia to include Bangladesh and Sri Lanka; and
- Rainfed arid /semi-arid tropical systems — mainly countries in South Asia excluding Nepal and Bangladesh.

Most of the resource-poor farmers in rainfed areas are small farmers or smallholders and the landless, with very small farm sizes (Devendra 2010). Out of an estimated 470 million small farms worldwide of less than two hectares of land, 85% are smallholders of which these 87% are found in Asia (Nagayets 2005). These figures do not include several million landless farmers and agricultural labourers especially in Asia.

Individual animal populations in Asia are diverse and relatively large. These were widely distributed across small farms which were the reservoirs of a large proportion of the main animal species (buffaloes, cattle, goats, sheep, chickens, pigs and ducks). Table 1 gives an idea of the diversity of available animals and their wide distribution across ecosystems and sub-regions.

Animals form an important economic and ecological niche, and their functions and contributions are numerous. They are consistently and widely owned by small farmers for a variety of advantageous reasons (Devendra 1983; Chantalakhana 1990):

- Diversification in the use of production resources and reduction of socio-economic risks
- Promotion of linkages between system components (land, crops and water)
- Generation of value-added products (e.g. meat, milk, eggs and skins)
- Income generation, investment, insurance and economic security
- Supply of draught power for crop cultivation, transportation and haulage operations
- Contribution to soil fertility through nutrient cycling (dung and urine)
- Contribution to sustainable agriculture, and environmental protection.
- Prestige, social and recreational values; and
- Development of stable farm households.

EFFECTS OF CLIMATE CHANGE ON ANIMAL PRODUCTION

Climate change seriously affect a number of important factors that are directly concerned with animal production. These factors include the following *inter alia*:

(1) Heat stress
(2) Agro-ecological zones
(3) Water availability
(4) Quantity and quality of the available feed resources
(5) Type of production system; and
(6) Productivity.

Heat Stress

The response to heat stress and the effects on animals are many and vary according to species, breeds within species, AEZ, physiological and nutritional status and genetic potential. Goats for example, are more adapted to harsher and drier conditions and have greater resistance to dehydration than temperate animals (Devendra 2007b). On the other hand, imported exotic animals from temperate climates will be more sensitive to heat stress than tropical animals. In general, tropical animals are more adapted to high temperatures, humidity and disease resistance.

With specific reference to animal production, climate change will bring with it a number of potentially significant yield reducing impacts. Table 2 summarises the situation with reference to types of key issues eg. heat stress, feed resources, climate change impact and opportunities for R&D. The information that is presented is not exhaustive but rather the range of issues involved, was attempted to be captured in a comprehensive way.

High temperatures and reduced feed intake significantly influenced productivity, and in the tropics, this may be between half and one-third of the potential of modern cow breeds (Parsons *et al*. 2001). Cow fertility, fitness and longevity may also be reduced (King *et al.* 2006). Heat waves have also caused substantial mortality in animals in the USA and northern Europe (Sirohi & Michaeltowa 2007). Moran (2005) has reported that in dairy cows the initial symptoms are behavioural and then physiological. Within sheds, these were observed: refusal to lie down, reduced feed intake, agitation and restlessness, reduced or halted rumination; open mouthed and laboured breathing; excessive salivation; inability to move; collapse, convulsion and coma; physiological failure and death.

Agro-ecological Zones

The climatic impact on the AEZs will also be mediated largely by high temperatures. Crop growth will be curtailed with the rise, with inadequate supplies of animal feed and then lower animal productivity. The severity of the problem will increase with reduced rainfall in the AEZs. The semi-arid and arid AEZs will be particularly vulnerable. It is quite feasible that with the more heat tolerant species like the goat, there would be overstocking, overgrazing and damage to the environment. The rangelands are thus

Table 1. Distribution of domestic animals by ecosystem and sub-regions in Asia (Devendra 1996).

Sub-region	Agroecosystem and animal species										
	Lowland irrigated			Lowland/upland rainfed			Semi-arid and arid			Highland	
	Buffalo/ cattle	Goats/ sheep	Pigs/ poultry/ ducks	Buffalo/ cattle	Goats/ sheep	Pigs/ poultry/ ducks	Buffalo/ cattle	Goats/ sheep	Pigs/ poultry/ ducks	Buffalo/ cattle	Goats/ sheep
China	***	*	***	**	***	***	*	***	*	**	***
Hindu-Kush	***	*	**	**	***	*	*	–	–	*	***
South Asia	***	*	**	**	***	**	*	***	–	*	*
Mekong countries	***	*	***	**	**	***	**	*	–	*	*
South East Asia	***	*	***	**	**	***	*	**	*	*	*

* Low concentration
** Medium concentration
*** High concentration

Table 2. Major Issues In animal production that will be affected by climate change Impacts.

Major issue	Potential climate change impacts	Opportunities for R&D
1. **Heat stress**	• Physiology • Metabolism • Reduced feed intake • Reduced reproduction • Increased mortality • Low productivity • Unsustainable production systems • Reduced multifunctionality	• Adaptation • Feed efficiency • Measures to increase intake • Supplementation • Improved management • Benefit of shade in integrated systems with tree crops
2. **Feed resources (Forages, crop residues, AIBP and NCFR) ***	• Reduced quantities • Poorer nutritional quality • More fibrous • Decreased palatability • Supplementation	• Use more heat tolerant plants • Food-feed systems • Use of multipurpose tree legumes • Conservation
3. **Land use systems**	• Shift to drland agriculture • Droughts • Water scarcity • Pressire on adaptation • Erosion of biodiversity • Diversification of agriculture • Sustainability • Increased nomadism • Displacement of households	• Heat tolerant plants and animals • Emphasis on rainfed agriculture • Maximising feed supply • Increased agronomic practices and use of animal manure to sustain soil fertlityfertility • Conservation practices
4. **Animal species and breeds**	• Adaptation • Possible reduction in size • Loss of biodiversity • Migratory systems • Uncontrolled and overstocking can cause environmental degradation (e.g.goats)	• Dynamics of nomadic and transhumant systems • Ensuring choice for AEZ • Understanding interactions with the environment • Improving Vulnerability and survival of the poor and their animals
5. **GHG emissions from enteric fermentation and manure, producing global warming**	• Reduced crop growth and animal productivity • Poor C sequestration • Intensification	• Improved use of grasses, legumes and agronomic practices • Use of dietary nitrates to reduce CH_4
6. **Integrated NRM and holistic systems***	• R&D capacity • Advantage of shade in plantations • Increased economic beneffits	• Interdisciplinarity • Use of systems perspectives
7. **Semi-arid and arid AEZs including rangelands**	• Reduced feeds • Overstocking • Environmental damage • Improved management. • Water use efficiency	• Control of numbers • Landlessness • Use of multipurpose leguminous trees

*AIBP – Agro-Industrial by-products
NCFR – Non-conventional feed resources
NRM – Natural resource management

Figure 1. Woman delivering cattle manure as the main source of fertiliser for rainfed crop cultivation in Nin Thuan province, South Vietnam.

Figure 2. South China black goats extensively grazing and feeding on rice straw in Nanjian province in China.

also very vulnerable. Controlled numbers and grazing is therefore an important management tool.

Water Availability

The availability of water will be the main determinant of crop growth. The impact of climate change on water availability is serious and varies from region to region, type of AEZs and pattern of agriculture. It is considered to be one of the greatest limiting factors facing crop water productivity and food security (Yinhong, Khan & Ma 2009). Producing 1 kg of rice requires 3500 litre of water, 1 kg of beef requires about15 000 litre of water, and a cup of coffee about 140 litre of water (Hoekstra & Chapagain 2008).

Irrigation where available is expensive and confined mainly to the high potential cereal growing arable land. Total rainfall and its distribution is therefore the main determinant of crop-animal dryland farming systems.

Quantity and Quality of Feed Resources

A major direct effect of climate change with respect to higher temperatures concern feed resources. The effect involve both quantities available and also quality.The direct effect of climate change on cropping systems is a reduction in yield of the crop and with it a reduction in the availability of crop residue for feeding ruminants. With rice for example, Peng *et al.* (2004) have reported in the Philippines that rice yield decreased by 10% for every 1ºC degree increase in temperature.

The ADB (2009) has recently also reviewed the effects of temperature rise on crop yields in South East Asia and has also projected that in four countries in South East Asia (Indonesia, Philippines, Thailand and Vietnam), there will be rice yield falls by about 50% in 2100 relative to the 1990 level. The efficient use of the feed resources to the extent possible will dictate to a very large extent the contribution from animals to total protein supplies (Devendra & Leng 2011).

Types of Production System

The significance of production systems and global warming needs to be considered from the standpoint of emission of greenhouse gases (GHGs). The principal strategy is to apply ways and means to keep GHG emission at the minimum levels. The grazing ruminant and manure management are implicated. Globally, livestock contribute 18% of total anthropogenic GHGs. Grazing animals make GHG emission, but grassland development can counter the emission and sequester C. Intensification is an advantage and it has been suggested that it will help to mitigate GHG emissions as less GHG will be produced per kg of product from an extensively reared system (Steinfeld *et al.* 2006).

Improved grass-legume pastures to feed grazing ruminants will have the beneficial effect of enhancing carbon sequestration and releasing more oxygen into the atmosphere. On the other hand, the presence of grazing ruminants will mean emissions of more CH_4 into the atmosphere, and their possible effects. In Brazil, Zebu cattle grazing tropical pastures produced a larger methane loss of 27 g/kg compared to either Holstein or Nellore cattle fed sorghum silage-concentrate diets that averaged 22 g/kg. Holstein or Nellore cattle on *Bracharia* or *Panicum* pastures consuming sorghum had methane losses that were close to the temperate forage-based diet of 20 g/kg (Lima *et al.* 2004).

More recently, consistent research results from Australia, Canada and Vietnam suggests that the fermentable nitrogen requirements of ruminants on diets based on low protein cellulosic materials can be met from nitrate salts (Trinh *et al*. 2009) and this potentially reduces methane production to minimal levels (Leng 2008). Trinh *et al*. (2009) demonstrated that with adaptation, young goats given a diet of straw, tree foliage and molasses grew faster with nitrate as the fermentable N source as compared with urea. Further studies from the same group have shown that nitrate can be used as a fermentable N source for beef cattle fed treated straw (Nguyen Ngoc Anh *et al.* 2010).This finding is of much relevance to intensive stall feeding systems.

Productivity

Agriculture is waning and the share of agriculture to the gross domestic product (GDP) is declining in many countries. The declining share of agriculture in the GDP is largely due to low productivity, resulting in low growth and lower income for people dependent on agriculture. In East Asia and the Pacific for example, growth in agriculture dropped from 4% in the 1980s to mere 0.1% in 2002–2003 (ESCAP 2008).

Productivity will ultimately be reflected by performance and lifetime output that have been influenced by the sum total of climatic effects on the animal. The magnitude of these output will in turn be determined by the efficiency of the mitigation and adaptation strategies that are applied. The latter needs to take cognisance of the following:

- Maximisation of the use of diversity of breeds and species
- Application of all available yield-enhancing and impact-oriented technologies that are suitable for individual environments; and
- Existance of socio-economic relevance and contribution to sustainable agriculture.

Dairy production is a complex multi-dimensional and multi-faceted sector. Among ruminant production systems dairying stands tall but is was also the most vulnerable to climate change, involving high quality animals and,

improved and efficient use of natural resources and preservation of the ecosystems. The vulnerability increases with the rise of exotic imports like Holstein-Friesian cattle. This involves both germplasm and production resources, often in peri-urban areas that sustains the needs of human livelihoods, In India, the dairy sector has been very well developed through participation predominantly by small farmers and the landless, backed by effective co-operative development. These individuals survive because of dairying and it is estimated that about 70% of all milk produced comes from this sector (Birthal 2008). Additionally, the sector integrates the elements of gender, cultural barriers, training and education, technology application and governance which has led to effective marketing networks. An estimated 60% of the working population generating 25% of the region's GDP are involved with agriculture (ESCAP 2008).

Mitigation and adaptation strategies are especially important in dairying. The three main reasons are:

- Direct benefits to enhance poverty-reducing impact, improved livelihood and nutrition of adults and children
- Considerable opportunities are created for small farmers and the landless to undertake improved dairy farming, diversify agricultural production, increase income, enhance food security and achieve levels of self-sufficiency; and
- Direct consequence of these benefits thrust are spill-over expanded interest in many neighbouring countries, involving increased investments in infrastructure, the importation of pure bred cattle and riverine buffaloes to boost milk production.

