2011/12 - 2012/13
Hong Kong Budding Scientists Award
Collection of Students' Proposals to Future World Problems / Authentic Problems

Gifted Education Section
Curriculum Development Institute
Education Bureau
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前言

教育局資優教育組於二零零五年開始籌辦第一屆「香港科學青苗獎」計劃及相關的培訓活動，目的在現有的平台以外，為學生提供一個以科學領域為背景的全面培育機會。

起初構思「香港科學青苗獎」的計劃時，我們已了解到本地各式各樣的科學比賽，因此計劃的設計，除注重培育科學資優生的潛能外，同時亦注入與其他比賽不同的元素，包括情意教育，避免資源重疊。

計劃首先要求參加比賽的學生，進行相關文獻的整理和研究，發揮他們的創意，為一個「未來世界難題／現實難題」提供不同的解決方案，從中訓練他們資料搜集、分析、綜合、評鑑及應用科學知識的能力。之後，學生需要訪問本地一位從事科學研究的學者。我們希望學生可透過面對面的訪談，了解成功科學家的奮鬥過程，他們／她們的科學研究對社會的貢獻，學習他們那種百折不撓的態度和精神，並且能夠深入認識科學的本質。我們相信，受人尊崇的成功科學家所應具備的素質，不單包括豐富的學科知識，而且還須具備良好的解決問題能力和道德修養。最後，評判更會提問學生有關解決方案的詳細資料，參與的學生便要磨練自己的應對及表達能力。

整個「香港科學青苗獎」計劃，歷時大半年，每一個環節都與下一個環節緊緊相扣。我們希望參與計劃的學生，視整個計劃為一個學習的歷程，並且能夠虛心聽取別人（指導教師及評判）的意見，不斷檢討現況，改進自己。
教育局籌辦這個比賽，不但給予學生多一個機會發掘及發展自己在科學方面的潛質，同時亦希望藉此機會，將比賽的題目，學生比賽時的經歷與評判學者的專業意見，整理成有高度參考價值的教材。我們期望教師們能夠參考本資源套，於學校層面推展相類的活動；或於校本課程中引入本計劃的理念，調適現有課程，讓更多的學生能夠受惠。

教育局資優教育組
初賽（科學知識測驗）

- 初賽的科學知識測驗，包括50分鐘的筆試－30題多項選擇題及2題結構式題目；
- 題目主要以課程發展議會初中科學科課程綱要及小學常識科課程綱要的內容為基礎，亦會涉及其他相關範疇；
- 試題分中文、英文版本。參賽校隊必須以報名參賽時所遞交的參賽語言作答；
- 試卷不提供任何方程式或公式；
- 參加半準決賽的甄選準則，會以每隊最佳得分的3位隊員的分數總和計算。中、小學組每組得分最高的20-30隊，會入選半準決賽。

半準決賽

- 參賽隊伍需要從3條「未來世界難題/現實難題」中選擇一題，提交解難方案報告；
- 內容需包括：
  - 簡介 — 簡單介紹所選難題的背景；
  - 解決方案 — 建議解難方案，並提出理據作解釋；需輔以插圖、圖片及相片等幫助說明所建議的解難方案；
  - 討論 — 討論解難方案的利與弊；
  - 總結及建議。
- 參賽隊伍需以學校報名時所選擇的語言（中或英）撰寫解難方案報告；
- 在中、小學參賽作品中，各選出最多15份進入準決賽。
準決賽

◆ 參賽隊伍須就評判團對自己隊伍的解難方案的提問作解答；
◆ 評判團會根據參賽隊伍遞交解難方案使用的語言，以廣東話或英語，
  提問學生；
◆ 解難方案的口頭答辯的評分著重：
  · 學生對題目之了解；
  · 學生能否回應評判團之表現；
  · 學生能否運用科學概念回答評判團之提問；
  · 學生的解難能力與彼此間的合作。
◆ 在中、小學隊伍中，各選出最多8-10隊進入決賽。

決賽

◆ 參賽隊伍需考慮評判在準決賽給予的意見，修改其「未來世界難題/現
  實難題」的解難方案。
◆ 決賽分為兩部份：
  第一部份：「未來世界難題/現實難題」解難方案
  · 參賽隊伍需在決賽當天遞報修訂的「未來世界難題/現實難題」的
    解難方案；
  · 遞報解難方案報告後，參賽學生需以學校報名時所選擇的語言回答
    評判的提問。
  第二部份：「科學家專訪報告」
  · 參賽隊伍需在決賽前訪問一位本地的科學家，並完成專訪報告；
  · 科學家專訪報告，需包括學生的反思部分——例如受訪科學家對社
    會的貢獻及學生從科學家身上學到的事情等；
  · 科學家專訪報告使用的語言，需與遞交的解難方案所選用的語言
    相同；
  · 參賽隊伍可以創意的方式，在決賽當天遞報「科學家專訪報告」，遞
    報方式不限——可以運用動畫、電子簡報、錄像或角色扮演等多媒體
    的方式；
  · 遞報科學家專訪報告後，參賽學生需以學校報名時所選擇的語言回
    答評判的提問。
2011-12
Winning Proposals
Hong Kong Budding Scientists Award
2011-12年香港科學青苗獎比賽題目
「未來世界難題/現實難題」

1. 廚餘問題

據報導本港每日產生逾3000公噸廚餘，約佔本港固體廢物量約三成。現時，大部分的廚餘，都會運往堆填區，令堆填區的空間越來越少。雖然政府擬於大嶼山小蠔灣興建廚餘廠，但每日最多亦只可處理200公噸廚餘。在可見的將來，廚餘的處理，仍然會是本港固體廢物處理其中的一個重要課題。試考慮實際情況，結合科學及科技的方法，計畫一項可行的方案，推薦給香港政府採用。計畫中的建議必須實用、具經濟效益、符合科學原則及有證據支持。

2. 城市的綠洲

我們居住的城市在全球暖化及熱島效應之下，每年的平均溫度已不斷上升。根據香港天文台的記錄，香港夏天的溫度可達35度攝氏。

本計畫的目的是去研究及設計在某特定戶外地方可使用的一個合適「屏障/遮光物」（shelter/shade），以減低各地日間的溫度。你們須從不同角度考量「屏障/遮光物」的設計，例如：「屏障/遮光物」擺放地方，其高度、使用的物料、結構及形狀等。你所設計的「屏障/遮光物」需通過不同的測試，並有足夠的數據以支持。

在報告內所提出你的解難方法需實用且有科學根據。我們歡迎有創意的設計，但這些設計需有科學概念及數據的支持。
3. 其他

試描述一個發生在香港，並和科學及科技相關的現實難題。你須要說明難題的重要性及提出解決方法。你的解難方案應把重點放在科學和科技層面上。另外，你的建議必須實用、具經濟效益、符合科學原則，並有證據支持。

例一：使用鎢絲燈引發的問題；

例二：利用科學方法探究一些電視或電影中曾經出現的情節是否在真實世界存在。例如：電影中主角向門鎖射擊，破壞門鎖及開門。此情節已被另一電視節目（Mythbuster）以科學角度證實不可能。
1. **Problem of Food Waste**

   It has been reported that there are over 3000 tonnes of food waste generated in Hong Kong daily which is 30% of total solid waste produced. Most food waste is now put in landfill and thus its space is decreasing rapidly. Although HK SAR government schedules to build a new food waste plant at Siu Ho Wan on Lantau Island, it can only treat at most 200 tonnes of food waste every day. Hence, food waste will still be one of the important issues of solid waste treatment in Hong Kong in the near future.

   Taking the actual situation into consideration, with reference to the scientific and technological methods, please write a proposal to the government on this issue. The suggestions in your proposal are required to be practical, cost-effective, scientific and evidence-based.

2. **The Oasis in the City**

   Because of the global warming and the heat island effect, the temperature in the city is getting higher and higher each year. According to the record of the Hong Kong Observatory, the temperature in summer can reach 35 degree Celsius in Hong Kong.

   The objective of the project is to investigate and design a suitable shelter / shade （屏障/遮光物） in a selected open area in the city, so as to reduce the “hotness” of the area in daytime. The design of the shelter / shade should include different aspects such as location, height, material used, structure and shape. Experiments have to be done with sufficient data to prove the effectiveness of the designed shelter / shade.

   Your solution(s) in the proposal should be practical and supported with scientific evidence. Creative solutions are highly appreciated but they need to be supported with science concepts and research data.
3. Others

Describe an authentic problem in Hong Kong which is related to science and technology. Justify its importance and then suggest some solutions to solve the problem. Your proposal should focus on the scientific and technological aspects. Besides, the solutions should also be practical, cost-effective, scientific and evidence based.

Example 1: The problem of using tungsten lamps;

Example 2: Examine the scenes in TV programmes or movies through scientific investigations and check the possibility in a real world. For example, characters in movies shoot to successfully break in a room by breaking the lock with gun fires. This scene has been “busted” from science in another TV programme “Mythbuster” through scientific evidences.
「廚餘問題解決方案」專題報告

大埔循道衛理小學
老師：黃倩婷
學生：葉志禧 胡碧文 吳穎琳
吳澤鉅 陳諾恩

引言:
現時香港堆填區已接近飽和，故再沒有空間存放廚餘。有些人會把廚餘轉化為肥料或用來發電，可惜這些方法需時較長，更牽涉資金、時間、人力及地方等問題。基於以上的原因，我們將探討如何把廚餘改造為天然的清潔劑。我們在網上瀏覽到「利用橙皮加酒精製成去油清潔劑」的善用廚餘方法。為了引證此方法的效能，我們利用新年期間剩餘的水果外皮，如西柚皮、柑皮、桔皮等，設計以下的實驗：

目的
測試把其他果皮（廚餘）加上酒精，比較它們與橙皮加酒精的去油效能，以達致進一步善用廚餘。

實驗假設
1. 不同果皮加上酒精會有不同的去油效能。
2. 其他果皮加酒精的清潔效能與橙皮加酒精的去油效能相近。

實驗步驟
1. 把橙、檸檬、西柚、沙田柚、
   沙糖桔和柑的外皮分別切成大小相約的條狀。
2. 將六種水果外皮分別放進盛載了300mL酒精〔75%濃度〕的六個膠瓶中。〔每瓶的總重量為500g〕

3. 把膠瓶蓋蓋上，並放在同一個密封的紙箱內。
4. 88天後，把各種100mL的混合物（已隔渣的水果外皮）分別倒入放有300mL水及30mL油（代表污垢）的六個膠瓶中，並且大力攪拌。

觀察膠瓶中油和水的乳化作用並記錄下來。
實驗原理
在這次實驗中，我們利用了乳化作用的科學原理作探究。根據葉名倉教授所言「乳化作用是指兩種原本互不相溶的液體（例如：油和水）在經過大力攪拌或者添加乳化劑等表面活性劑之後，有一方形成微粒狀，分散於另一方中而互相混合成為均勻狀態。而這樣的作用下所產生的液體就稱之為乳化液。乳化液的組成要素有：
1. 流動相：用來當作分散介質，通常是水（親水基）。
2. 固定相：在乳化液中呈現微粒狀或懸浮狀，通常是油（親油基）。」

本實驗將指定的水果皮加上不同濃度的酒精，當作清潔劑（乳化劑）使用，如果愈多油被乳化（水和油混和變得混濁），就代表那個量杯中的「清潔劑」較有效。

結果
透過觀察實驗結果（附件一）及用直尺量度油的厚度（附件二），比較不同果皮加酒精與橙皮加酒精的去油效能，發現檸檬皮加酒精最好，而沙田柚皮、西柚皮加酒精則與之較相近，至於沙糖桔皮、柑皮加酒精的效果稍遜。

感想：
這次實驗十分有意義，因為親手製造出可以去油的清潔劑，既節省金錢、方便，又較容易實踐，更令甚少關心廚餘問題的我們，加深了認識，沒想到普普通通、毫不起眼的廚餘，竟可成為生活上的好幫手。還有我們學會了很多科學知識，例如乳化作用——可以將互不相容的液體混和；公平測試——實驗過程的周邊條件要相同，免得產生誤差，影響結果。最後，組員在整個過程中能充分發揮合作精神，真是難能可貴！希望香港政府採用我們的方案。
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### 附件一：

#### 100人對各樣本之評分

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附件二：

用直尺量度油的厚度

1. 用直尺量度油的厚度

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<td>沙糖桔皮 + 酒精</td>
<td>檸檬皮 + 酒精</td>
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附件三：

其他果皮 + 酒精

1. 在準決賽時，評判曾建議可試用蘋果皮、香蕉皮加上酒精，測試一下其去油效能。但經過實證後，蘋果皮、香蕉皮加上酒精去油效能不大，再者蘋果皮和香蕉皮容易氧化，加上酒精後，更容易變為啡黑色，影響外觀。相反沿用柚子科果皮加上酒精後，其亮麗的橙色，較易令人接受。因此，繼續沿用柚子科果皮作為測試對象。

評語：

同學們於日常生活中，觀察到廁餘轉化為肥料和能源的各種限制，促使他們於網上搜集廁餘其他用途的資料，再設計實驗來測試不同果皮的清潔效能。整個探究過程，十分值得欣賞。而同學亦能注意實驗設計部分的公平性，證明同學能掌握科學研究的要點。如果同學能將不同果皮的清潔能力與市面上的清潔劑比較，甚至比較不同酒精濃度對清潔效能的影響，整份研究報告會更完整。
科學家專訪報告 —— 劉善雅博士

劉善雅博士與學生、老師的合照

童年時，劉博士對科學的興趣不大，反而較喜愛語文及音樂科，直至中學時期，才開始對科學產生興趣，當中有三個原因。首先，中學科學所包含的範疇較廣。此外，有一次，她看見老師進行一個實驗，在實驗過程中由於儀器過熱，令到其中一支試管爆炸，她覺得科學原來是很危險的，但同時也很刺激。最後，她受到一位科學老師影響，令她愛上科學。

在小學階段，劉博士並沒有閱讀一些科學書籍及做實驗的機會，直至初中時，她才有機會接觸科學及進行一些實驗，讓她發揮對科學探究的潛能。

劉博士選擇從事生物醫學是因為她對解剖及動物的生理結構有濃厚的興趣。此外，這門學系本身和人及醫學有關，她打算把學到的知識幫助人類。同時，能做更有意義的研究，可幫助醫學的發展。

令劉博士印象深刻的是兩個科學實驗。其中一個是她在懷孕中的白兔媽媽裏抽取一些細胞，觀察當中有甚麼蛋白質可以令白兔寶寶健康成長，她要先讓白兔媽媽懷孕，然後殺死牠，但白兔媽媽在死前會大叫，令劉博士覺得十分殘忍。她覺得為了實驗目的也要忍無奈把動物殺死，十分無奈。另外一個實驗是要培植細胞，她需要養殖一些實驗用的老鼠，再抽取當中的細胞。但幾天後，發現所有細胞均用不到，令劉博士很沮喪。另外一次在養殖老鼠的期間，觀察到那隻老鼠進食的方式很懶惰，令她感到很有趣。
當劉博士遇到實驗失敗時，她會再接再勵，反思實驗的不足之處，然後進行改良。她並不會持續地把失敗或成功放在心裏，因為失敗會令人沮喪，而成功會令人自滿。

作為一位女性科學家，劉博士認為在從事科研方面其實與男性科學家沒有甚麼大差別，男女性科學家均需具備細心的特點，只是大家在思想方面會有些分別。

此外，女性從事科研工作需具備勇於嘗試、有毅力、堅持及創新的特點。另外，由於要兼顧家庭，女性科學家需好好分配工作及家庭的時間，要堅持平衡兩者。

劉博士認為我們建議利用果皮加酒精轉化為天然清潔劑的報告方案可以向大眾推廣。因為我們所提出的方案與一般天然清潔劑如檸檬汁及白醋等比較會有其優勢，當中最重要的是能善用廚餘，既環保，又能節省金錢。

在日常生活中，劉博士也會利用不同的方法減少廚餘，如不會煮食過量，盡量利用簡單的烹調方法，例如利用蒸代替炸。

對於我們這群熱愛科學的同學，劉博士給予我們一些提醒。她提醒我們科學有很多範疇，我們不要急於為自己定型，要先享受科學，多觀察不同的東西，多看一些課外書籍，甚至可以在家中做一些簡單的實驗。
訪問完結後，學生誠邀劉博士參觀本校新建成的「地球家園探知館」和「有機種植園」

參考資料：
◆ 中文大學生物醫學學系：
  http://www.sbs.cuhk.edu.hk/TeachingStaffDetails.asp?lang=chi

◆ 中文大學生物醫學學系新聞發佈：
  http://www.cuhk.edu.hk/cpr/pressrelease/100108c.htm

◆ 劉善雅博士的相關背景資料參考：
  content=tc&query=%E5%A8%89%E5%96%84%E9%9B%85&go

24
Can Music Improve IQ Scores?

Diocesan Girls’ Junior School
Teacher: Ella Chan, Ellen Tam-Au
Students: Celeste Wu, Serena Tsui
        Divina Yung, Hannah Szeto
        Fion Tse

Introduction
The exam days are coming up, and we want to try everything to improve our marks and intelligent quotient (IQ). We noticed that in a baby commercial on TV, listening to music could raise our IQ. We were wondering if it could work for us. So, we decided to conduct an experiment with the question: Will listening to music improve our IQ performance; and if so, what type of music will improve our IQ performance on an IQ test?

Our Research
The Brain
The ear transmits sound to the brain through specific parts of the middle and inner ear. Experiments show that when listening to music, the reacting part of the brain is the striatum area. Studies have proven that brain neurons are usually excited by music. According to research, the frontal lobe deals with reasoning.

‘Mozart Effect’
Not many experiments have been done on the Mozart Effect and the information gathered from these tests all differ from one another.

In the 1990s, people found out that listening to Mozart’s music would actually improve your memory. Unfortunately, researchers discovered that the ‘Mozart Effect’, as they had come to call it, only lasted for about 10-15 minutes. People who were tested only benefited from the music temporarily. On the contrary, some experiments have been conducted where the results did not support the benefits of the ‘Mozart Effect’.
IQ

In 1993, Howard Gardner stated that there were eight intelligences: Spatial, logic or math, musical, linguistic, kinesthetic, interpersonal, intrapersonal and finally, naturalist.

Music Included in the Experiment

Our objective of this experiment is to find out if different kinds of music can affect IQ test results. We chose six kinds of music to investigate on: jazz/blues, lullaby, rock, pop, country and classical. These six kinds are selected because they are all in some ways different and distinctive from each other. They are also among the most popular kinds of music. Moreover, they represent different eras in the history of music. To pick songs for our experiment, we made sure we picked music that has a voice part and are classics of each genre. (See Appendix 1)

Creating the IQ Test

After choosing the music, our next task was to design the IQ test. The questions in the test were picked from IQ tests in books. They can be classified into three groups: spatial, verbal and mathematical. We picked these three types of questions because they are the most common in IQ tests. The questions were also rated by our team to evaluate the age-appropriateness of the questions.

Hypothesis

We predict that Classical music will improve IQ scores because Mozart was a classical composer.

Procedures

1. Group the sampling students into groups of fifteen and assign them into designated rooms. (Appendix 2)

2. Teacher will give out instruction using a script provided. (Appendix 3)  

1 Our team identified the need to create a “cover-up” for our IQ test because if we told the students they were writing an IQ test, they would have been mentally prepared which would affect their performance and our results. The “cover-up” also ensured that students tried their best.
3. Give out Test 1. (See sample of Test 1 in Appendix 4)
4. Allow students 15 minutes to complete Test 1.
5. Collect Test 1.
6. Teacher will make an excuse to allow time for music to be played.
7. Play assigned music in each classroom for 10 minutes. For the control group, students wait in silence with no music played for 10 minutes.
8. Give out Test 2. (See sample of Test 2 in Appendix 5)
9. Allow students 15 minutes to complete Test 2.
10. Inform students of the real purpose of the IQ test.
11. Mark the tests and record the scores anonymously.

**Conclusion**

According to our results, the control group and the group listening to pop music lead to similar improvements on IQ score (Refer to Appendix 6 for our Result Tables). Therefore, while not listening to any music will improve our IQ score, our result suggests that pop music would also improve IQ score if you were to listen to any kind of music.

This result is different from our hypothesis. One potential reason on why no music was best could be that during the 10 minutes of silence, students might use the time to review the questions they had done in test 1 in their mind, which might allow them to be better prepared for test 2. Another possible reason is the complete rest they can get from the silence, which might also play a factor in IQ performance.