EXPANSION OF BUFFALO PRODUCTION WITH CLIMATE CHANGE

Although the impact of climate change will affect animal production in various ways, a combination of mitigation and adaptation to revised management techniques can counter these Beyond good adaptation, it is especially important to recognise concurrent good performance.

In this context, buffalo production in India, stands tall throughout the developing countries among food production systems which involve ruminant animals. The advances made in India over the last four to five decades through the Anand model of "Operation Flood", involve some 13 million farming families. They process about 90 million kg of milk per year mainly from dairy buffaloes, and making farmers and the landless shareholders of the whole chain of marketing and processing of milk as a testimony of the fact. The sector also integrates the elements of gender, cultural barriers, training, education, technology application and governance which led to effective marketing networks.

Dairy production is a complex multi-dimensional sector that is targeted. The improved and multi-faceted sector which concernes the efficient use of the natural resources and preservation of the ecosystems in a manner, that can sustain the needs of human livelihood for several millions of poor people who are mainly small farmers and the landless. They sell an estimated 70% of all milk produced from this sector (Birthal 2008).

Concerning ownership, it has been reported that the landless also owned buffaloes and cattle, and more importantly that both the group and small farmers accounted for the largest share of households (70.1%) and the largest ownership of buffaloes (38.9%). The same groups are also the poorest of the poor but continue to provide a substantial proportion of milk through mainly informal marketing systems. The larger farmers will continue to flourish with scope for expansion of operations due mainly to access to credit.

Associated with the ownership of buffaloes and cattle according to land holdings, it is interesting to note the distribution of buffaloes across AEZs. Table 3 presents related data also from India. While the irrigated AEZs are the traditional environments of the species, there is clear evidence that buffaloes are also expanding into mainly rainfed AEZs. Over a 25 year period between 1982–1997, Table 3 indicates that the buffalo population growth rate was highest in the arid area (Government of India 1997). The combined population growth rate of 5.2% per year for the arid and rainfed areas is over two times that of the irrigated areas. Table 3 indicates the following:

- Buffalo populations are clearly expanding beyond the traditional irrigated areas into the more difficult and less favoured rainfed environment
- The trend also suggests the wider adaptive powers of buffaloes in the semi-arid and arid AEZs
- The higher proportion of ownership of buffaloes by the landless, marginal and small farmers clearly emphasises the value of the species to the poorest of the poor and the most vulnerable
- Associated with above, the benefits to enhancing nutritional and food security is enormous; and
- The trends underline the importance of targeting development initiatives that can focus on buffaloes and cattle in appropriate rainfed environments with potential impact on the improved livelihood of the poorest of the poor.

CONSERVATION OF GENETIC DIVERSITY

An important broader inference from Table 3 is the issue of recognising the implications of breeding and conserving indigenous animal genetic resources as means to mitigate climate change. As such, buffaloes as shown in the

Table 3. Distribution of buffaloes across AEZs in India (1972–1997) (Adapted from Govt. of India 1997).

Agro-ecological zone (AEZ)	Area share (%)	Share in buffalo numbers (%)		Annual growth rate (1982–1997 (%)
		1972	1997	
Arid	8.3	2.5	4.7	3.8
Rainfed	51.2	43.9	43.5	1.7
Hills and mountains	3.4	2.1	1.1	1.2
Coastal	7.9	8.2	1.1	0.8
Irrigated	15.2	38.4	41.9	1.9
Total	86.2	98.2	99.9	–

NB. The data excludes Jammu and Kashmir.

data, and also goats because of their preference for dry environments, are therefore important for multifunctional reasons and the conservation of valuable breeds. Hoffmann (2010) has also suggested that climate change can be disruptive to agro-ecosystems of origin and breed which justifies conservation. At Present about 25 improver breeds existed which can be beneficially used. There were as many as 13 distinctive dairy 'improver breeds' of goat which were that are potentially useful for appropriate introduction to promote wider usage both within as well as in other countries with a similar climate. Such a strategy is constrained at present by several issues like diseases that have to be settled together with the controlled usage of chosen introduced breeds when their usage is justified for specific reasons. Additionally, there are also issues such as disease regulations, trade restrictions, knowledge base and value in breeding programmes. Nevertheless, there are three resultant important implications:

- Breeding, multiplication and conservation of the species and their potential expansion especially to rainfed areas and small farm systems would need priority attention
- Productivity enhancement increased the contribution especially to food and nutrition security, livelihood of the poor, rural growth; and
- Increased opportunities especially for trade in live animals and animal products.

IMPLICATIONS AND STRATEGIES TO COPE WITH CLIMATE CHANGE

A direct consequence of the potentially negating effects of reduced productivity from both crops and animals to meet current and projected future demand is to disengage farmers from participating in competitive market share and to increase import.

The strategies for coping with climate change involved a combination of mitigation and adaptation, both of which had to be addressed simultaneously. Concerning the first strategy, ways and means to the extend possible have to be found to reduce CO_2 emission and therefore global warming. The second strategy involve accelerating the process of adaptation that will be required to cope, especially with increased temperature. The animal component will have to be more heat tolerant without compromising productivity. In that context, greater emphasis needs to be given to dryland agriculture. The need for more vigorous R&D on numerous issues is underlined.

Mitigation

The principal strategy in biological terms is the excellent information in the ADB (2009) report which although focused on South East Asia relates to GHG emission in the agricultural sector and includes the following:

- Feeding straw-based complete diet
- Reduction in fertiliser-related emission
- Reduction in CH_4 emission from rice paddies
- Reduction in CH_4 emission from large dung heaps such as in intensive pig production in China and buffalo dairies in Pakistan
- Reduction in emissions from land use changes
- The breeding and conservation of indigenous animal genetic resources as a means to mitigate climate change
- Sequestration of C in agro-ecosystems and especially integrated tree crops-ruminant systems, such as with oil palm in Malaysia; and
- Production of fossil fuel substitutes.

In South Asia, more variable AEZs are common, typified by most of northern India and Pakistan having semi-arid to arid conditions. The AEZs are characterised by even higher temperatures than those in the humid AEZs, lower rainfall, and shorter length of growing period (LGP). The major issues and practices of concern in South Asia include droughts, dryland agriculture, rangeland management, animal production and landlessness. Climate

change has had a serious impact on the agricultural sector as well as the very poor people and livelihood systems in South Asia.

Shade in Plantation Crops

The presence of shade from plantation crops is a major advantage to animal production, especially if it involves dimported exotic stock. Several options exist in the context of stratification. With the oil palm environment in Malaysia, the production options include the following (Devendra 2009):

- Increase in breeding of goat numbers and productivity
- More intensive utilisation of the available forage biomass and AIBP in situ
- Development of intensive zero grazing systems
- Improved NRM
- Increase institutional support for integrated resource utilisation
- Encouragement of interdisciplinarity and a focus on holistic oil palm-based production, and
- Encouragement of 'market pull' and access to markets and marketing.

Adaptation

Asian farmers have a long history of adaption to the changes and effects of the biophysical environment. Adaptation has entailed in practice the use of risk minimising strategies and adoption of innovative low-input practices that can adapt to environmental change. They have done this through a deep understanding of farming systems and experience, and more particularly the use of traditional knowledge and traditional systems that are suited to particular AEZs.

POLICY REQUIREMENTS

The implementation of the R&D activities for coping with the effects of climate change in agriculture will also need realistic policy elements to ensure the success of a pragmatic agenda.

The policy requirements which are appropriate for agriculture, are reflected in the following:

- Affirmation of official policy to provide increased investments to address waning agriculture
- Priority for the contribution of buffaloes to food security and increased self-reliance
- Priority for concerted R&D of rainfed agriculture and small farm systems
- Increased focus on the development of marginal and fragile lands
- Improved water efficiency for cropping systems and land use systems
- Priority for pro-poor community-based activities that can adapt to climate change
- Promotion of ways and means to enhance C sequestration and reduce emissions of GHG; and
- Capacity building to deal with climate change.

R&D: THE NEED FOR INVESTMENTS

There is a need for concerted R&D given the extreme paucity of information concerning climate change. It is also justified in view of waning agriculture in the face of the exploding population growth, inadequate animal protein supplies, rising food prices, and the need for accelerated development of the frontiers of food production (Devendra 2010b). Adaptive research is the priority to stimulate progress in most countries.

It is relevant to note that estimated returns to agricultural R&D are high and often high enough, to justify an even greater investment of public funds (Pardey & Beintema 2001) as reflected by the massive investments and policies that resulted in the success of the Green Revolution in India. More recently, the FAO (2011) has also emphasised critical investments for agricultural research to increase productivity and to enhance the ability of agricultural systems, especially smallholder farms to cope with climate change and resource scarcity.

The R&D agenda must necessarily be pro-poor and specifically target the less favoured areas (LFAs) or rainfed areas. More importantly, it must also target the more densely populated areas populated by very poor people. This approach ensures that there will be maximum impact of the R&D activities on a greater pool of poor beneficiaries in the LFAs. The potential value of these areas and especially for animal production has recently been reviewed (Devendra 2012).

CONCLUSIONS

The threats of climate change and potential impact on animal production, especially on food insecurity were real and inevitable. Several strategies exist that were potentially important and needed to be pursued vigorously in interdisciplinary R&D terms to mitigate the impact of climate change. Key themes that merit attention include *inter alia* as follows:

- Development of the potential value of rainfed areas and improved use of LFAs in pro-poor initiatives
- Breeding and conserving indigenous animal genetic resources as important means of mitigating the impacts of climate change;

- Wider expansion and benefits of integrated tree crops-ruminant systems, including stratification and C sequestration; and
- Wider application of the breakthrough finding that the use of nitrate salts potentially reduces methane production in ruminants to minimal levels.

There is great urgency for the capacity of R&D to address the issues and intensify the efficient use of the natural resources. Increased investments and institutional commitment are also necessary to support the preservation of the environment, improving productivity and human welfare.

ACKNOWLEDGEMENTS

The author is appreciative of the comments of the reviewers which were very helpful in finalising this review.

Date of submission: December 2011
Date of acceptance: March 2012

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A Transformational Role for our Varsities

A.R. Omar
Senior Fellow/Founding President, Academy of Sciences Malaysia;
Former Science Advisor PM's Dept.

At the 34th convocation of UPM in October 2010 in a speech for the conferment of emeritus professorship of the university, I had suggested a defined new role for our public universities in line with current emphasis in national transformation, and that they be called transformational universities (TUs). What also prompted me to do so was the active discourse on the changing role of universities among academic in the West.

During a talk in Kuala Lumpur in July 2007, Prof Tim Wilson of Hertfordshire University described his university and a few other UK universities, as business-facing. They deliver education through a business perspective. Courses are designed with industry input. They adopt a "revolving door" approach to business. They support entrepreneurship. They promote user-driven R&D. They give credits for business internship. They are therefore different from the older academic facing UK universities such as Oxford and Cambridge. However, most universities now are a mixture of both.

Richard Levine, writing in the August 2006 issue of the *Newsweek* magazine, described a number of "global universities". "They seek students from around the world. They send their students abroad. They offer courses that address the challenges of an interconnected world. They undertake collaborative research programs to benefit all humanity". The top five global universities were American. Cambridge and Oxford came in 6th and 8th, respectively. Two Japanese and two Australian universities were in the top 40. The only Asean representative was the National University of Singapore (NUS) at 31st position.

Similar to the global university concept is the third generation university (3GU). This was described by Prof J.G. Wissema of the Delft University of Technology, Netherlands, in his 2009 book *Towards the Third Generation University*. 3GUs are characterized by active competition globally for the best students, academics and research contracts, undertaking interdisciplinary research focusing on global issues, pursuing active R&D commercialization and encouraging the development of technostarters from among students and faculty. Because of the importance given to commercialization, they have an elaborate organization and management structure. MIT and Cambridge are among of 3GUs, while the Institut Teknologi Bandung is an example of a university in transition to a 3GU.