We realized that the group listening to pop did best in both trials not only because its fast tempo might excite brain cells, but perhaps because pop is the favorite type of music for preteens nowadays. This makes pop music the most effective type, as reasoned also by the scientist, Dr. Mason Leung, we interviewed. With classical music being the worst, we think it might be because the slow tempo in classical music slows down brain activity; thus decreasing their IQ test performance. Yet it might not be relaxing enough for a complete rest, as lullaby might have, which is why lullaby has a higher score improvement.
We also made some interesting discoveries after looking deeper into different areas of the test. Every group did worse in the Mathematics part of the IQ test except for the group listening to pop music. As for verbal IQ score, there was no difference on whether you listen to music or not. In fact, not listening to music would better improve your spatial IQ score.

**Limitations to our findings**

Because of our lack of time and resources, our findings can only be applied to the following criteria:

- Female students, ages 11 – 12
- IQ test conducted in English
- Only 3 components of IQ are tested
- Finding is only on short term effect of IQ performance, since IQ performance was tested immediately after listening to music

**Further Explorations**

We could have tested different age groups and different genders since all our students are girls. We might further investigate on whether students’ IQ performance can be improved after they listen to their favorite piece of music. We also want to find out whether the music affects the brain temporarily or whether it has a longer effect. The length of music being played and the frequency of playing it are also areas that we can look into.

**References**

**Books:**


**Websites:**

http://dictionary.reference.com/browse/striatum


http://lrs.ed.uiuc.edu/students/lerch1/edpsy/mozart_effect.html

Appendix 1 – Songs reference

Rock
Artist: Bob Dylan
Song name: ‘Like a Rolling Stone’
Song duration: 8 min 12s
http://www.youtube.com/watch?v=DdRZ1gFhZP0&feature=fvst

Artist: Elvis Presley
Song name: ‘Heartbreak Hotel’
Song duration: 3 min 4 s
http://www.youtube.com/watch?v=olqe-JnHzjU&feature=fvst

Artist: The Beatles
Song name: ‘Love Me Do’
Song duration: 2 min 15 s
http://www.youtube.com/watch?v=_xuMwfUqJJM

Jazz
Artist: Frank Sinatra(duet with Elvis)
Song name: ‘Love Me Tender’
Song duration: 1min 49 s
http://www.youtube.com/watch?v=0LhpJ8hVAfQ

Artist: Louis Armstrong
Song name: ‘What a Wonderful World’
Song duration: 2 min 21 s
http://www.youtube.com/watch?v=-Aba0IVdE2c

Artist: The Happenings
Song name: ‘I Got Rhythm’
Song duration: 3 min 05 s
http://www.youtube.com/watch?v=0O0z3LdhZn0
Pop
Artist: Jordin Sparks
Song name: ‘Battlefield’
Song duration: 3 min 53 s
http://www.youtube.com/watch?v=suPlYwJ3YvM&ob=av2n

Artist: Jason Mraz
Song name: ‘I’m Yours’
Song duration: 4 min 1 s
http://www.youtube.com/watch?v=cl88QEIl-Xc

Artist: Glee-Chris Colfer & Lea Michele
Song name: ‘Defying Gravity’
Song duration: 2 min 22 s
http://www.youtube.com/watch?v=tiW5ZRQlqEI

Classical
Artist: Beethoven
Song name: 9th Symphony - Ode to Joy
Song duration: 9 min and 54 s
http://www.youtube.com/watch?v=_C9RPUQ1vwQ&feature=related

Artist: Pavarotti and Friends
Song name: La Traviata – Brindisi
Song duration: 3 min 20 s
http://www.youtube.com/watch?v=uYLvusd6aYw

Artist: Luciano Pavarotti
Song name: La Donna È Mobile (Rigoletto)
Song duration: 2 min 51 s
http://www.youtube.com/watch?v=xCFEk6Y8TmM
**Country**

Artist: John Denver  
Song name: Country Roads  
Song duration: 3 min 11 s  
http://www.youtube.com/watch?v=oN86d0CdgHQ

Artist: Dolly Parton  
Song name: Little Sparrow  
Song duration: 4 min 12 s  
http://www.youtube.com/watch?v=EgEH8Xjxpw4

Artist: Glen Campbell  
Song name: Rhinestone Cowboy  
Song duration: 3 min 11 s  
http://www.youtube.com/watch?v=8kAU3B9Pi_U&ob=av2e

**Lullaby**

Artist: Johannes Brahms  
Song name: ‘Lullaby’  
Song duration: 3 min 2 s  
http://www.youtube.com/watch?v=t894eGoymio

Song name: ‘Hush Little Baby’  
Song duration: 1 min 19 s  
http://www.youtube.com/watch?v=uo6XUtqDssQ&feature=related

Song name: ‘Edelweiss’  
Song duration: 2 min 12 s  
http://www.youtube.com/watch?v=zuQkZD3F2EQ&feature=related
Appendix 2 – Grouping of the sampling students

The grouping of students from different classes is to ensure a random sampling. All groups completed the experiment at the same time to ensure fairness.

<table>
<thead>
<tr>
<th>Group</th>
<th>Class Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>#1-5</td>
</tr>
<tr>
<td>2</td>
<td>#6-10</td>
</tr>
<tr>
<td>3</td>
<td>#11-15</td>
</tr>
<tr>
<td>4</td>
<td>#16-20</td>
</tr>
<tr>
<td>5</td>
<td>#21-25</td>
</tr>
<tr>
<td>6</td>
<td>#26-30</td>
</tr>
<tr>
<td>7</td>
<td>#31-36</td>
</tr>
</tbody>
</table>

LOCATION FOR YOUR GROUP

<table>
<thead>
<tr>
<th>Room</th>
<th>6A (Group)</th>
<th>6B (Group)</th>
<th>6C (Group)</th>
<th>Total no. of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>6A</td>
<td>6A Group 1</td>
<td>6B Group 2</td>
<td>6C Group 3</td>
<td>15</td>
</tr>
<tr>
<td>6B</td>
<td>6A Group 2</td>
<td>6B Group 1</td>
<td>6C Group 2</td>
<td>15</td>
</tr>
<tr>
<td>6C</td>
<td>6A Group 3</td>
<td>6B Group 4</td>
<td>6C Group 1</td>
<td>15</td>
</tr>
<tr>
<td>6D</td>
<td>6A Group 4</td>
<td>6B Group 3</td>
<td>6C Group 4</td>
<td>15</td>
</tr>
<tr>
<td>Science Room</td>
<td>6A Group 5</td>
<td>6B Group 6</td>
<td>6C Group 5</td>
<td>15</td>
</tr>
<tr>
<td>5D</td>
<td>6A Group 6</td>
<td>6B Group 7</td>
<td>6C Group 6</td>
<td>15</td>
</tr>
<tr>
<td>4D</td>
<td>6A Group 7</td>
<td>6B Group 5</td>
<td>6C Group 7</td>
<td>16</td>
</tr>
</tbody>
</table>
Appendix 3 – Teacher’s script for experiment

Teacher’s script

Because the written TSA has been cancelled this year, the EDB has required all P6 students to take a test today for assessment to evaluate their readiness for secondary school. The results of this test will be recorded and included in your application for secondary school.

For this test, you will receive a question paper and an answer sheet. You are not allowed to put any marks on the question sheet. If you need to do rough work, there is space at the bottom of your answer sheet or the back of your answer sheet. Please read the questions carefully and record all your answers onto the answer sheet.

As this is a very important assessment, it is especially important that you do not talk and try your best. Any sound you make will lead to your test paper being taken away from you and a mark of zero will be recorded in your application. The test has only 15 questions and we will give you 15 minutes to do it.

(Pass out answer paper)

Please write down your name, class, class number and group number on your answer sheet now. Put down your pens or pencils when you are done.

There are a mixture of short answer questions and multiple-choice questions. Please put only 1 word in each box for short answer questions and you only have to put the letters of the answer to your multiple choice questions.

I will pass out the question papers to you now. Please make sure you pass them backwards face down and when you are doing your work, you do not write on the question papers at all.

(Pass out question paper face down)

You have 15 minutes. Please turn the paper over and you may start now.
(start timer)

(Announce time left every 5 minutes and let them know when there is 1 minute left)

(After 15 minutes)

Pens down, please do not talk at all until I have left the room as this is the requirement set by EDB. Please turn your answer sheet over so your answers cannot be seen by the students in front of you and pass it up. Then, pass up your question papers also. Remember, you are not allow to talk at all.

(After collecting all the paper, pretend to look over them and start your acting!!)

Oh no! There is a second part for the test and I have forgotten it. Please stay quiet. DO NOT TALK.

(Room 4D, Science Room: Send out the budding girl to get tests.)

(Room 6A, 6B, 6C, 6D, 5D, Pretend to make phone call and ask for test to be delivered to room)

While we wait for the tests to be delivered, let’s listen to some music since we are not allowed to make any sounds. DO NOT TALK!

(play music for 10 minutes)

(After you get the new tests)

For this test, you will receive a question paper and an answer sheet. You are not allowed to put any marks on the question sheet. If you need to do rough work, there is space at the bottom of your answer sheet or the back of your answer sheet. Please read the questions carefully and record all your answers onto the answer sheet.

As this is a very important assessment, it is especially important that you do not talk and try your best. Any sound you make will lead to your test paper being taken away from you
and a mark of zero will be recorded on your report card. The test has only 15 questions
and we will give you 15 minutes to do it.

(Pass out answer paper)

Please write down your name, class, class number and group number on your answer
sheet now. Put down your pens or pencils when you are done.

There are a mixture of short answer questions and multiple-choice questions. Please put
only 1 word in each box for short answer questions and you only have to put the letters of
the answer to your multiple choice questions.

I will pass out the question papers to you now. Please make sure you pass them backwards
face down and when you are doing your work, you do not write on the question papers
at all.

(Pass out question paper face down)

You have 15 minutes. Please turn the paper over and you may start now.

(start timer)

(Announce time left every 5 minutes and let them know when there is 1 minute left)

(After 15 minutes)

Pens down, please do not talk at all until I have left the room as this is the requirement
set by EDB. Please turn your answer sheet over so your answers cannot be seen by
the students in front of you and pass it up. Then, pass up your question papers also.
Remember, you are not allowed to talk at all.

This is the end of the test.

Actually, all of you have just taken part in a science experiment designed by the Budding
Scientists. What they want to find out is whether listening to music will improve your IQ
which was why you have to take two IQ tests. We couldn’t tell you because if you had known what we were testing, you would have mentally prepared for it and it would affect the results of the experiment.

Thank you for participating and when the Budding Scientists have completed their competition, they will share their results with you.

If you have any questions, you may go ask Miss V Tang, Mrs E Yu or Mrs E Au.
# Appendix 6 - Results

## Table 1a: Mean and median of test scores (TRIAL 2)

<table>
<thead>
<tr>
<th>Type of Music</th>
<th>Classical</th>
<th>Country</th>
<th>Jazz</th>
<th>Lullaby</th>
<th>Pop</th>
<th>Rock</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test*</td>
<td>Test 1</td>
<td>Test 1</td>
<td>Test 1</td>
<td>Test 2</td>
<td>Test 1</td>
<td>Test 2</td>
<td>Test 1</td>
</tr>
<tr>
<td>Mean</td>
<td>5.33</td>
<td>5.07</td>
<td>5.40</td>
<td>5.40</td>
<td>5.20</td>
<td>5.67</td>
<td>4.50</td>
</tr>
<tr>
<td>Mean Change</td>
<td>(0.27)</td>
<td>0.73</td>
<td>(0.13)</td>
<td>1.07</td>
<td>1.73</td>
<td>0.60</td>
<td>1.38</td>
</tr>
<tr>
<td>Median</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Median Change</td>
<td>(1.00)</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>2.00</td>
<td>1.00</td>
<td>2.00</td>
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</tbody>
</table>

## Table 1b: Mean and median of test scores (TRIAL 1)

<table>
<thead>
<tr>
<th>Type of Music</th>
<th>Classical</th>
<th>Country</th>
<th>Jazz</th>
<th>Lullaby</th>
<th>Pop</th>
<th>Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test*</td>
<td>Test 1</td>
<td>Test 1</td>
<td>Test 1</td>
<td>Test 2</td>
<td>Test 1</td>
<td>Test 2</td>
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<tr>
<td>Mean</td>
<td>4.12</td>
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<td>4.67</td>
<td>5.39</td>
<td>4.33</td>
<td>4.60</td>
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<tr>
<td>Mean Change</td>
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<tr>
<td>Median</td>
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<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Median Change</td>
<td>0.00</td>
<td>1.00</td>
<td>(1.00)</td>
<td>0.00</td>
<td>1.50</td>
<td>0.00</td>
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</table>
### Table 2a: Test total scores raw data (TRIAL 2)

<table>
<thead>
<tr>
<th>Type of Music</th>
<th>Classical</th>
<th>Country</th>
<th>Jazz</th>
<th>Lullaby</th>
<th>Pop</th>
<th>Rock</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
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* Remark: Test 1 (Before Listening to Music;) Test 2 (After Listening to Music)

** Some students were absent on the day of the experiment which caused the different numbers of sample size.
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<td>2</td>
</tr>
<tr>
<td></td>
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<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

| Sample size**| 15        | 15      | 15     | 15      | 15   | 15     | 15       | 15       | 15       | 15     | 15     | 16     | 16     |
| Mean         | 1.20      | 2.00    | 1.20   | 2.07    | 1.40 | 1.67   | 1.40      | 2.27      | 1.27      | 2.20   | 1.20   | 2.07   | 1.31   |
| Mean Change (Test 2 vs Test 1) | 0.80 | 0.87 | 0.27 | 0.87 | 0.93 | 0.87 |
| Median       | 1         | 2       | 1     | 2       | 1    | 2     | 2         | 2         | 1         | 2     | 1     | 2     | 1.5    |
| Median Change (Test 2 vs Test 1) | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 |

42
### Table 3c: Spatial Test score raw data (Trial 2)

<table>
<thead>
<tr>
<th>Type of Music</th>
<th>Classical</th>
<th>Country</th>
<th>Jazz</th>
<th>Lullaby</th>
<th>Pop</th>
<th>Rock</th>
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<td></td>
<td>Test 1</td>
<td>Test 2</td>
<td>Test 1</td>
<td>Test 2</td>
<td>Test 1</td>
<td>Test 2</td>
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<td>2</td>
<td>2</td>
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<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Sample size**</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Mean</td>
<td>2.27</td>
<td>1.73</td>
<td>1.80</td>
<td>2.20</td>
<td>2.20</td>
<td>1.87</td>
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<td>Mean Change</td>
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<td>0.40</td>
<td>0.13</td>
<td>0.60</td>
<td>0.20</td>
<td>0.33</td>
<td>0.50</td>
</tr>
<tr>
<td>Median</td>
<td>2</td>
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<td>2</td>
<td>2</td>
<td>2</td>
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</tr>
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<td>Median Change</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Comment:
Students investigated if listening to music could improve IQ. They started this investigation because some research data showed that Mozart’s music could improve the memory for a short time, which is usually called the Mozart Effect. It was appreciated that the students compared the effect of different genres of music on IQ, rather than just trying to prove the effectiveness of Mozart Effect. It is suggested that the students may further diversify the tested samples with different ages and genders and mother tongue languages were used for the IQ test.
廚餘研究

聖保羅書院小學
老師：李滿林 黃小燕
學生：杜知行 陳靖謙 鄭凱峰
周正賢 黃苡晉

一、概論
香港每日產生約3,000公噸廚餘。將之當垃圾棄掉，會造成環境問題（佔用堆填區、產生惡臭）。所以我們構思一個簡單、低成本的處理方法，為環保出一分力。

二、測試及結果

◆ 實驗一
廚餘的普遍處理方法是堆肥，為了改良它，我們加入細菌去加快分解速度。又會用蟲去吃掉廚餘。禾蟲是雀鳥的飼料，較易買到，而且販商會用碎穀餵它們，故可能也會吃廚餘。

用橡筋和布塊包着杯頂
（防止禾蟲逃脫）

泥土100克

用標準化食物做廚餘
椰菜葉10克
麪包皮10克
肉10克

泥土100克

變項：
1. 酵母菌1茶匙
2. 益生菌飲料1茶匙
3. 禾蟲3條
4. 對照
經過兩星期後，再用這些泥土來種眉豆(2粒)，每天記錄豆芽平均長度。

<table>
<thead>
<tr>
<th>豆芽長度（厘米）</th>
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<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
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<tbody>
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<td>実験組（酵母菌）</td>
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<td>1</td>
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<td>2</td>
</tr>
<tr>
<td>実験組（禾蟲）</td>
<td></td>
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<td>2</td>
<td>2.5</td>
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<tr>
<td>對照組</td>
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<td>2</td>
<td>2</td>
<td>2.5</td>
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</tr>
</tbody>
</table>

分析：加入細菌後的泥土，栽種效果並不明顯。然而加入禾蟲，效果稍佳，相信是它們食了廁餘，再排出糞便，成為植物的肥料。

◆ 實驗二
我們發覺禾蟲能令泥土肥沃，是處理廁餘的有效方法。它們所排出的糞便可作肥料，蟲本身可作飼料甚至是糧食（含豐富蛋白質，中菜有一道禾蟲蒸蛋）。因此就測試禾蟲偏好哪些廁餘。

實驗方法：
1. 預備兩份10g食物，分別放入2個膠盒。
2. 在其中一個盒加入5條禾蟲，另一個盒不加禾蟲（作為對照，因為食物會因水份蒸發而變輕），然後蓋好。
3. 以其他食物重複步驟1,2。
4. 每日紀錄食物重量。
結果：

<table>
<thead>
<tr>
<th>食物</th>
<th>日數</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>重量(克)</td>
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<td></td>
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<td></td>
<td></td>
</tr>
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<td>3</td>
<td>4</td>
<td>5</td>
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<td>7</td>
</tr>
<tr>
<td>飯</td>
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<td>6.8</td>
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<tr>
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<td>9.5</td>
<td>9</td>
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<td>8.4</td>
<td>7.5</td>
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<tr>
<td></td>
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<td>9.7</td>
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<td>9.2</td>
<td>8.6</td>
<td>8</td>
<td>7.7</td>
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<td>9.1</td>
<td>8.8</td>
<td>8.6</td>
<td>8.5</td>
<td>8.2</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
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<td>9.3</td>
<td>9.2</td>
<td>9</td>
<td>8.8</td>
<td>8.4</td>
<td>8</td>
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<tr>
<td>芒果皮</td>
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<td>8.9</td>
<td>8.2</td>
<td>7.5</td>
<td>6.7</td>
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<tr>
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<td>8.3</td>
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<td>蘿蔔（熟）</td>
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<td>8.6</td>
<td>7.8</td>
<td>7.6</td>
<td>7.2</td>
</tr>
</tbody>
</table>
分析：大部分食物重量都较对照轻，表示被虫蛀食了。
實驗三

我們再思考平日煮食時，都會加入鹽作調味料和油，對蟲的進食有影響。

實驗方法與實驗二大致相同，兩份熟椰菜（20克），其中一份加入指定份量的鹽油，另一份不加。兩份食物都加入5條禾蟲。

<table>
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<tr>
<th>添加劑</th>
<th>日數重量(克)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>7</th>
</tr>
</thead>
<tbody>
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<td>14.2</td>
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<td>17</td>
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<tr>
<td>0.2ml油</td>
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<td>20</td>
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<td></td>
<td>對照組</td>
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<td>19</td>
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<td>17.8</td>
<td>17.2</td>
<td>16.8</td>
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<tr>
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<td>19.6</td>
<td>19</td>
<td>18.3</td>
<td>17.5</td>
<td>17</td>
<td>15.8</td>
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<tr>
<td></td>
<td>對照組</td>
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<td>19.8</td>
<td>19.3</td>
<td>18.9</td>
<td>18.3</td>
<td>17.9</td>
<td>17</td>
</tr>
</tbody>
</table>
分析：禾蟲不會進食高鹽的食物（低鹽則仍會）。對有油份的食物也會進食。

**實驗四**

之前沒有詳細統計禾蟲的存活率，所以用50條禾蟲重做實驗二。

<table>
<thead>
<tr>
<th>食物</th>
<th>日數</th>
<th>1</th>
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<th>3</th>
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<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
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<td>生存禾蟲數目</td>
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<td></td>
<td></td>
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<td>33</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>對照組</td>
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<td>43</td>
<td>38</td>
<td>36</td>
<td>34</td>
<td>33</td>
<td>32</td>
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</tbody>
</table>

分析：飯對禾蟲的存活沒有明顯影響。最初禾蟲的死亡比率較高，之後下降，相信是餘下的都較健壯和適應力強。
三、結論

建議用一個載有禾蟲的有蓋膠筒，每天將合適的廚餘（不連骨、殼等，高鹽的
穀菜要先沖洗）放入。最後取出禾蟲作食用或飼料，渣滓和糞便可作肥料。普
遍家庭未必用得着，但可以供給本地農業。