There was also an argument for UKs universities to focus more on the local community. Prof John Goddard of Newcastle University had in 2009 called for re-inventing the civic university in a publication by the national endowment for science, technology and the arts (NESTA). This proposal according to Goddard ("finds a parallel in the tradition of US land-grant institutions which have ... a duty to develop the communities in which they decide … to the future Newcastle University is given as an example of born-again civic university")

What then is the situation in Malaysia? Universiti Putra Malaysia (UPM) was modeled after the US land-grant colleges whose functions were teaching, research and extension. Extension was a major activity of UPM. Facilities for practical aspects were extensive in order to serve well its constituency — the farming community. When UPM changed its name to Putra, the facilities were largely dismantled and the extension service discontinued. UPM became just like any other Malaysian universities. However, UPM is now repositioning itself to again lead in the new agriculture, implying the application of hi-tech and modern management, high value-added agribusiness and sustainability.

Five Malaysian IPTAs are now research universities (RUs), of which one is the apex university. All have strengthened their infrastructure for science, technology and innovation (STI) and their effort in research, development and commercialization (R,D&C). They are also developing the organization and management structure for R,D&C in the manner of the 3GU described earlier, but with less global engagement. Our RUs are therefore in a good position to contribute directly to the national socio-economic transformation programme. This is one major attribute of a transformational university, the other being holistic human capital development.

Holistic human capital (HHC) development means, the development of the full human potential comprising "a portfolio of different skills and assets" required by both government and industry. HHC embraces intellectual capital (strategic thought process), skill capital (technical competency), social capital (inter-personal skill, communication, cooperativeness, smart partnership), entrepreneurial capital (creativity, innovativeness, entrepreneurship, managerial), physiological capital

(commitment, passion, dedication, self-belief) and spiritual capital which includes ethical values and integrity.

The HHC components can be delivered either formally as part of the courses or non-formally through a conducive campus environment. For example, elements of entrepreneurship and management can be incorporated as part of the core for all courses. The ethnic composition of our students together with the presence of foreign students can be harnessed to enhance the social and physiological capital.

Success in developing HHC will produce superior knowledge workers. These are people who can provide solutions to problems, working alone or in a team; are equipped with core competency; be highly motivated, adaptable and possess the capacity for life-long learning to master new skills; can become a risk taking technostarters, with smart partnership work ethics. The HHC development will create an innovative and creative workforce, critical for success in the innovation economy.

Unfortunately the task of developing the HHC cannot be left to the university alone. It has to begin at home, through the school system and eventually at work. However, the TU does not have to wait. It can start designing programs and creating the ecosystem immediately.

A transformational role for our public universities implies a bigger commitment to the national socio-economic transformation programme, through two major initiatives; firstly a holistic human capital development contributing to a creative, innovative and civilized workforce; secondly an enhanced capacity for excellence in STI and for R,D&C contributing to both capacity building and wealth creation. It's time to transform, to be transformational.

Space Research Areas and Capacity Needs – Gaps, Issues and Challenges

R. Varatharajoo[1]

Malaysia has adopted various strategies in developing its space sector. Indigenous space technologies would enable a sustainable growth of the space field and at the same time develop the strategic space technologies. Therefore, issues related to the current space research level are fundamentally crucial to be highlighted. Subsequently, the space focus areas can be derived in order to meet the expectations of the national and international space technology growth requirements, which are moving on to a stronger posture in R&D. In the absence of a strong R&D national space industry leadership, the Malaysian space sector remains in a traditional downstream mode of the world space technology supply chain ever since. The space technology supply chain can be divided into the ground segment and the space segment. This paper examines the current space research activities in Malaysia within the framework of the space technology supply chain. As a result, a preliminary gap in the overview of space research in Malaysia is established.

In this paper the status of space research Malaysia is presented. The views discussed herein are those of professional views that are deeply thought to be informative; and therefore, the nature of the arguments is towards a general understanding. The aerospace sector has been identified as one of the major contributors to the nation's wealth in the early 1990s. For example, the turnover of the aerospace industry hovered around RM25 billion in 2010. This trend was maintained and gradually kept increasing as well. However, the aerospace engineering field in Malaysia can still be considered at a developing stage.

We have witnessed some serious activities since a decade ago covering the education, research, business, etc. The interest is actually spurred by the *National Aerospace Blueprint* (MiGHT 1997). The blueprint identifies key initiatives for transforming Malaysia into a regional and international aerospace nation by year 2015. The blueprint includes 45 noble recommendations to achieve this clear goal. It is important to note that the recommendations focus primarily on the human capital and aerospace facility investments within the country. In parallel, a roadmap was also drafted together with some policies. The roadmap covers mainly the aeronautical field; whereas the astronautical field (space) was seen as a relatively smaller contributor to the national aerospace annual turnover. It is a fact that the astronautics field has been introduced only some 20 years ago compared to the aeronautical field, which has been around since the Malayan Airways days in 1950s. Therefore, its technology development activities are even less matured compared to that of the aeronautical activities. In such an infant state, the manned space mission had already been executed without acquiring all the necessary space technologies.

Actually, Malaysia has bypassed most mandatory space technology developments and participated in small satellite, medium-satellite and manned space programme through the foreign space facilities. Obviously, there is a huge technological vacuum in the domestic space field. In the following section, the space field and its research areas will be generally discussed. Thereafter, the national space field mapping will be carried out in order to identify the space R&D gap. Subsequently, the crucial space research vacuum can be revealed.

SPACE RESEARCH AREAS

Generally, space research can be divided into two categories, i.e. the space segment and the ground segment. The space segment consists of all the activities related to space sciences (e.g. astronomy, planetary protection, space life sciences, etc.), spacecraft (e.g. satellites and space modules) and rockets. The ground segment consists of all the activities performed in ground stations (e.g. telemeasures, telecommands, etc.). In fact, the ground segment can also be considered as a part of space applications. Figure 1 elaborates the space activities in Malaysia with respect to a typical classification of space clusters. Note that the manned and unmanned capsules are considered as the integrated rocket parts before their orbit insertions. It is worthwhile to mention that Figure 1 only considered developed or acquired space technologies in

[1]Department of Aerospace Engineering, Universiti Putra Malaysia, 43400 Selangor, Malaysia
Corresponding author (e-mail: renu99@gmx.de)

Malaysia. Therefore, a direct purchase of space solutions is not considered. Figure 1 shows that the space R&D activities have been conducted. The outcome of those *R&D Activities are Ground Models and Low-cost Models*. The *Ground Models* refer to the Earth-based space solutions, e.g. ground station solutions, laboratory space solutions or space engineering models. The *Low-cost Models* refer to those *Ground Models* that are ready and can be tested in a specific space mission. The *Flight Grade Models* are space solutions that have clocked operation hours in space. Once the *Flight Grade Models* are available; the models can then be considered as *Commercial Space Models* for commercialization.

The *Unmanned* and *Manned Capsules* are concerning the human exploration in space. At the moment, *R&D Activities*, *Ground Models* and *Low-cost Models* can be found in the *Satellite Systems and Applications* cluster in Malaysia. For the *Rocket Systems* and *Space Science* clusters only the *R&D Activities* and *Ground Models* are available. Obviously, the *Flight Grade Models* could not be developed due to the lack of maturity in *R&D Activities* and *Ground Models*. It is clear that there are opportunities for improvements in terms of space R&D in Malaysia.

SPACE RESEARCH CAPACITY NEEDS

The space research gaps have to be indentified profoundly so that the corresponding space research capacity needs can be correctly established. The content of each space cluster in Malaysia will be discussed below.

Satellite Systems and Applications

There are a reasonable number of activities related to *Satellite Systems and Applications* in Malaysia. The *Satellite Systems* comprise of satellites and satellite ground stations. Satellites can then be divided into platforms and payloads. A satellite platform holds all the vital subsystems such as power, communication, altitude and orbit determination and control, thermal and onboard computers (Varatharajoo 2003). Usually, a platform can be a standard feature for most satellites. On the other hand, payloads (e.g. communication devices, optics, radar, etc.) vary depending on the satellite missions. There are *R&D Activities* concerning the satellite subsystems leading to *Ground* and *Low-cost Models*. However, these activities are mostly concentrated on the satellite integration works which are practical and engineering in nature. The lack of profound

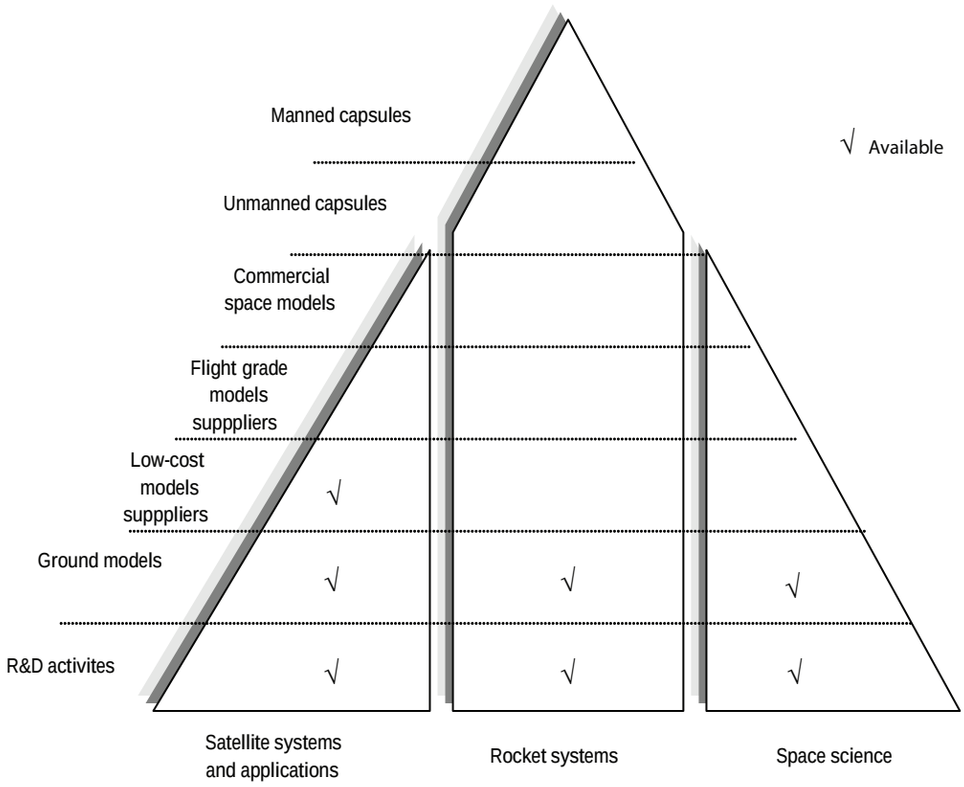

Figure 1. Classification of space clusters and activities in Malaysia. The classification is based on the article contributions mapped using SCOPUS irrespective of their total number of contributions in each a cluster. The annual space research contribution growth is around 20%.

satellite subsystem and payload research works precludes their reporting in top space journals. Nevertheless, there are space scientific works on satellite subsystems reported in top space journals.

The *Satellite Applications* such as the remote sensing activities (e.g. meteorology, earth observation, etc.) and communication solutions (radio frequency, radar, GPS, etc.) are reasonably active in Malaysia. Many satellite application research works have been reported in a wide range of engineering/science journals. It can be seen that most of the *Ground* and *Low-cost Models* for satellite applications are very specific and localized, e.g. remote sensing softwares and communication solutions. Therefore, it is difficult for these models to be incorporated into the existing satellite systems as *Flight-grade Models*. An absence of scientific research efforts concerning the satellite ground stations is also evident at this point. In fact, indigenous ground station solutions can fetch a high commercial value, which can be the driving factor for research in this area.

Rocket Systems

The *Rocket Systems* comprise rockets and their ground stations. There are basic *R&D activities* and *Ground Models* mainly on the solid fuel sounding rockets. The liquid fuel option has been recently proposed as well. Only very few scientific works on rocket systems are reported in common engineering journals. The *R&D activities* on other rocket elements such as structures, liquid fuel engines, guidance and control systems, onboard computers, separation systems, docking systems and heat protection systems are not available. Therefore, rocket extended elements such as the ground stations, life support systems, manned and unmanned capsules are not available as well. Thus, any rocket research venture would be fine. However, such efforts seem to be remote at the moment due to the lack of human capital and heavy budget.

Space Science

There are *R&D activities* in *Space Science* leading to the development of practical *Ground Models*. The *Ground Models* are mostly concentrated on system integration as well (e.g. simple telescope system). Ground Models concerning the space probes and space flight experiments are not available. Most research activities are observation and measurement works related to the astronomy, meteorology and radio sciences; and these research findings have been mainly reported in a wide range of common engineering/science journals instead of top space journals. Crucial and profound space science research work should be started mainly on planetary protection (e.g. space debris, meteorites, asteroids, etc.), space weather and scientific balloons. On the other hand, space science activities related to microgravity conditions such as for life sciences can be initiated through drop-towers or parabolic flights. However, space life science research works are rather desirable if a country is hosting human space flights.