優點：
◆ 處理簡易（相對有些方法要定時加酵素或放水）
◆ 費用低（一包禾蟲約200條10元，專用酵素百餘元一樽）
◆ 蟲的生命力不俗

缺點：
◆ 禾蟲外貌不是人人能接受，更不要說要食用（可考慮賣給餐廳）
◆ 廚餘及禾蟲在過程中會有一股臭味
◆ 估計要數以千條禾蟲才能吃掉一個家庭的廚餘
◆ 生的食物、骨頭、殼，加了大量調味料的食物不適合

四、延伸研究
◆ 將食物磨碎後的效果
◆ 實際廚餘箱的設計（要考慮透氣、不能讓它們逃脫、能方便取出禾蟲）
◆ 禾蟲與廚餘的大致比重
五、反思

實驗前：
◆ 對廚餘不太熟識，當初毫無頭緒
◆ 沒有想到用蟲來食廚餘

實驗時：
◆ 對禾蟲感到很好奇
◆ 要每天做量度和記錄不容易
◆ 很期待實驗結果，確定我們的構思是否可行

實驗後：
◆ 對結果很鼓舞，明白到原來要做公平測試並不容易
◆ 要發揮團結精神才能有成果
◆ 了解到生活細節與環保息息相關

六、參考資料
苗栗縣環境保護局（2006）：廚餘問與答
http://futek168.myweb.hinet.net/qna.html

地球之友（2011）：惜飲惜食減廚餘

評語：
同學的研究過程很有條理。他們先研究加入禾蟲的廚餘能否成為有效的肥料，然後再找出禾蟲會進食的食物，最後再將油和鹽加進食物來模擬廚餘，以推斷禾蟲會否進食廚餘，再計算食物對禾蟲存活率的影響。每個實驗均能承接上一個實驗的結果，整份研究報告有連貫性，屬於高水平之作。如果能將食物被禾蟲消耗和對照實驗水份蒸發的速率分別出來並作比較，可使數據更有力。
Designing a Cooler Bus Stop in Open Area

Cheung Sha Wan Catholic Secondary School
Teacher: Mr Cheng Tsz Him, Mr Chin Ho Wai, Mr Wat Hoi Tim
Student: Ko Cheuk Fai, Lee Yun Wing, Leung Pak Yui,
Lung Hoi Tat James, Ming Cheuk Yin Ricky

1. Introduction

1.1 Demarcating of Topic

In some open area directly under sunlight, temperature is particularly high. A practical shelter is essential. Based on experiences in real life, it is intolerably hot to wait for 10-15 minutes even under a shelter. Discernibly, existing bus stop shelter is insufficient for blocking the intense sunlight during summer. Therefore, modification for the design of bus stop shelter is proposed in this investigation. The major focus in this investigation is the bus stop shelter in open area.

1.2 Background Info

For typical bus stops in Hong Kong, most shelters are made of aluminium, plastic, glass, and iron. Dimensions are as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Height(m)</th>
<th>Width(m)</th>
<th>Length(m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>~2.5</td>
<td>~1.5</td>
<td>3-7</td>
</tr>
<tr>
<td>Glass</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sau Mau Ping Road, Twun Tong
Tin Shui Road, Tin ShuiWai
2. Research Objectives

The primary objective of this investigation is to modify the design of bus stop in open area, in order that people in the bus stop will feel cooler and meanwhile being user friendly. More precisely, the bus stop should execute the followings:

1. Lower the temperature to a pleasant level
2. Green and environmentally friendly
3. Minimal maintenance is needed

3. Research Theory

3.1 Heat Transfer

Heat is transferred in three ways: conduction, radiation and convection.
**Conduction**

To lower the ceiling temperature of the shelter, attempt would be made to reduce the conductivity and thus requires a longer time to attain a thermal equilibrium. The ultimate aim is to prolong the time for reaching equilibrium up to four or five hours. That is, the ceiling of the shelter will remain at a lower temperature around noon.

**Radiation**

Considering radiation of the bus stop shelter is the foremost source of heat to the people, attempt would be made to reduce infra-red radiation emitted by the ceiling of bus stop shelter. To achieve that, materials with the poorest absorption of radiation should be used for the shelter, which can reduce the transmission of radiation.

**Convection**

Convection of air should be strengthened to transfer heat away.

**3.2 Evaporation**

During evaporation, heat is absorbed. Thus, the temperature can be lowered simply by the evaporation of water. With fine droplets of water mist, it can perform rapid evaporation and absorb heat away.

![Evaporation Diagram](image-url)
4. Experiments

A 1:7 model is constructed to simulate a real bus stop in summer time. The dimension of the model bus stop is 70cm(L)20cm(W)35cm(H). The power of the sunlamp is 8200W = 1600W and the light covers an area up to 1.2m².

4.1 Reasons for the Set Up

1. The environment for the experiment is controlled.
2. The radiation emitted by the sunlamps is uniform and controlled by the power supply. The power output simulates the real situation of sun radiation power (1400W).
3. The convection is controlled by wrapping with plastic sheet. The air is still and therefore prevents the convection of the cool surrounding air affecting the result.
4. Equilibrium can be maintained easily.

Figure 4 Set Up for Experiments
4.2 Constraints

There are several inevitable constraints in performing the experiments as stated above.

1. People sweat when they feel hot. Thus, the evaporation of sweat absorbs heat and results in a decrease on temperature of the human body. In the experiment, the dummy is unable to sweat and fails to demonstrate a real situation as a normal human body.

2. The intensity of heat generated by the sunlamps decreases with distance. This differs from the real circumstance where the radiation remains unchanged under sunlight.

3. The dummy is a non-living thing and the body temperature is not kept at 37°C. It is discovered that the temperature will be at equilibrium where the air temperature is controlled to 30°C after an hour. Hence, each experiment is performed for two hours to attain thermal equilibrium.

4.3 Blocking Radiation

Experiment 1: Investigating the Absorption of Radiation for Different Materials

**Aim:**
To select the materials for the shelter with the poorest absorption of radiation

<table>
<thead>
<tr>
<th>Apparatus:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Plate</td>
</tr>
<tr>
<td>Aluminium Plate</td>
</tr>
<tr>
<td>8 sunlamps</td>
</tr>
<tr>
<td>6 Concrete plates</td>
</tr>
<tr>
<td>Plastic Sheet</td>
</tr>
<tr>
<td>4 Temperature Sensors</td>
</tr>
<tr>
<td>Acrylic Plate</td>
</tr>
<tr>
<td>2 Computers</td>
</tr>
<tr>
<td>2 Data loggers</td>
</tr>
</tbody>
</table>

Figure 5 Set Up of Experiment 1
Procedures:
1. Set up as Figure 5.
2. Turn on the sunlamps and record the temperature change over time until steady state.
3. Repeat steps 1-2 with different shelter materials and conduct a control experiment without any shelter.

Result:
Table 1 Average Temperature at steady state for different shelter materials

<table>
<thead>
<tr>
<th></th>
<th>No shelter</th>
<th>Aluminium shelter</th>
<th>Glass shelter</th>
<th>Acrylic plate shelter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shelter (°C)</td>
<td>82.09</td>
<td>80.76</td>
<td>84.86</td>
<td>85.90</td>
</tr>
<tr>
<td>2. Ceiling (°C)</td>
<td>82.08</td>
<td>55.42</td>
<td>73.34</td>
<td>82.59</td>
</tr>
<tr>
<td>3. Dummy’s hair (°C)</td>
<td>88.72</td>
<td>39.67</td>
<td>59.05</td>
<td>66.79</td>
</tr>
<tr>
<td>4. Clothes (°C)</td>
<td>55.76</td>
<td>34.98</td>
<td>34.97</td>
<td>39.14</td>
</tr>
<tr>
<td>5. Concrete floor (°C)</td>
<td>71.10</td>
<td>34.97</td>
<td>57.34</td>
<td>62.20</td>
</tr>
</tbody>
</table>

Analysis:
By conducting this experiment, it is clear that aluminium plate was the best material to block radiation among those being tested. It substantially reduces the temperature of the dummy by 21-49°C, which is the largest decrease. It can thus be concluded that aluminium is a poor absorber of radiation.

However, it is also noted that the ceiling of the aluminium plate still reaches a high temperature of 55.42°C. Thus, further improvement should be made to lower the temperature of the ceiling to reduce the radiation emitted to the passengers.

Consequently, for the rest of study, aluminium plate is used for the top side of the shelter.
4.4 Slowing Down Conduction

Experiment 2: Investigating Different ways in Slowing Down Conduction

**Aim:**

To investigate the effectiveness in lowering the ceiling temperature by decreasing the heat conductivity.

<table>
<thead>
<tr>
<th>Apparatus</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turf</td>
<td>1</td>
</tr>
<tr>
<td>2 Aluminium Plates</td>
<td>2</td>
</tr>
<tr>
<td>8 sunlamps</td>
<td>2</td>
</tr>
<tr>
<td>6 Concrete plates</td>
<td>2</td>
</tr>
<tr>
<td>5 Temperature Sensors</td>
<td></td>
</tr>
<tr>
<td>2 Data loggers</td>
<td></td>
</tr>
<tr>
<td>2 Computers</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6 Set Up of Experiment Two
**Procedures:**

1. Set up as Figure 6.
2. Turn on the lamps and record the temperature change over time for 2 hours
3. Repeat steps 1-2 with a turf on top.

**Results:**

Table 2 Average Temperature at steady state for different Designs

<table>
<thead>
<tr>
<th></th>
<th>1 layer</th>
<th>2 layers</th>
<th>1 layer with turf</th>
<th>2 layers with turf</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shelter (°C)</td>
<td>80.76</td>
<td>89.14</td>
<td>90.4</td>
<td>91.92</td>
</tr>
<tr>
<td>2. Ceiling (°C)</td>
<td>55.42</td>
<td>45.13</td>
<td>47.9</td>
<td>42.86</td>
</tr>
<tr>
<td>3. Dummy’s hair (°C)</td>
<td>39.67</td>
<td>38.47</td>
<td>38.8</td>
<td>37.54</td>
</tr>
<tr>
<td>4. Clothes (°C)</td>
<td>34.98</td>
<td>34.11</td>
<td>34.2</td>
<td>33.67</td>
</tr>
<tr>
<td>5. Concrete floor (°C)</td>
<td>34.97</td>
<td>37.38</td>
<td>38.44</td>
<td>38.81</td>
</tr>
</tbody>
</table>

**Analysis:**

From the above result, it can be concluded that using double layers of aluminium plates is more effective in lowering the ceiling temperature. In addition of a turf on top, the ceiling temperature can further reduced to about 42°C. As air is a poor conductor of heat, and the evaporation of the water in the turf will absorb heat, the temperature is lowered.