CONCLUSIONS

The issue that hampers the growth of local space research is the high dependency on global space players. Instead, the fundamental development in the space field geared towards self R&D capabilities are deemed to be the only realistic solution in making Malaysia a sustainable space nation. Otherwise, Malaysia would always remain as the end user at the downstream level of the space technology supply chain. In this regards, we should stop importing these crucial technologies, but start developing indigenous (novel) technologies instead. The success in achieving this goal depends mainly on the long-term commitment of the space researchers, the government on one side representing the nation, and the space industry. Therefore, researchers should expand their research scopes and establish external linkages if necessary to develop more *Ground Models* leading to significant *Low-cost Models* and *Flight-grade Models* in order to bring a positive impact of space research in Malaysia.

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Development of Hybrid Rice for Food Security in the World

Long-Ping Yuan[1]

The current world population is 7 billion and will reach 8 billion in 2030. Meanwhile, the annual loss of land to other use is 10 to 35 million ha, with half of this lost land coming from cropland. It is expected that 60% more rice should be produced in 2030 than in 1995. Currently, 1 ha for rice production provides food for 27 people. By 2050, 1 ha will have to support 43 people. Facing such severe situation of population growth pressure plus cropland reduction, it is obvious that the only way to solve food shortage problem is to greatly enhance the yield level of food crops per unit land area through the advance of science and technology.

Rice is a main food crop. It feeds more than half of the world's population. Therefore, rice plays a very important role in food security and poverty alleviation. Theoretically, rice still has a great yield potential to be tapped and there are many ways to raise rice yield. This could be achieved by: building irrigation works; application of more fertilizer; improving soil conditions; cultural techniques and breeding of high yielding varieties. Among them, it seems at present that the most effective and economic alternative is to develop hybrid varieties based on the successful experience in China.

It has been proven that practically for many years hybrid rice has achieved more than 20% yield advantage over improved inbred varieties. In recent years, hybrid rice coverd 58% or 17 million ha of the total rice area in China. The nationwide average yield of hybrid rice was 7.3 t/ha, about 1.4 t/ha higher than that of inbred varieties (5.9 t/ha). The yearly increase of grains in China due to the growing of hybrid rice could feed 70 million people annually. Therefore, hybrid rice has been playing a critical role in solving the food problem in China, thus making China the largest food self-sufficient country.

China makes increasing progress in the development of hybrid rice technology. In order to meet food requirement for all Chinese people in the 21st century, a super rice breeding programme was set up by the China Ministry of Agriculture in 1996. It was divided into three phases, and the yield targets were:

Phase I (1996–2000) 10.5/ha
Phase II (2001–2005) 12/ha
Phase III(2006–2015) 13.5/ha
(Average yield at two locations with 6.7 ha each in two consecutive year)

Through morphological improvements plus the use of inter-subspecific (*Indica/Japonica*) heterosis, very good results were achieved in developing super hybrid rice varieties.

Several pioneer super hybrids were developed by 2000 which met the Phase I yield standard and released for commercial production since 2001. In recent years the area under these pioneer super hybrids was around 2 million ha and the average yield was about 8.3 t/ha.

The breeding of Phase II super hybrids was successfully attained in 2004. The planting area of these hybrids was 500 000 ha in 2010 and the average yield was over 9 t/ha.

Excitingly, a super hybrid variety-Y Liangyou No. 2, yielded 13.9 t/ha on average in a 7.2 ha demonstration plot last year. It meant that the goal of phase III super rice breeding programme was attained.

The above facts indicate that the super hybrid rice has a very bright future. If super hybrid rice covers an annual area of 10 million ha in China and with an yield increase of 2 t/ha, it is expected that the annual increase grains will reach 20 million tons. This means another 70 million more people can be fed every year.

Hybrid rice has been proven to be a very effective approach to greatly increase yield not only in China, but also outside China. Vietnam and India have commercialized hybrid rice for years. In recent years, about 700 000 ha were covered with rice hybrids in Vietnam. On average, the yield of rice hybrids is 6.3 t/ha while that of the inbred varieties is 4.5 t/ha. As a consequence of planting hybrid rice on large-scale commercial production for years, Vietnam emerged as the second largest rice exporting country. Besides, many other countries, such as the Philippines, Bangladesh, Indonesia and USA, have also achieved great success in extending hybrid rice technology. For example, in the Philippines, under technical assistance from the China National Hybrid Rice R&D Centre, hybrid rice was

[1]China National Hybrid Rice Research and Development Center, Mapoling, Furong District, 410125 Changsha, Hunan, P.R. China
Corresponding author (e-mail: lpyuan@hhrrc.ac.cn)

commercialized since 2002. In 2010, the area under rice hybrids was increased to nearly 200 000 ha and the yield advantage was two tons per ha. Based on this achievement, the Philippines government has lauched an ambitious plan. The target is to expand the area of hybrid rice to one million ha by 2012. Even in USA, the super country, hybrid rice also has greater yield advantage (>20%) over their local varieties. The area under hybrid rice was 400 000 ha in 2010.

These facts clearly show that hybrid rice technology developed by China is also effective to greatly increase rice yields worldwide. If 50% of the conventional rice is replaced by hybrid rice, and estimating on a 2 t/ha yield advantage of hybrid rice, it is estimated that the total rice production in the world will be increased by another 150 million tons of rice which can feed 400 million people each year.

Therefore, I firmly believe that hybrid rice, relying on scientific and technological advances, and the efforts from all other aspects, including governments, private sectors, NGOs and particularly from FAO and IRRI, will have a very good prospect for commercial production, and moreover continue to play a key role in ensuring the future worldwide food security in the new century.

Wildlife Rescue and Rehabilitation Center: Do We Need One in Malaysia?

S. Vellayan
Associate, Academy of Sciences Malaysia
Faculty of Medicine, UiTM 40450 Shah Alam

Rehabilitation is a process involving sick or injured animals displaced from the wild to nurse them back to fitness in captive condition and subsequently release them back into the wild, with their welfare being the underlying concern. The programme could be categorized at different levels by individual rehabilitation, species, community or biodiversity level. There should be clarity of thought on whether it is the conservation of species or the welfare of individuals that takes priority. Rehabilitation is for individual animal welfare, but simultaneously addresses conservation related issues. The massive destruction of the forest has resulted in animals coming out from their 'homes' and getting knocked down by trains or road vehicles, entering into housing areas and thus they become a threat to the public. Those who keep them as pets, hand them over to zoos or simply abandon them when they grow fiercer, and if they fall sick, the public is not in the position to give medical care. This is when poachers come into the picture, and these poor animals are killed for their meat or for medicinal value. Thus, there is an urgent need to have such a centre so that a home with proper medical attention can be found from them. Such centers already are established in Thailand, Indonesia, India, Vietnam and China, particularly focusing on birds of prey, wild cats, primates, ungulates and other species. We must understand that the department and zoos for that matter have limited space, limited facilities, and cannot accommodate the increasing numbers of such animals sent, found or confiscated. If no attempt is made to protect them, it can be foreseen that the population of wild animals would continue to decrease. Besides being sent there for protection, animals at the center could also be used by universities to conduct studies, especially to look into emerging viral, bacterial and parasitic diseases.

Wildlife rehabilitation is becoming more common in developing countries. This is complicated by local economic, cultural, and health concerns. Like zoos and wildlife management agencies, wildlife rehabilitation is neither good nor bad. There are excellent programme and unacceptable programmes in both developed and developing nations (Anon 1999). Programs in developing countries are confronted with: (1) High costs relative to local living standards; (2) Differences in political priorities from those in developed countries; (3) Cultural attitudes with different values placed on animals and among various species; (4) Limited technological resources; (5) Threatened or endangered species; and (6) Species and situations that pose serious health concerns for animals and humans. Unlike the typical rehabilitation center in developed countries, programme in developing countries rarely receive animals because they are sick, injured or orphaned but more frequently handle animals confiscated form the pet or commercial trade by law enforcement officials. This difference affects the approach needed for rehabilitation programmes.

Veterinarians and rehabilitators from developed countries participate in helping to develop wildlife rehabilitation programme and have an ethical obligation to promote approaches and practices that will truly benefit wildlife rather than benefit any organizational or personal agendas (Anon 1999).

In addition to the many considerations involved in rehabilitating wildlife in developed countries, we need to be aware of other issues inherent to working in different cultures and environments and with different species if we are going to be truly successful. Many of the major issues can be categorized as: (1) Animal welfare concerns; (2) Local attitudes; (3) Professional development; (4) Ecological and population issues; (5) Politics; and 6) Financial issues.

Animal Welfare Concerns

A common reason for rehabilitating and releasing wild animals is the increasing concern in modern societies for the individual animal's well-being (Robston 1992; Sikarskie 1992). This concern has led to the development of some very well managed rehabilitation programmes in North America and Europe, facilitated by the political, economic, and cultural environments in which they developed. In developing countries, the international community and sensitized local individuals also see animals being kept in less than desirable situations and want to see something done about it. Financial resource and/or attitudes towards

animals frequently result in those being maintained in situations below the optimum level required for their physical or psychological health. Despite the lack of financial resource, many government agencies, private organizations, and individuals in developing countries around the work have wild animals in their care (Sajuthi *et al*. 1992). Often, no alternatives for better housing exist.

The post-released situation for the animal may include displacement by others with established territories, injury, debilitation form malnutrition or sickness, and eventual death thereby raising welfare questions (Cayford & Perciral 1992). Beyond the concern for the welfare of the released animal, we should consider that improperly performed reintroductions can displace conspecifics or spread disease to established animals in the area, endangering their well-being. Therefore, releasing animals into the wild in suboptimal situations contradicts true welfare concern for them and others in the release area. Facilities that provide good housing or a semi-captive environment is one solution for some of these animals, but these opportunities are not common in developing countries.

Helping to establish appropriate living environments, whether in captivity or semi captivity, is one way individuals in developed countries can help these animals. Another way is to help educate those involved in rehabilitation programme in developing countries about the use of euthanasia. Although in some instances, cultural influences may preclude this option, in most countries resistance to the idea of euthanasia is not very different from that in developed countries (Sajuthi *et al*. 1992). For the well-being of an animal, bending the rules of political correctness should be justifiable for a veterinarian. By extremely conservative estimate, thousands of non-domestic animals are being held in terrible conditions while concerned individuals discuss the subject. Although not the solution to the wild life rehabilitation issue, euthanasia for many of these individuals would be a human solution to their suffering. In developed countries, unreleased sale animals are usually placed in good housing conditions are euthanized and options tend to be the exception rather than the rule.

The post-release effects can be addressed by good monitoring of released animals and the other animals in the environment. Although the same concerns exist in developed countries, workers in undeveloped countries are often forging new grounds with little experience and poor financial resource. The release of healthy animals in areas where they do not threaten other animals combined with some method of monitoring should be the goal for all programmes. This is a third area where we can help to ensure the well- being of animals. Not every released animal requires the full expense of evaluation and/or radio tracking. But these procedures are necessary in the long-term plan to establish suitable techniques until the procedure for a given species at a given location is proven to be effective and save.

Local Attitudes

Public attitudes towards animals vary tremendously among different socio-economic, cultural, and religious groups in all countries of the world. In developing countries, the lack of funds available for maintaining wild animals in captivity can be exacerbated by local attitudes and/or traditions that may identify some species as undesirable or useful as food or medicine.

In North America and Europe, wildlife rehabilitation programme can provide a vehicle for expanding public awareness about conservation issues. By taking advantage of media opportunities or school programme, local people and political bodies can be educated about threats to wildlife and the environment. In education programme at 14 wildlife rehabilitation centers in the United States, 715,9000 visitors were reported to have participated (Caldecott & Kawanagh 1983; Cayford & Percival 1992). Visitation at a government run wildlife rehabilitation facility for orangutans (*Pongo pygmaeus*) in Sepiluk, Sabah, Malaysia, exceeds 200 000 annually and provides an exceptional opportunity for educating local people about conservation issues. Other rehabilitation centres allow access only to tourist or research volunteers willing to pay large amounts of money. This policy may result in significant income for managers and staff, but it comes at the cost of alienating local people (typically not able to afford the fee) and possibly missing their most important audience. Some facilities such as the orang-utan center in Sabah have avoided this situation by having different fees for local and foreign visitors.

Care must be taken in educational programme to avoid in advertently giving the message that these animals make interesting and suitable pets. Another potential negative by product of enhancing public awareness through rehabilitation programme is a backlash of public opinion regarding the distribution of government or international donor funds to developing countries. This includes having limited access to good housing, adequate food, and proper medical care. The image of showing more concern for animals than for the local population can lead to attitude that may be counterproductive to conservation efforts in general. Anticipating this problem and making efforts to mitigate negative effects is integral to the long-term success of programme and may be accomplished with appropriate public awareness programme or by ensuring tangible benefits to local communities. With an understanding of local attitudes, properly managed rehabilitation centres in developing countries can play an important role in public education and in nurturing respect for animals.

Professional Development

In addition, to educate the public, about conservation of wildlife rehabilitation, programmes should provide educational opportunities for individuals who require training in the care and handling of indigenous wildlife. This practice is common in North America, with veterinary schools are utilized as rehabilitation centers for the training of students. By providing experience for local professionals, rehabilitation operations in Malaysia could be enhanced to facilitate local capabilities. Practice with rehabilitating animals may provide the only opportunity to develop the skills needed for handling rare or endangered species. Unlike most species in programmes in developed countries, species often found in developing country rehabilitation programmes are often endangered or threatened. International involvement is appropriate when local expertise is not available to provide adequate training. Experienced zoo veterinarians could contribute to training efforts at these facilities or provide training in their respective areas of work (zoos, etc.) Rehabilitation programme are handicapped frequently in developing countries by inexperienced staff, and the involvement of experienced foreign professionals would be a valuable contribution.

Wildlife Health Issues

The first challenge is the availability of local veterinarians involved in wildlife health care. Most local veterinarians have little exposure to wildlife medicine, do not have access to medical information on the species, and typically do not have the financial resources to care for wildlife.

Clearly the health risks associated with releasing rehabilitated animals requires veterinary input (Anon 1999, 1992; Caldecott & Kavanagh 1983; Karesh 1993; Sikarskie 1992), but the lack of available experienced veterinarians has at times resulted in the substitution of inexperienced volunteers from developed countries. Although it may seem that any veterinarian, veterinary students, or person with non domestic animal experience from a developed country is better than without veterinarian at all. This is not the case. There is no reason that an individual considered unqualified to be responsible for wildlife care in North America to be considered as qualified in a less-developed country.

Skilled local veterinarians may be present in the country but are not necessarily available and ready to be included in projects. As professionals, we should make a conscious effort not to facilitate the exclusion of local veterinarian but be supportive of a leading role in ensuring their participation.

Field work in developing countries has been traditionally used by North American and European universities for graduate and post-graduate student self-teaching experience in many of the biological sciences. This approach is inappropriate when the health and well-being of individual animals and populations is at risk. We should not consider developing countries as a training ground for veterinarians or veterinary students without ensuring proper supervision.

A second challenge arises from the lack of available equipment, supplies, and diagnostic capabilities, pharmaceuticals, or inactivated vaccines that veterinarians take for granted in developed countries. In most countries, it is a difficult task to have a feline viral serology panel run in a wild felid and obtains the vaccines to protect the cat from these diseases. Similarity, few of the diagnostic and therapeutic tools that a North American avian practitioner might use on a daily basis would be found in bird rehabilitation programme in most countries of the world. More importantly, continued access to these items or the money to pay for them must be ensured for the continuation of the programme.

Access may require modification of governmental regulations regarding importation of medical equipment and pharmaceuticals, and the funding requires a secure financial source. Limited availability of appropriate materials, like the lack of available professional skills, is a serious hindrance to implementing a good rehabilitation programme in a developing country. Programme that proceed to release animals without resolving these needs are doing a disservice to the animals and providing legitimate support to appointments of wildlife rehabilitation.

A third health issues in many developing countries relates to the species being rehabilitated, their susceptibility to disease to which they are normally not exposed, and the potential for these animals to transmit these disease to wild populations after their release.

Developing countries typically receive animals confiscated or donated from captive environments, often with exposure to domestic animals and humans. In some cases, animals are confiscated overseas and exposed to species from other continents before being returned to the country of origin. These animals may then be slated for re-introduction back into remote areas where native wildlife has not been exposed to diseases of domestic animals and humans, or to exotic diseases. Many of these diseases are difficult to accurately diagnose, treat, or prevent even with extremely sophisticated medical resources. These factors cannot be ignored and place a tremendous burden of responsibility on programme in developing countries. The health risks to humans and animals presented by working with confiscated orangutans with tuberculosis and/or hepatitis B (Sajuthi *et al*. 1992) is a good example of the difficulties faced in developing countries.

Ecological and Population Benefits

Most wildlife rehabilitation programme have developed due to the concern of individual people for individual animals. Unlike restocking or translocation programme, few if any rehabilitation programme have been initiated to save a population or species from extinction. The rehabilitation and re-introduction of individuals may play a significant role in stabilizing or augmenting a wild population. Population census and distribution data, as well as modeling capabilities, are necessary to determine the benefit or impact of releasing more animals in a given area. Analyses of the population dynamics of free-ranging orangutans (Anon 1993) and gibbons (*Hylobates spp*.)(Anon 1994) indicates that introduction of young rehabilitated animals to an existing population has no effect on population viability, whereas reducing the loss of adult females from poaching and habitat loss is essential to avoiding extinction.

Given the identified risks, such as the introduction of disease, a clear benefit to wild populations should be demonstrable before releasing animals in areas with resident wild animals. Areas free of susceptible species or disease vectors should be used as an alternative when financial resources are available. Utilizing confiscated animals to establish new free-ranging populations may be of greater biological conservation value than releasing animals into an area already near carrying capacity or with an unknown population status. Establishment of new populations of orangutans is now being attempted is East Kalimantan Indonesia and is being planned for an area on the island of Sumatra. Transfer to long-term care facilities, or euthanasia should be considered when suitable release sites cannot be identified or when the release programme cannot ensure safety for established wild populations.

Political Realities

Most programme in developing nations deal with charismatic, endangered, or threatened species. These animals generate local and international attention, which leads to political ramifications. Often, the animals are obtained as a result of law enforcement activity. The decision regarding the fate of these animals is then complicated by political and legal factors.

Government or public agencies are responsive to public opinion. Local or international attention to a crisis may lead to an effort more effective in displaying responsiveness than in protecting wildlife. Even a single injured mammal or bird on a tourist beach can end up featured in a newspaper and generate public pressure for response. Although agencies in North America and Europe face these same problems, the situation in developing countries is exacerbated by the lack of programme, experienced personnel, and funds to deal effectively with these situations. Common practices of citizens in killing and eating turkeys (*Meleagris gallopavo*) to celebrate Thanksgiving in the United States has been little affected by the fact it seems barbaric or disgusting to some people in Southeast Asia. In developing countries economically tied to developed countries, international attention or pressure can misdirect the attention or priorities of local government authorities. Organizational resources can be easily depleted in dealing with these situations and therefore reduce other activities which might have more broad ranging effect on wildlife. In our concern for the well-being of individual animals, we should not allow such effort to be a substitute for or to displace effective conservation programme in developing countries.

Political pressure can result in the release of animals unsuited for release or the captivity of animals that are releasable. Both situations require prudent diplomacy and a professional approach to affect the greatest conservation impact without scarifying the well-being of the animals involved. Nationalistic attitudes may prevent sending non-releasable animals to oversea facilities that can provide a better captive plan than in the country of origin. International pressure on a government may force the release of sick or behaviourally impaired animals back into the wild.

Costs

The allocation of limited financial resources is a major concern to everyone involved with wildlife rehabilitation efforts. Operations run on shoestring budgets may work in a small number of situations, such as when animals are inexpensive to care for, the rehabilitation period is short, and medical needs are minimal. In developing nations, the cost of facilities and labour is typically low which is an advantage of in-country programme. However, the high cost of proper food, medications, diagnostic tests, etc. can become prohibitive. One vaccine may cost the daily wage of a staff member. Expenses for essential supplies and equipment represent a much higher percentage of total costs, thereby limiting the use of these items. At some point, decision regarding the allocation of financial resources must be made. For example the costs of proper medical and quarantine care (Sajuthi *et al*. 1993) of a single confiscated orang-utan for six month in Indonesia was calculated to be approximately USD1000. This figure approximates the annual salary of one of two park guards, raising the question of how much Indonesian habitat and wildlife could be protected with the same amount of money. This estimate did not include the costs incurred during the 2–5 years typically associated with rehabilitation of orangutans once they are released from quarantine (William 1995). The medical costs alone during the quarantine of confiscated gibbons in Thailand have been estimated to be USD364/animal (Rolston 1992). This

information is critical for making appropriate decisions regarding allocation of financial resources. A commonly heard justification for avoiding difficult financial choices is that the funding sources are different. But we all play a role in helping to direct funding sources over time. Private donors and government agencies can be educated to shift priorities and must understand that the value of a rehabilitation programme, like any conservation activity, differs among situations (William 1995).

Project costs must be weighed against total project benefits. A low-cost project that may have little effect on wild populations may still be of high value from the conservation education and animal welfare perspective. Home, low-cost projects, can have substantial impacts on wild populations. A high-cost project with the same characteristics may be worth doing, but alternative uses of the funds may accomplish more. Cost cutting that result in increasing the risks to the rehabilitated animals and/or the wild populations is professionally unacceptable. This risk to the rehabilitator is low, immense. When costs are accurately identified, decisions among projects can be made to increase the per dollar impact.

CONCLUSION

Rehabilitation programme in Malaysia face a wide range of critical issues. Programme must be evaluated on a case-by-case basis to determine their effectiveness in achieving their stated goals and to determine the validity of those goals themselves. Programme in Malaysia face even greater challenges because of limited financial and professional resources. Lack of access to technology, equipment, and supplies, differences in public attitudes, the conservation status of species typically involved, and political realities. In some situations, rehabilitation programme may play a role in enhancing conservation of wildlife must remain objective, professional, and aware of the inherent complexities when developing, implementing, or evaluating these programme.

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Algae, the Next Palm Oil

Ahmad Ibrahim
Fellow, Academy of Sciences Malaysia

Everyone knows about palm oil. To many it is synonymous with Malaysia. Though not native to the country, Malaysia has made palm oil a global leader in the oils and fats trade. The benefits are mutual though. While Malaysia has changed the destiny of palm oil for the better; palm oil has reciprocated by helping the country tackle rural poverty. Consumers worldwide now recognise palm oil as one that offers unique advantages over other oils. It was once an almost unknown commodity hidden in the lush jungles of Western Africa. And thanks to palm oil, much of the poverty in rural Malaysia has literally disappeared. FELDA is one visible evidence of such transformation which many other countries try very hard to replicate.

Over the years, palm oil has become a prime national asset. Each year it generates billions of Ringgit to Malaysia's coffers. It is also a major provider of employment. Growth is however an issue. Its expansion has slowed down considerably in recent years because of limited land. Many predict the most it can expand is 5 million hectares. It now stands at 4.5 million hectares. This is made even more challenging by environmentalists demanding a moratorium on the opening up of new land for agriculture. Now the industry is looking to science for help. Scientists are now working hard to develop higher yielding oil palm to expand production. This may however take years. Many Malaysian palm oil companies have now ventured abroad to expand. Indonesia is one favourite destination. But lately, many have looked at Africa as another target.

With the projected stagnation in palm oil production in the country, new crops are being evaluated. One which has come to light belongs to the algae and the seaweed family. At a recent Academy of Science Fellows inaugural lecture, Prof Phang Siew Moi of University Malaya shared her findings from many years studying algae and seaweed. Her results showed algae holds enormous economic potential. They confirm the growing scientific evidence on the efficacy of the algae species as a source of many products the world needs. Add to that the fact that algae can efficiently mop up carbon dioxide, the leading greenhouse gas, the crop can help alleviate global warming and the consequent climate change.

One product being touted as a potential output of algae cultivation is biofuel. Studies have revealed that there are algal species that can rival palm oil's high yield on a per hectare basis. This means on the same crop area algae can produce more oil than the oil palm. Some results suggest even three to four times more. But more important is the fact that algal cultivation is not limited by the land scarcity. It can be grown on water. In fact some marine algae have been found to yield not only oil which can be converted to biofuel, but also other compounds which can be used in food and nutraceuticals. Scientists believe there exist some exotic algal species which can produce many other bio-compounds for mankind. More research will unravel such treasures.