**4.5 Enhancing Convection**

Experiment 3: Investigating the cooling effectiveness of enhancing the convection using an electrical fan.

From the above experiments, two layers of aluminium with turf is the ideal solution found. Hence, it is used for the rest of the study.

To make people feel cooler, circulation of air is of concern. An experiment is performed to investigate the cooling effectiveness of enhancing the convection using an electrical fan.
**Aim:**
Determine the cooling effectiveness of enhancing the convection using an electrical fan.

**Apparatus:**
- 2 Aluminium Plates
- 8 sunlamps
- 5 Temperature Sensors
- 6 Concrete plates
- 2 Data loggers
- Electrical fan
- Dummy
- 2 Computer

**Procedures:**
1. Set up as Figure 7
2. Turn on the lamps and fan
3. Record the temperature of the hair and clothes of the dummy over time for two hours
4. Conduct a control experiment with the same set up without turning on the fan.
Result:
Table 3 Average Temperature at steady state with ans without electrical fan

<table>
<thead>
<tr>
<th></th>
<th>With Electrical Fan</th>
<th>Without Electrical Fan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shelter (°C)</td>
<td>80.73</td>
<td>91.92</td>
</tr>
<tr>
<td>2. Ceiling (°C)</td>
<td>38.57</td>
<td>42.86</td>
</tr>
<tr>
<td>3. Dummy’s hair (°C)</td>
<td>35.32</td>
<td>37.54</td>
</tr>
<tr>
<td>4. Clothes (°C)</td>
<td>31.56</td>
<td>33.67</td>
</tr>
<tr>
<td>5. Concrete floor (°C)</td>
<td>39.93</td>
<td>39.81</td>
</tr>
</tbody>
</table>

Conclusion:
From the above result, it can be shown that electrical fan can further reduce the average temperature of the dummy by ~2°C.

4.6 Heat absorption by Evaporation
Experiment 4: Investigating the cooling effectiveness by evaporation of water mist

Aim:
Determine the cooling effectiveness by evaporation of water mist.

<table>
<thead>
<tr>
<th>Apparatus:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Aluminium Plates</td>
<td>8 sunlamps</td>
</tr>
<tr>
<td>5 Temperature Sensors</td>
<td>6 Concrete plates</td>
</tr>
<tr>
<td>2 Data logger</td>
<td>nozzle</td>
</tr>
<tr>
<td>Dummy</td>
<td>2 Computer</td>
</tr>
<tr>
<td>Turf</td>
<td>Electrical fan</td>
</tr>
</tbody>
</table>
Procedures:
1. Set up as Figure 8
2. Turn on the sunlamps and electrical fan
3. Record the temperature of the hair and clothes of the dummy over time for two hours.
4. Conduct a control experiment with the same set up without water mist.

Result:
Table 4Average Temperature at steady state with and without water mist
Conclusion:
From the above result, it can be shown that water mist can dramatically lowered the temperature of dummy by about 4-8°C.

5. Automated Maintenance

From the above experiments, it is established that using electrical fan and water mist are useful in cooling. However, it is only needed provided that the weather is hot. During cold weather, that would merely be a waste of energy. By virtue of this, this system should be made automatic and function only when passengers are waiting in hot weather. With power from a solar panel equipped with electric energy storage system, no extra energy is required. From estimation, a 1 m² solar panel is needed. (See appendix I for the details of calculations.)

As the whole design is controlled automatically, maintenance is merely needed for the turf. To reduce loss of soil from heavy rain, protection nets can be used to cover the turf. However, manual cutting of grass is still required.

5.1 Flow Chart

Figure 9 Flow Chart for Automation
5.2 Apparatus Cost

All that required for the design is simply a solar panel, a micro-controller, an electrical fan, two water valves, a nozzle, a temperature sensor and an ultrasonic sensor. (See appendix II for the automated program.)

Figure 10 Apparatus for Automated Maintenance

<table>
<thead>
<tr>
<th>Apparatus:</th>
<th>Cost (retail price):</th>
</tr>
</thead>
<tbody>
<tr>
<td>120-150 W solar panel</td>
<td>~$3000</td>
</tr>
<tr>
<td>Electric energy storage system</td>
<td>~$1000</td>
</tr>
<tr>
<td>Electrical fan</td>
<td>~$150</td>
</tr>
<tr>
<td>2 water valve</td>
<td>~$402</td>
</tr>
<tr>
<td>nozzle</td>
<td>~$10</td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>~$10</td>
</tr>
<tr>
<td>Ultrasonic sensor</td>
<td>~$300</td>
</tr>
<tr>
<td>Micro-controller (the cost of a mass produced</td>
<td>~$1000</td>
</tr>
<tr>
<td>tail made MCU can be reduced to about ten</td>
<td></td>
</tr>
<tr>
<td>dollars each)</td>
<td></td>
</tr>
<tr>
<td>Total Cost:</td>
<td>~$4550</td>
</tr>
</tbody>
</table>
6. Final Solution

6.1 Selecting Materials for the top side of Shelter (Dummy’s hair -49°C, Ceiling -27°C)

Despite the fact that aluminium plate is the best reflector of radiation, grass turf is preferred. This is because of the absorption of heat by the turf is superior to that of the aluminium plate.
6.2 Reducing heat conductivity by two aluminium layers with air gap and turf (Dummy’s hair -2°C, Ceiling -13°C)
Reducing the heat conductivity by two aluminium layers with air gap and a layer of grass turf can prolong the time for reaching thermal equilibrium. Hence, the ceiling temperature can be lowered and less infrared radiation will be emitted to the passenger.

6.3 Enhancing Convection by Adding Fan (Dummy’s hair -2°C, Ceiling -4°C)
Enhancing convection can help transfer heat away. By doing so, the temperature under shelter can be lowered.

6.4 Absorbing Heat by Evaporation (Dummy’s hair -8°C, Ceiling -1°C)
Considering evaporation is an efficacious method of cooling, it can be used to cool down the air under the shelter. A clean and common coolant is selected for this simple purpose: water. To enhance the evaporation rate and minimizing inconveniences to the people, water mist is suggested. Together with the fan, rapid evaporation is attained. (See appendix III for the details of water usage.)

6.5 Automated Maintenance
To prevent energy waste, the whole system (fan, water mist cooling) should only operate under hot weather. The system should operate automatically when the temperature is high. Consequently, no energy is wasted and no extra manpower is needed except grass-cutting. Gutter and protective nets are also needed to prevent loss of soil from heavy rain.

6.6 Solar Power
A small solar cell and a power storage system should be installed on the shelter. With power generated by solar cell, no extra energy is needed for the whole design.
7. Conclusion

In conclusion, with all the designs made above:

1. The temperature of dummy's cloth decreases from 55°C to 27°C.
2. The temperature of dummy's hair decreases from 88°C to 27°C.

In brief, it is evidently proven that together with a radiation-resistant shelter, electrical fan and water mist cooling, the temperature of the dummy body can reduce from an extraordinarily high level (>50°C) to an acceptable level (26°C). Aim is achieved.

8. References

Encyclopaedia of Bus Transport in Hong Kong, http://hkbus.wikia.com/wiki
TaoBao: http://www.taobao.com
Appendix I: Power Consumption for Automated Devices

<table>
<thead>
<tr>
<th>Device</th>
<th>Power Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical fan</td>
<td>~100W</td>
</tr>
<tr>
<td>2 Water Valve</td>
<td>~2x10=20W</td>
</tr>
<tr>
<td>Micro - Controller + Temperature Sensor + Ultrasonic Sensor</td>
<td>~20W</td>
</tr>
<tr>
<td>Maximum Power Usage</td>
<td>~140W</td>
</tr>
</tbody>
</table>

Solar Intensity in Sunny Day ≈ 1000Wm-2

Efficiency of a Solar Cell ≈ 15%

Area of the Solar Cell ≈ 140W / (1000Wm-2 15%) ≈ 1m2

Appendix II: Automated Program

Test program - without watering the glass

```c
#include <hardwareinfo.c>
#include <GetUltrasound.h>
#include <SetLED.h>
#include <SetFan.h>
#include <GetTemperature.h>
unsigned long T,X;
int main(void)
{
    while(1)
    {
        X=GetUltrasound(_ULTRASOUND_X_);
        T=GetTemperature(_TEMPERATURE_T_);
        if(X<50 && T>35)
        {
            SetFan(_FAN_F_,0);
            SetLED(_LED_N_,1);
        }
        else if (X<50 && T>30)
        {
            SetFan(_FAN_F_,0);
            SetLED(_LED_N_,0);
        }
        else
        {
            SetFan(_FAN_F_,1);
            SetLED(_LED_N_,0);
        }
    }
}
```
Appendix III: Water Usage

From the above investigation, water mist is highly effective in cooling. Assume that the hottest time is 09:00-15:00, the water mist is solely needed for six hours. Water is also needed for watering the grass turf.

The cost is calculated below:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Cost</td>
<td>$4.16/m³</td>
</tr>
<tr>
<td>$1.71/m³ (sewage fee)</td>
<td></td>
</tr>
<tr>
<td>Total Cost</td>
<td>$5.87/m³</td>
</tr>
<tr>
<td>Max. water usage for mist (6 hours)</td>
<td>34.0cm³/min (0.012m³/6hours)</td>
</tr>
<tr>
<td>Water usage for watering the grass turf (20 mins)</td>
<td>300 cm³/min (0.006m³/20 mins)</td>
</tr>
<tr>
<td>Max. total water usage</td>
<td>0.018 m³/day</td>
</tr>
<tr>
<td>Cost</td>
<td>$0.11/day</td>
</tr>
</tbody>
</table>

Comments:

Students tried to compare the effect on insulating temperature by different materials commonly used at bus stops. The experiments were carried out comprehensively from choosing aluminium as the principle heat insulating material to other add-on peripherals, such as electrical fan and nozzle. All of these showed that the scientific mindsets of the students are detailed and careful. It is suggested that students may present the statistical analysis to show whether the temperature reduction by those add-on peripherals is statistically significant.
Interview with a Scientist

An Interview with Professor Chi-Hou Chan
Ph.D. Illinois, FCIE, FIEEE, FIET, Fellow of Electromagnetics Academy, CEng Chair Professor, Department of Electronic Engineering, the City University of Hong Kong
Cheung Sha Wan Catholic Secondary School
Lung Hoi Tat, Ming Cheuk Yin Ricky, Ko Cheuk Fai, Lee Yuen Wing, Leung Pak Yui

Background

Professor Chan graduated from St. Francis Xavier College in 1977. While receiving secondary school education at St. Francis Xavier College, he met an MIT electrical engineer who inspired him to pursue a career in science and engineering. He furthered his studies in electrical engineering at Ohio State University in the United States. Since 1996, Chan has been working as a Professor of Electronic Engineering at City University of Hong Kong. Majored in Antennas and Microwave and Millimeter-Wave Components and Subsystems, Professor Chan contributed to society by inspiring his students with innovative ideas.