There are some working on algae as a business. The small seaweed industry in the waters of Sabah is a good example. But unfortunately, the downstream business of extraction and refining is mostly done outside Sabah. This means the country is losing out on the higher value products of seaweed. Similarly there are attempts to grow algae in the country. But this has not been supported by the latest technology in terms of species selection as well as downstream processing. Even the R&D on algae in the country is not properly co-ordinated. It may be high time to change all this. If Malaysia is to efficiently tap on algae as a new growth sector, more co-ordination is called for. More resources may be needed to nurture and expand this industry. It may be worth looking at the palm oil model. We need to institutionalise the support system in order to help grow the algal business into another instrument of wealth generation for the country. Looking at the many high value products that algae offer, the algae industry may prove to be even more lucrative than palm oil!

No Stopping Rare Earths Expansion

Ahmad Ibrahim
Fellow, Academy of Sciences Malaysia

Ask any taxi driver in Kuantan, the east-coast state of Peninsular Malaysia, about rare earths. Or listen to any coffee shop talk in Balok on Lynas. Chances are many will have negative things to say about the health and safety risks associated with rare earths processing. Though the scientific facts say otherwise, a majority of the public in Kuantan are convinced that rare earths spell danger for their well-being. The question is, are they fed the right facts? Are they being misled? Whatever it is, there is no denying that those who vehemently oppose the rare earths plant in Gebeng have succeeded in shaping public opinion in their favour. But how will that affect future foreign investments to Malaysia? Especially those high technology investments which carry some level of risks related to safety and health, even though manageable with the proper system.

Judging by the pace of new technologies entering the marketplace in recent years, we will be seeing more such opportunities. How do we deal with that? Do we just close our doors to such investments? Or do we prepare ourselves to safely manage and benefit from such opportunities? One thing is clear though; the advent of the green economy will most definitely increase mankind's dealings in new materials which can be challenging and risky. We need to know how to manage such materials if we are to benefit from them. If we fail to do that, many others are already lining up to deny us the opportunities. This is already seen in the rare earths business. While a small minority in Kuantan are spreading negative facts about rare earths, everywhere else in the world many are jumping on this business bandwagon. China, for example, is expanding its involvement in the rare earths business.

Most would agree that we need to seek new avenues to drive the nation's growth. Very few would dispute the fact that the country's socio-economic future faces many threats. The petroleum sector, for example which for years has been a major contributor to the country's coffers, is showing signs of decline. The nation's oil and gas reserves cannot last forever. Though new areas are being explored, it is just a matter of time before we join the likes of countries which were at one time flushed with oil wealth but now having to depend on import. A good example is the North Seas oil. Not much oil is left there now.

Can revenue from the rare earths business come to the rescue? Judging by the worldwide scramble to invest in the rare earths business, there may be realistic opportunities in rare earths. Rare earths have some how emerged as a strategic material for the world. This has led to a rise in the global interest in the rare earths business. According to industry analysts, China, as the leading supplier, aims to control the trade in rare earths. By imposing export control on rare earths, China also wants to influence world prices. Analysts believe, China is buying time to build the downstream sector by controlling supply as well as keeping prices high outside China. Any new source of supply outside China would therefore not augur well for China. Analysts see Lynas as bad news for China. With increasing supply from sources such as Lynas, prices may decline attracting more players into the downstream sectors.

Meanwhile, the rest of the world is campaigning hard to expand the supply source of rare earths outside China. Recently, there was a big rare earths conference in Canada to discuss strategies for increasing rare earths production outside China. There was no one from China, and when news of Lynas getting their pre-operating license was announced, there was jubilation at the conference, as told by a Malaysian participant. The latest development is that new rare earths processing plants are sprouting in many parts of the world. These include the USA, Australia, Europe and Africa. Apparently, the interest in rare earths is not just because of their demand in green technology products. Rare earths have on the other hand also found strategic applications in the military. Can Malaysia afford not to support investments in rare earths?

Integrated Approach to Fight Diseases

C.P. Ramachandran
Senior Fellow
Academy of Sciences Malaysia

Remember the SARS outbreak a while back? Remember the chaos it created for international travel? In Asia, at least, air travel almost came to a standstill, Then came H1N1. Again, the tourism trade suffered.

In recent years, we have all been badly affected by the emergence of infectious diseases. These differences include SARS, swine flu, bird flu, H1N1, Nipah virus, dengue and many others. This has not only led to the loss of loves but it also inflicted serious disruptions to businesses such as tourism and international travel.

Why have infectious diseases suddenly become rampant? Scientists have linked the rise in the new and previously suppressed infectious diseases to the dramatic change in global climate as well as the environmental changes sweeping the planet. The worrying part is that man has been found largely responsible for such changes.

It is through human activities that the levels of greenhouse gases in the atmosphere have increased at alarming rates. Experts now agree that the consequent warming of the world by the uncontrolled release of such greenhouse gases is now the most serious threat to the sustainability of the human race.

Why exactly are such new diseases appearing? Scientists believe that a driving force behind the emergency and re-emergence of such diseases has much to do with the disturbance and destruction of natural habitats. Cutting down forests for agriculture as well as the unchecked pollution of rivers and other water bodies promote viable conditions for new and old disease-causing microbes to thrive.

This is further exacerbated by the mushrooming of urban slums in many developing countries which lack proper sanitation. Will this change? How do we balance the need to open up new lands for agriculture and food production, but at the same time safeguard the habits of life threatening microbes?

Take the case of the dangerous Nipah virus which created a serious public health scare in Malaysia a while back. It was found in Asian fruit bats. In the late 1990s, it emerged as a fatal disease in humans. This has been linked with a combination of forest fires in Sumatra and the clearing of forests for agriculture. In their search for fruits, the bats came into closer contact with domestic pigs. This gave the virus the change to spread to people who handle pigs.

A similar situation was also reported in Bangladesh. This issue of environmental degradation and a rise of many new and old infectious diseases is complex. It is causing increasing concern among scientists and public health specialists.

Overall, it seems natural habitats which are left intact tend to keep infectious agents in check, whereas an altered and degraded environment tends to shift the natural balance triggering the spread to people of new and existing diseases.

Since 2008, man has been confronted by no less than 346 infectious diseases. These are distributed in a haphazard fashion across 220 countries. Apparently three new diseases are described every two years, and a new infectious organism published every week. It is very alarming. Over 1600 human disease-causing organisms have been reported, each with a specific type of susceptibility characteristics. This creates a lot of pressure on diagnostic laboratories.

How do we deal with such frequent outbreaks of infectious diseases? Can we adopt more preventive measures rather than a fire brigade kind of approach?

Since the situation is man-made, only man can do something to arrest the problem. Much can be done to reverse the current trend. First, the public health infrastructure for infectious diseases control must be rebuilt.

There is substantial evidence to show how better regional planning and developing, including urbanization, agricultural expansion and conservation of forests and ecosystems can minimise and even reduce such outbreaks.

There is no quick fix to the problem. What we need is an integrated approach. This will involve meshing social and economic development programmes, as well as environmental and natural resource management, with intervention premised on disease ecology and community participation. Only then can the spread of such infectious diseases be effectively contained.

MAHATHIR SCIENCE AWARD FOUNDATION (904190-H)

He is known as the "Father of Hybrid Rice" and has won many awards for his innovative breakthrough. In 2011, he was named as the winner for Mahathir Science Award in recognition of his courage to think independently, out of norm, in his rice breeding work. Prof Yuan LongPing, the Director General of China Hybrid Rice Research and Development Centre, through his innovation has resulted in the development of hybrid rice, a staple food of the tropics and has consequently revolutionised global rice production and has led to improved sustainability.

This year, Mahathir Science Award Foundation is calling the nomination for 2013 Mahathir Science Award to scientists, researchers and institutions who share the same aspiration as Prof Yuan LongPing and other Mahathir Science Award past winners. The Foundation is pleased to receive nominations from scientists, researchers and institutions that has made internationally recognized scientific breakthrough in pioneering tropical research which has brought greater positive impact on the well-being of society. **Submit the nomination now and visit our website for further information.**

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Joint G8+ science academies' statement on Water & Health

Access to clean water and sanitation was declared a human right by the United Nations on July 28th, 2010.

Background

The Millennium Development Goal (MDG) 7C states: "*Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation*". The Academies of Science of the G8+ countries stress that accessibility, quality and protection of water resources are fundamental to human health in rural and urban areas worldwide. The objectives of MDG7 are imperative in helping to achieve the MDGs on poverty, universal education, food and energy security, gender equality, child and maternal health, most critically, MDG4, reducing child mortality. Diarrhoea-related illnesses kill more children under five years old than AIDS, malaria and measles combined and are the second leading cause of child death. Over 85% of diarrhoea worldwide is due to unsafe water, inadequate sanitation or insufficient hygiene.

A focus on improving sanitation is urgently needed as there has been significantly less progress in this area than in access to safe water. Furthermore, through population growth, increasing pollution and climate change, water as a resource will become scarcer: it is estimated that around 3 billion people will be living in water-scarce countries by 2050. Today, almost 900 million people lack access to a clean water supply, with 2.6 billion people lacking proper sanitation: the direct and indirect effects of a lack of clean water and sanitation are profound.

Within the last decade, more than 1 billion people in the world have now gained access to safe drinking water; much less progress has been made on sanitation and this has a major impact on human health. It is estimated that the MDG sanitation target will not be met in Sub-Saharan Africa for more than half a century; this is clearly unacceptable. An estimated 16% of the population in Europe, and just under 40% of the world population also lack suitable sanitation.

Nearly 20% of the world population - mainly in rural areas- still practise open defecation, resulting in 300 million tons of untreated human excreta polluting fresh water resources each year. This contributes significantly to the transmission of more than 20 different infectious diseases. In addition, domestic animal populations and their excreta are increasing, as diets change to a higher meat intake. Furthermore, improper urban and industrial waste disposal threatens surface and underground water resource quality.

In the absence of improved sanitation, the efficacy of expensive vaccines and chemotherapy to control water-borne infectious diseases is seriously compromised. Policy-makers must understand that access to drinking water and sanitation facilities go hand in hand. Solving the lack of water services for tap water supply, treatment, hygiene and sanitation would mitigate many other health, economic and social problems. Providing sustainable access to safe water and sanitation is one of the most crucial development interventions in helping poor people to lift themselves out of poverty. It is also one of the most *cost-effective* public health measures.

Water and health impacts

Major health issues are associated with unsafe water. They include:

- Water-borne infectious diseases - some of animal origin - including cholera, and other diarrhoeal diseases, hepatitis, amoebiasis.
- Water-related vector-borne diseases such as malaria, filariasis, schistosomiasis and dengue, affecting more than 500 million people worldwide.
- Diarrhoeal diseases represent one of the major sources of morbidity/mortality in developing countries, accounting for the death of between 1.5 and 2 million children under the age of 5, annually (UNICEF_WHO, 2010). Alarmingly, 50% of hospital beds in the developing world are occupied by patients with water-borne diseases.
- Increasing concentrations of organic pollutants through anthropogenic activity (whether industry, agriculture or groundwater management related) and of naturally occurring arsenic, fluoride and nitrates in water all constitute human health hazards. They require either the development of alternative water resources or appropriate cost-effective treatment technologies. Regulations on chemicals need to be improved through better understanding of eco-toxicity and the toxicology of chronic exposure to micro-pollutant mixtures. Traditionally prevalent in industrial countries, chemical pollution is now emerging as a public health concern in developing countries. These countries are now also confronted with massive urbanization. Areas of greatest population density present different challenges to rural populations. The re-emer-

gence of cholera is largely due to the spontaneous and burgeoning growth of mega-cities, townships, shanty towns and favelas with no sewage systems or infrastructure. Major improvements have to be made in sewage treatment.

- Water and sanitation issues can be intrinsically linked to land issue and whilst access to water and sanitation is now recognised as a basic human right, this is often overlooked for displaced people; a problem that will become all the more important with increasing mass migration.

Socio-economic impacts of sanitation and safer water

The improvement of sanitation and use of safe water would strongly impact:

Economical development and lost productivity

Diarrhoeal diseases account for an estimated 4% of the total DALY (Disability Adjusted Life Year) global burden of diseases, nearly 90% attributable to unsafe water supply, lack of sanitation and hygiene.

Education

Approximately half a billion school days are lost each year due to water-borne diseases. The lack of adequate facilities in schools is one of the factors that prevent girls from attending school, particularly when menstruating. Gender-sensitive sanitation, together with education and hygiene, especially handwashing, has significantly reduced the incidence of water-borne and diarrhoeal diseases, *e.g.*, in Bangladesh and Morocco.

Public health

Promoting sanitation must be a priority for the development of public health if we are to attain the MDGs. Achieving the MDGs will depend on the promotion of international coordination, community-based cost-effective technologies - such as membrane filtration units - that have dramatically improved access to microbiologically clean water from individual to community scales.

Integrated Water Management

An integrated approach to managing at watershed level should address the biogeophysical, climatic, social and economic issues related to water management particularly within river basins.

Looking to the future

The objectives recommended above can be met with a budget estimated at 12 billion US dollars per year over 10 years to address sanitation problems of the concerned populations (MDG7C). The benefits of fulfilling the sanitation programme are so rewarding, both socially and economically, that the Academies urge the leaders to address this concern and identify methods to meet the financial challenge.

Recommendations

The Academies of the G8+ countries strongly recommend the following action plan to their Governments:

- Develop basic infrastructure for sanitation and maintenance, to achieve acceptable quality water as key priorities and reduce rural/urban disparities. Sanitary facilities in schools are a priority, adapted to local, environmental, technological and cultural constraints.

- Promote education including training of professionals and technicians; help to improve management of water quality, in order to change the behaviour of populations regarding water supply.

- Fund research and development for the identification of pathogens of animal origin and the development of simple, low-cost and efficient markers. Further epidemiological studies are needed to develop vaccines against water-borne pathogens.

- Promote capacity-building to improve water management and hygiene standards; support watershed level community-based actions favouring the key role of women both in rural and peri-urban areas (“*unheard voices of women*”).

- Establish networks of competence at national, regional and global levels to improve the efficiency of water use in domestic context, as well as in agriculture and industry, through research and innovative practices that are ecologically oriented.

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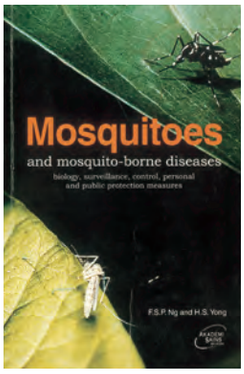

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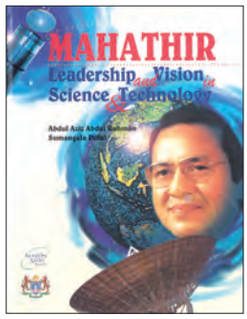

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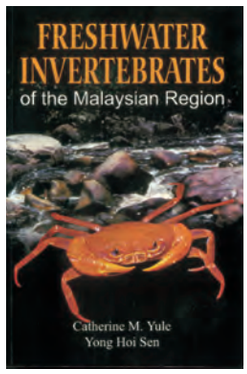

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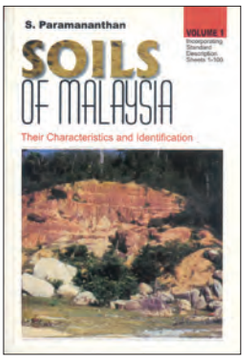

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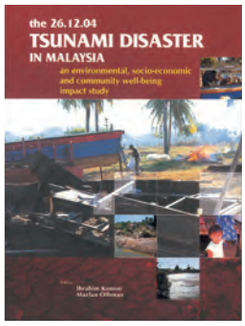

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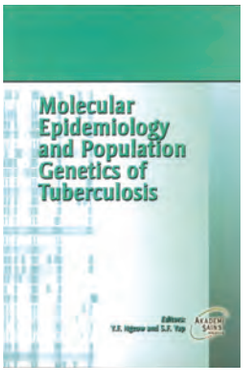

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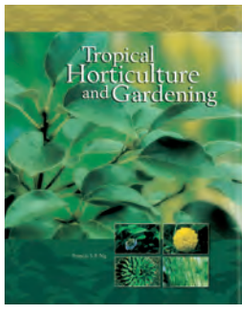

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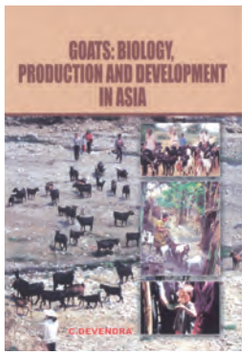

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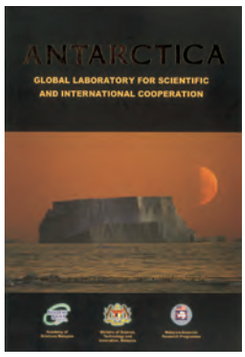

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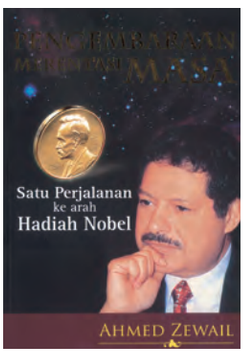

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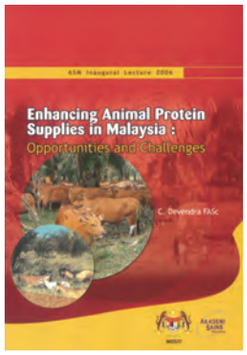

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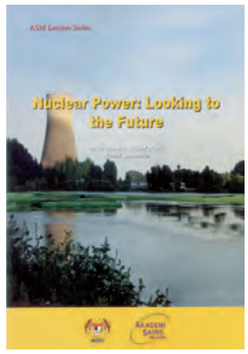

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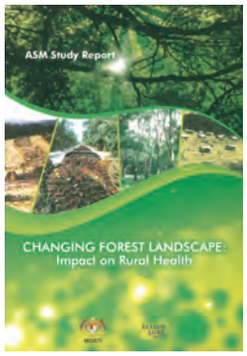

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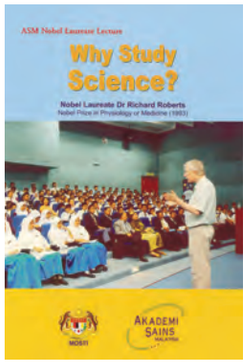

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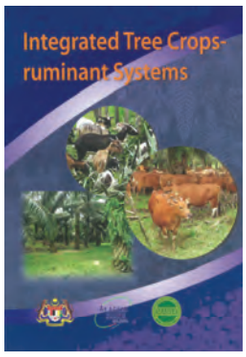

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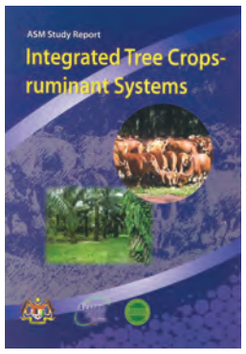

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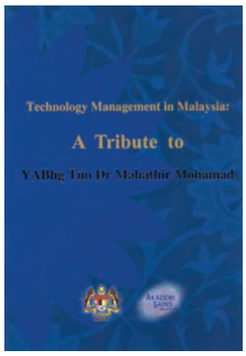

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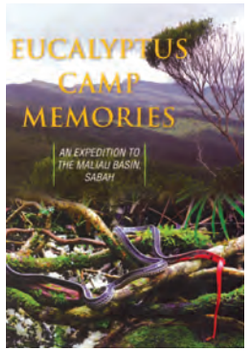

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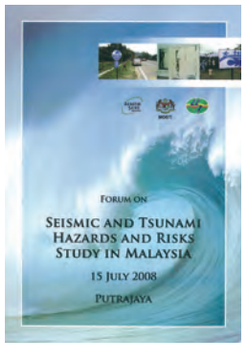

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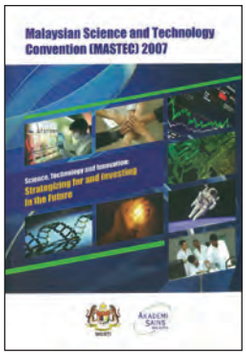

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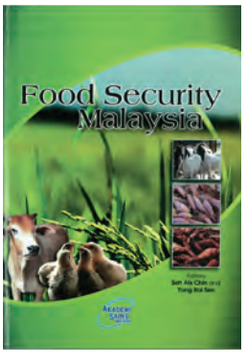

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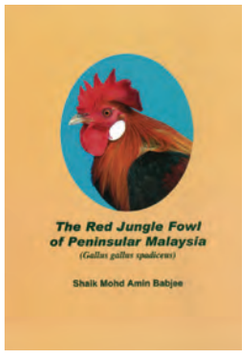

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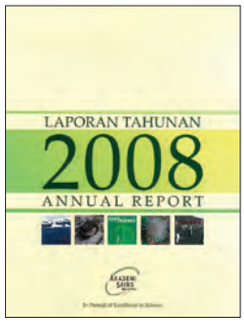

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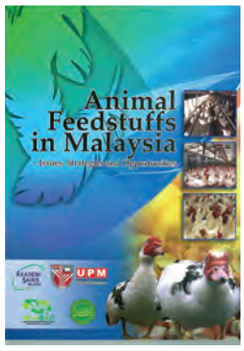

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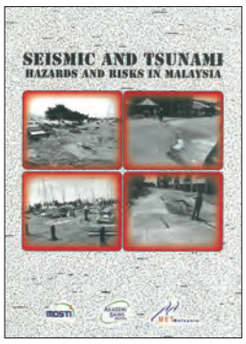

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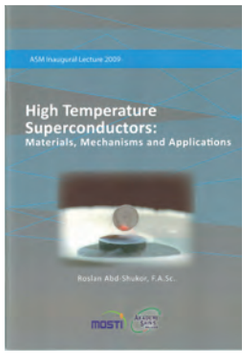

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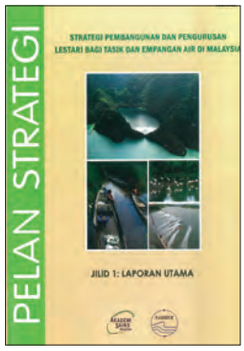

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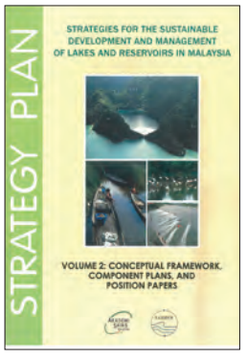

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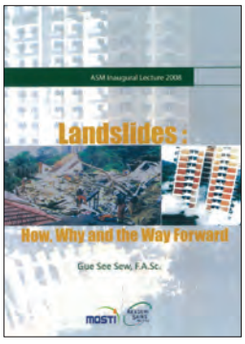

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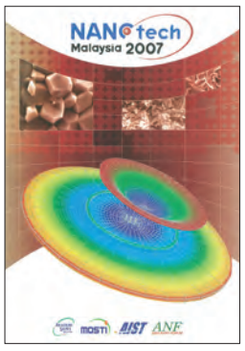

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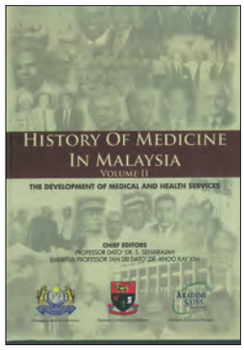

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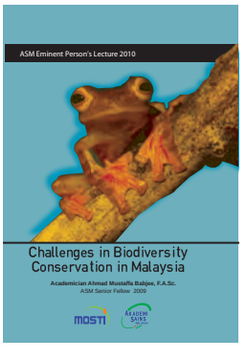

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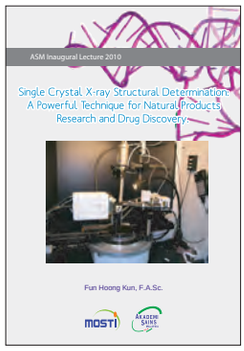

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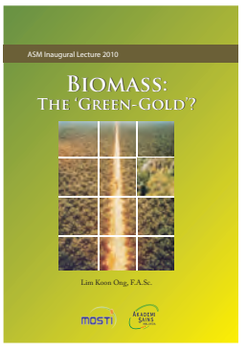

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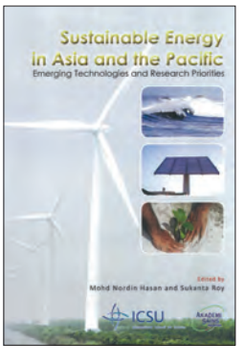