In recognition of their outstanding achievements in advancing millimeter wave technologies and application, Professor Chan and his team was conferred a second-class honour in the 2011 State Technological Invention Award(STIA) at the Great Hall of the People in Beijing.

City University team was conferred State Technological Invention Award (STIA) at the Great Hall of the People.
Professor Chan’s Electronic Engineering

Electronic Engineering is about the practical use of technology. “Practical and yet innovative,” Chan said as he defined the field of study. In the State Key Laboratory of Millimeter Waves at City University of Hong Kong, professors came up with innovative ideas to advance the application of antennae in wireless communication.

How Chan’s research contributed to the world

Do you still remember the time when Wenchuan Earthquake happened in Sichuan Province? If you were one of the survivors from the natural disaster and you were unable to contact the rescue, would you ever desire to have a satellite mobile phone? In the past, when natural disasters such as earthquake and tsunami occurred, the communication network tended to break down. The rescue missed the “golden 72 hours” and thus many victims died.

The antennae for the user terminal of the Beidou 1 Satellite positioning system were used in rescue work after the Wenchuan Earthquake.
Professor Chan and his team made antennas for user terminal in the Beidou (COMPASS) Navigation Satellite System, which enables people to use satellite phones to contact the control centre and inform them of trapped persons anytime.

There is a difference between the USA and the Chinese satellite system. For the US satellite system, the communication is in single direction, which means users can only know their present locations but the ground control does not. However, for the antennae Chan invented, the communication is bidirectional.

The satellite handheld mobile can emit signals to the satellite giving the precise locations to the control centre. When natural disasters occur and all the infrastructures are destroyed in a particular region, the rescue can still easily find out the location of the survivors. Besides, survivors can inform the rescue of the seriousness of injury.

“Our antennae are useful and help save lives.”

Professor Chan is now on the process of making smaller and lighter satellite antennae without reducing its functions. His work will be more difficult and yet he wants to serve people practically.
Being asked about the greatest satisfaction as a professor, Professor Chan replied, “The greatest satisfaction of my job is to see achievements of my students. I hope they can stretch their potential and be focused on everything.”

The vital qualities for a researcher

Observance

Professor Chan noted an outstanding researcher should always be vigilant of things around. “There is a layer on the glass of the microwave oven. Have you ever thought of the use of that layer?” asked Professor Chan. Researchers observe things in their daily life.

Curiosity

“Why are things like this? What if I reverse them, say for example the filter of the microwave oven?” Everyone can be curious. A good researcher never accepts ideas and thoughts without questioning. Instead he/she should question with inquisitive mindset.

Perseverance

Through your investigation, you may not be able to accomplish the experiment. “We carried out experiments by simulation. In the past, we did not have apparatus up to 500 gigahertz to simulate the situation. Some of our researches have been waiting for 10 years until the technology ripens.” Now they have enough resources to go on. However, within those years, he never gave up.

“I will wait until I have got enough resources to carry out. Our hearts never die.”

Open-mindedness

Last but not least, being open-minded and not following the tradition is the key element for a great researcher. In the past, scientists thought that current flowed from the positive to the negative. But some proofs state that the fact is the opposite of what people believed. For most of the breakthrough in science, they were originally proposed by open-minded scholars.
Scientific research in Hong Kong

Adequate resources?
In Professor Chan’s eyes, Hong Kong has adequate resource to develop scientific investigation. “In the past few years, universities in Hong Kong have employed many world-class professors and scholars. The subjects are of high standard as well.” said Professor Chan. For sure, the government can increase the support to promote scientific researches.

![Microwave Antenna Measurement System](image)

*Microwave Antenna Measurement System, which is an advanced apparatus, can be an example to show that Hong Kong has adequate resource to develop scientific investigation.*

The role of government
Most government officials responsible for the development of science are not science professionals. “As I mentioned, Hong Kong has both software and hardware to develop scientific investigation. But more cooperative work is needed by the government. We should learn from successful countries such as Singapore and South Korea which are famed for their mobile phone brands.”

![Flag of Hong Kong](image)

Some words for today’s teenagers
Professor Chan encourages us to equip ourselves in the following aspects:

Persistence and diligence
“Your academic performance is not the only factor to succeed.” From the eyes of Professor Chan, learning is just an integrated training. To be successful, it is not determined by solely academic results. For instance, Li Ka Shing did not receive tertiary education. His persistence contributed most to his successful career.
**Communication skills & team spirit**

With the help of others, we can achieve more than we can. “We professors can somehow foresee students’ career regarding their cooperation with others,” noted Professor Chan. He believes that team spirit is how we achieve “when 1 plus 1 is greater than 2”. For sure, we should have communication skills before doing that.

“With communication skills, 1 + 1 > 2”

Nevertheless, Professor Chan added, “you teenagers should not expect others to help you, but also pay your own effort.”

“You can learn these from the extra-curricular activities. Whether you are a scientist or a businessman, these are equally important to us.”

**Epilogue**

It has been a great chance for us to learn from Professor Chan. He is approachable and explains every message behind his stories.

For instance, he told us that one of his students failed to find the solution to a question. However, Chan insisted that the problem could be solved, just that the method remains to be found then. For sure, we students are always disheartened by failures after failures. Yet, we have learnt from Professor Chan that solutions are often waiting to be discovered.

We learnt that perseverance is the key to the find out the method of solving the problem.

In our eyes, Professor Chan pursues his career in the field of science. His wish is not to earn a fortune, but to serve the public through advancing technologies. It is our honour to have such a researcher who always comes up with innovative ideas, for the benefit of society and brings us convenience.
Professor Chan told us that people do not have equal opportunities in life. Not everyone’s parents could provide guidance for their children in their studies. We should always be open-minded to seize every chance so as to upgrade ourselves. With the greatest effort, that will surely make miracles even in the simplest life.

From left to right: Professor Chan, Ricky Ming, James Lung, Jeffrey Ko, Matthew Lee

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The world’s largest display of the regional flag of the HKSAR at Siu Sai Wan Sports Ground in September.

Oasis in the City

St. Paul’s Co-educational College
Teacher: Lau Oi Ha, Tse Wai Tak
Student: Simon Wong, Edwin Chan,
David Chan, Dominic Law,
Brandon Ma

Introduction

Due to global warming and urban heat island effect, the temperature of the urban areas in Hong Kong is increasing each year. There are two major causes for the urban heat island effect.

Firstly, heat from the sun is trapped between the buildings instead of released to the cooler air around. Materials commonly used in urban areas for pavement and roofs, such as concrete and asphalt, have significantly high specific heat capacity than the surrounding rural areas and are good thermal conductors. This causes the heat energy from the sun, waste heat from automobiles, air conditioning, industry, and other sources of heat energy to be stored in the materials, thus increases the temperature in the urban areas.

The other cause is due to light reflection. The tall buildings within many urban areas provide a lot of surfaces for the reflection and absorption of sunlight, increasing the efficiency with which urban areas are heated. This is called the “urban canyon effect”.

In summer, the temperature in summer can reach 35 degree Celsius, according to the Hong Kong Observatory. During that time, people have to suffer from the unbearable heat while waiting for the buses. To make the bus stops cooler, our group has decided to design a shelter so as to alleviate this problem.

Proposed Designs

We hereby propose three designs for our bus stop shelter.
Light reflecting materials

Light reflecting materials have shiny surfaces, which are poor radiation absorbers.

This can reduce the transfer of electromagnetic waves from the sun to the ground because some of the waves are reflected back to the atmosphere. As less electromagnetic wave is transmitted, less heat is transferred to the ground. This alleviates the urban heat-island effect.

Semi-transparent UV Filter

Semi-transparent UV filters can filter the UV waves emitted by the sun. Less UV waves is transmitted to the earth. Therefore, less heat is transferred to the ground. One advantage of the UV filter over the light reflecting materials is that no lights are reflected, and it will not cause as many disturbances to residents nearby as the latter will.

Solar fans

The solar panels absorb the EM waves from the sun and convert them into electric energy. The electric energy acts as a power supply to the fans. They increase the air flow, which also increases the rate of evaporation of water in the bus stop. During evaporation, latent heat of vaporization is absorbed by the water. Therefore the temperature decreases. Furthermore, heat convection can be accelerated by the fans.

Cooler air can be drawn into the shelter and the temperature will drop even more.

Experiment

Objective

To study the heat-reducing effect of different materials

Principle

By heat insulation, the change of the temperature in a room decreases. In the experiment, we measure the change in temperature for each room under the three designs to compare
which of them insulate the most amount of heat. Due to limitations in our laboratory, we use a lamp to simulate the sun as an energy supply, and used a few card boxes and cut the top and part of the side of it to stimulate the environment of a bus stop in real life. A plastic shelter is to simulate the current shelter of the bus stop, and to hold the heat-insulating materials.

**Apparatus**

4 card boxes, 4 transparent plastic board, 4 100W lamps, 4 temperature sensors and data loggers, 1 utility knife, 1 ruler

**Materials**

1 roll of tape, 3 solar panels, 400cm² aluminium foil, 400cm² semi-transparent UV filter, 400cm² used CD

**Procedures**

1. Place a transparent plastic board on top of the card boxes so as to provide a platform for mounting different heat-reducing materials.

2. Cut the CD-rom into pieces and place them onto the plastic shelter so that they cover the whole shelter. Cover another shelter with the semi-transparent UV filter. Put the solar panels on the third shelter and connect them to a fan installed inside the box.

3. Put the shelters onto the four cut cardboard boxes with the fourth shelter acting as a control. Pin the temperature sensors into the middle of the boxes.