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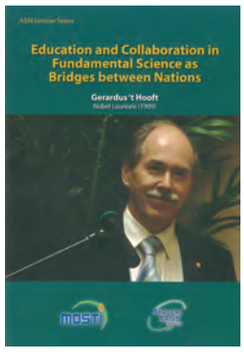

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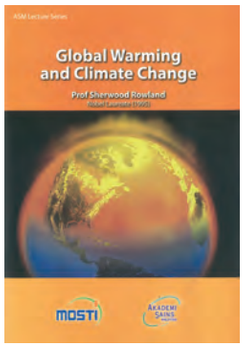

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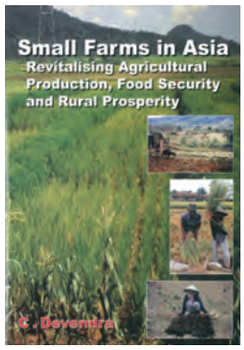

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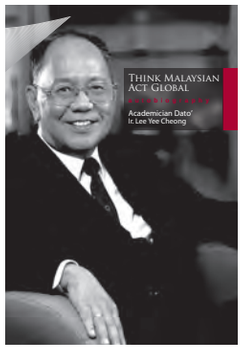

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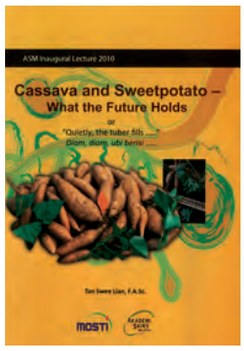

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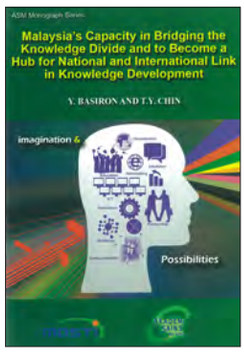

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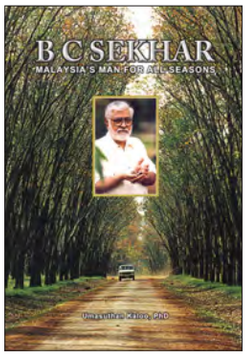

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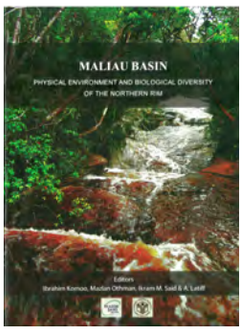

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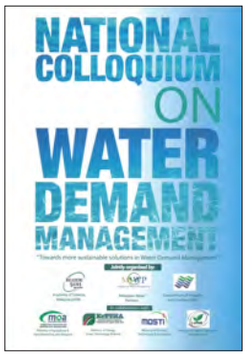

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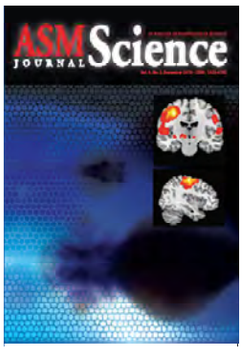

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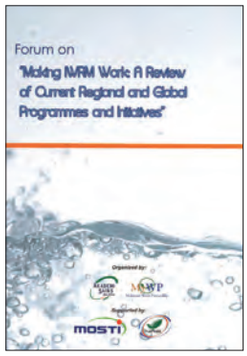

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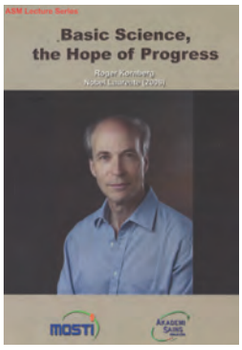

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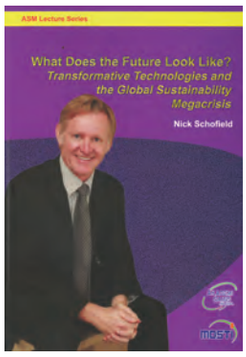

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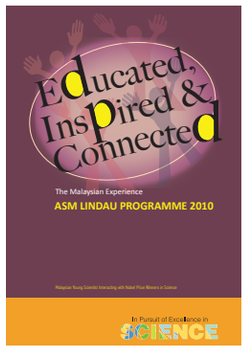

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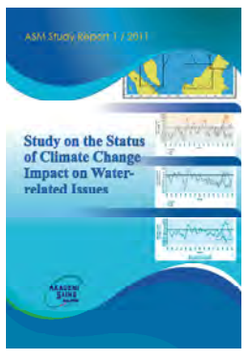

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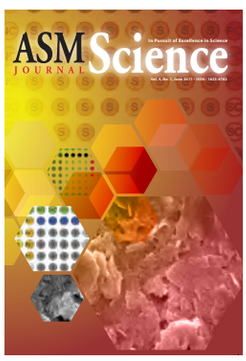

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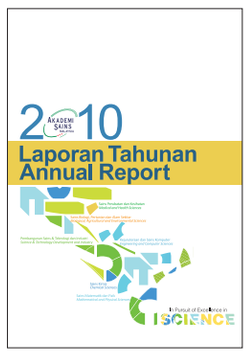

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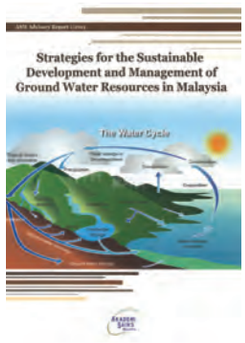

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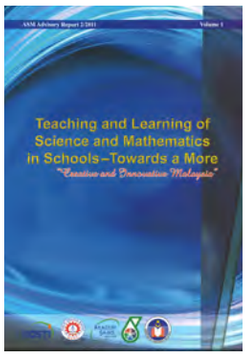

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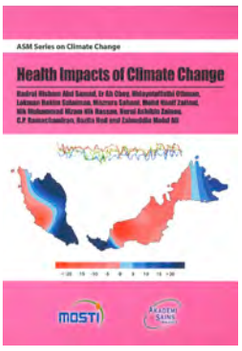

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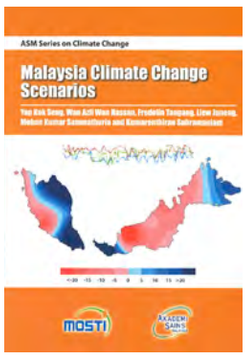

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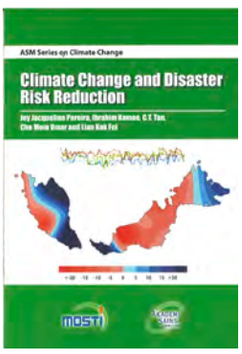

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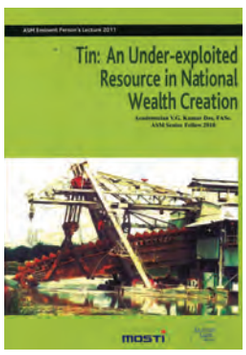

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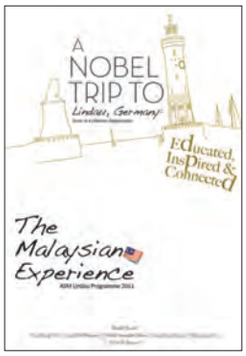

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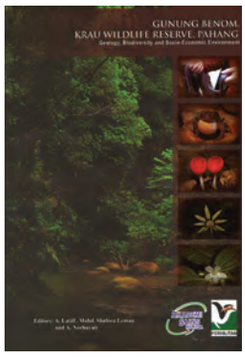

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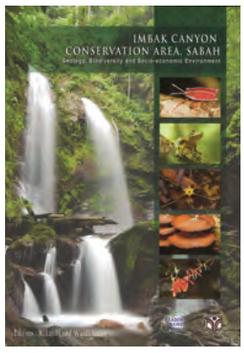

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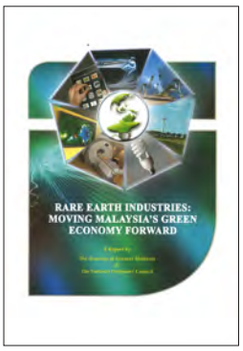

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Each issue of the journal will also feature Reviews/ Commentaries presenting overviews on aspects such as Scientific Publications and Citation Ranking, Education in Science and Technology, Human Resources for Science and Technology, R&D in Science and Technology, Innovation and International Comparisons or Competitiveness of Science and Technology etc. Reviews/Commentaries will encompass analytical views on funding, developments, issues and concerns in relation to these fields and not exceed 5000 words in length and 40 cited references.

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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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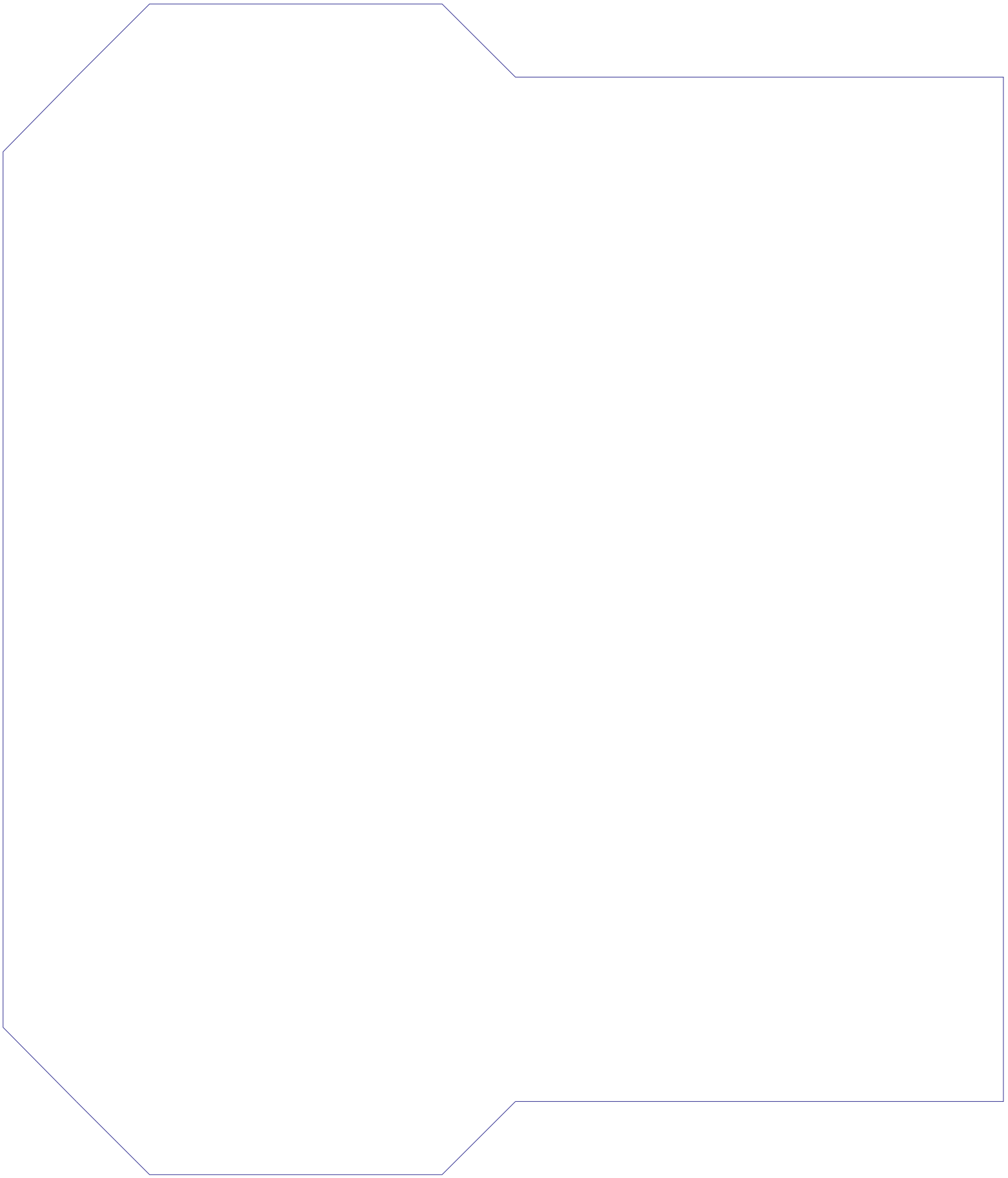

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