4. Turn on the lamp and measure the temperature for around 140 minutes.
Photos showing our experimental setups

Fig. 1 Control set up

Fig. 2 Solar fan set up

Fig. 3 CD set up

Fig. 4 Semi-transparent coating set up
Results

Fig. 4 A graph showing the change in temperature throughout the whole experiment.

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>CD</th>
<th>Semi-transparent coating</th>
<th>Solar fan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial temperature</td>
<td>20.5</td>
<td>20.3</td>
<td>20.6</td>
<td>20.3</td>
</tr>
<tr>
<td>Temperature after 140 min</td>
<td>23.7</td>
<td>23.0</td>
<td>23.8</td>
<td>21.7</td>
</tr>
<tr>
<td>Change in temperature</td>
<td>3.2</td>
<td>2.7</td>
<td>3.2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Fig. 5 A table showing the change in temperature over 140 minutes.

Conclusion of the experiment

From the above results, we can see that the most efficient material in lowering the temperature of the box is the solar fan and the CD comes next. Apart from that, we can also see that there is no significant difference in the change in temperature between the semi-transparent coating and the control setup which implies that the coating is not really useful in heat-proofing.
Theory behind our experimental setups

The major heat source of the city is the sun, which emits heat by radiation. Heat then passes through the atmosphere and finally reaches the earth surface, the place where we are living. Here, a 100W lamp is to simulate the sun as the heat source.

In an open area (for example, a bus stop), most of the heat is transmitted to people in the bus stop by radiation. Conduction is not a major form of heat transfer to people because air surrounding us is a poor heat conductor. Heat can be transferred to other places by convection, but the direction of heat transfer by that method would be upwards instead of downwards (from the atmosphere to the earth surface). Since our objective is to investigate and design a suitable shelter that reduces “hotness”, we have divided the process of cooling into two aspects, reduce heat gain and increase heat loss.

Reduce heat gain

To reduce heat gain by our proposed shelter, we reduce radiation absorption. Since we would like to reduce heat gain while conserving the light energy of the sun, we have chosen semi-transparent UV filter and used CD for our experiment because both materials should effectively block heat absorption. The difference between the two materials is that the UV filter allows light to pass through while the CD does not.

Increase heat loss

To increase heat loss of our proposed shelter, we increase the convection rate. In one of our setup there is a solar fan- a fan powered solely by solar panels. We hope that by installing a fan under the shelter, heat convection can accelerated such that it draws in cooler air from the outside. Then, the temperature can be lowered.

Further Investigation

The most efficient material in lowering the temperature of the box is the solar fan, however, the cost of a large solar panel is expensive. Instead of using a solar panel to convert solar energy to electrical energy, here we consider the possibility of using a Stirling engine.
A Stirling engine is operated by the temperature difference between the top side and the bottom side so that the piston can be pushed and hence convert the heat energy of the air into the mechanical energy of the flywheel.

The Stirling engine is an external combustion engine, as all heat transfers to and from the air take place through the engine wall and contrasts with an internal combustion engine. Unlike a steam engine, the Stirling engine has a fixed volume of air.

The working principle of the Stirling engine consists of compressing cool gas, heating up the gas, expanding the hot gas, and finally cooling the gas before repeating the cycle. The efficiency is restricted by the Carnot cycle, which depends on the temperature difference of the air on the top side and the bottom.

The Stirling engine is noted for its high efficiency to steam engines, quiet operation, and it can be used nearly when there is temperature difference. This engine is more efficient and safer than a comparable steam engine.

**Our Stirling Engine**

Here are some photos showing how we made our Stirling engine.

1. Here are some of the materials used for building up the Stirling Engine.

2. Put 4 screws into the holes of the copper plate and in 90 degrees to secure its position. Place a plastic ring on the bottom copper plate as to prevent the air from escaping from the chamber afterwards.
3. Place the plastic wall of the chamber onto the bottom copper plate.

4. Put on the upper part which consists of the displacer piston and plastic tubing and add the remaining screws into the holes.

5. Check if there is any space between the copper plate and the plastic chamber wall.
   It is very important as the air will escape from those places.

6. Place the piston into the little chamber.

7. Try on the piston see if it works or not.

8. Screw the stand to the top copper plate and attach the flywheel to the stand. Then, place the hooks of the piston onto the centre of the flywheel.
Conducting the Experiments

We carried out the following experiment to test out our hypothesis that a Stirling engine can replace the solar panel to power up a fan. We recorded the speed, temperature difference and electricity generated by the engine over different periods of time.

For the tests, we used hot water and other heat sources on one side and icepack to decrease temperature on the other side. This can make the temperature difference maximized. Then, we will use a multimeter to record the electricity produced by the Stirling engine and its speed.

First, we found out that the flywheel of the Stirling Engine loses much energy due to its light weight, we decided to try to add weight to the wheel in order to store more kinetic energy on the flywheel by creating an inertia, thus making the engine run faster and smoother. We added four weights, each weighing 2 grams, onto the rim of the flywheel of the engine and each of them are 90o with each other.
The results are as follows:

From the results, we can see that the Stirling Engine which we added weight on generates nearly the same electricity comparing with the original one under different temperature difference. But from the graph, we can find out that with a lower temperature difference, the modified Stirling engine can produce electricity at a temperature difference lower than the original one. Adding weights could make the Stirling engine more effective as the Stirling Engine move in a even a little temperature difference.

In short, we found out that adding weights would make the Stirling Engine spin increase its effectiveness and power up a fan.
Our other hypothesis was that adding a solar reflector could concentrate more heat energy onto the plates of the Stirling engine with the same light source, increasing the temperature difference.

We carried out the following experiment to test our theory that this stirling engine can be used in a bus stop to produce electricity.

1. We had two set-ups. For the first set-up, we just put the Stirling engine under a strong lamp as a source of heat energy and a cup of ice is added under the engine.
2. For the second set-up, we did the same, but put a solar reflector behind the engine to reflect light from the lamp onto the Stirling engine.

Below are the results:

Comparing set-ups 1 and 2, the speed of spinning of set-up 2 is much higher than that in set-up 1. It shows a significantly high efficiency result. From these results, we can conclude that the solar reflector can concentrate heat energy on the copper plate and increase the temperature difference of the Stirling engine under a certain amount of light and heat energy, which can increase the speed of spinning of the flywheel.
**Conclusion**

It could be shown that solar fans reduce heat better than light reflecting materials such as CDs. Instead of adopting the solar fan design only, we suggest combining the two materials by putting some light reflecting materials under the solar fan when producing the shelters. In addition to the fan connected to the solar panels, heat in the bus stops can be further reduced. People will no longer need to suffer from the intense heat when they are waiting for their buses. Even if they have to wait for a long time they will feel less annoyed as they can enjoy the cool and comfortable environment while waiting.

Apart from bringing comfort to people waiting for their buses, this design is also environmentally friendly. No fossil fuels have to be burned when the fans are in operation. This will not worsen the pollution situation in Hong Kong.

To reduce the cost, we may also apply the stirling design:

For our Stirling Engine, the amount of electricity generated in our experiments is limited, as there is only one engine. We have not tested that whether connecting a few Stirling Engines in series could multiply the voltage of the electricity produced. If it is possible, then the greater electricity generated through the Stirling engine can be used in more places, widening the application range. For example:

The metal columns to hold the shelter can be painted in white. This reduces the damage and prevents oxidation of the metal columns. Plus, painting the columns in white can reduce the heat absorbed as white surfaces are poor radiation absorbers.
This also helps alleviating the urban heat island effect.

To further beautify our shelters, we can paint the surface of the light reflecting material and also the fans. When people are waiting, they can look upwards and appreciate the beautiful paintings on the ceiling instead of having nothing to do.

In short, we put a layer of light reflecting materials under the solar panels or the stirling engine and to install fans under the two layers. The metal columns would be painted in white. All the designs would help reducing the heat in the bus stops, and brings contribution in bettering the earth.

**Comment:**

Students attempted to investigate an effective method to cool down the temperature at the bus stops during summer, so that the waiting passengers could feel more comfortable. It is highly appreciated that the students could observe some problems from our daily life and find out a research gap to improve the current situation. The use of the Stirling engine as an environmental friendly fan was creative. It is suggested that students may improve the efficiency of the Stirling engine and reduce the cost.
Problem of Food Waste

The Y.W.C.A. Hioe Tjo Yoeng College
Teacher: Tong Wai Kit
Student: Chan Chun Yam, Chau Yeung, Lo Hoi Ching, Wu Ching Wa, Lee Nga Ting,

Introduction

(I) What is food waste?
According to the United Nations, food waste is food loss which occurs during the retail and final consumption stages due to the behavior of retailers and consumers -- which is, the dumping of food.

(II) Food Waste problem in Hong Kong
In 2009, Hong Kong generated about 18,000 tonnes of municipal solid waste (MSW) every day. Despite continuous expansion of the source separation and recycling programmes for MSW, there are still some 9,000 tonnes of MSW which need to be disposed of at our three landfills each day. Of these, some 3,280 tonnes are food waste, constituting about 37% (largest) of the waste disposed. Of the food waste generated daily, some 960 tonnes are from commercial and industrial (C&I) sources such as restaurants, hotels, wet markets, catering and food processing industries. The amount of food waste arising from the C&I sector has been increasing steadily, the amount in 2009 was more than twice that of 2002 (Legislative Council, 2010). In this project our focus is on the treatment of food waste produced from restaurants and homes. (Environmental Protection Department, 2010)
Possible Solutions to food waste problem in Hong Kong

As we all know, Hong Kong is not an agricultural city. If all the food waste is used as organic fertilizer, there will definitely be an excess. The unused organic fertilizer will be a kind of waste or require transportation to other areas, hence burning up more fossil fuels.

Recycling bins are located in various areas of Hong Kong. The different types of waste are separated based on their properties. Using the same idea, we recommend that food waste be separated into different types, including used oil, carbohydrates, vegetables and others. Food wastes, especially from restaurants and the food industry can be easily separated into different types, saving time and money. Biological or chemical methods can be used to convert different types of food waste into other materials useful in areas where the waste is produced.

(I) Used Oil
(i) Making Soap from used oil

Large amounts of used cooking oil, which can be used to make soap, are discarded by restaurants every day. In one experiment, we collected used oil from our school tuck shop. Like other restaurants, the main purpose of the oil is for deep frying food such as French fries and chicken wings.

• Method – Saponification

Add used cooking oil to concentrated sodium hydroxide solution. Keep stirring until the mixture thickens. Lastly, pour the mixture into a mould and leave to solidify.

To make soap from 1 liter of used oil, we need 1 liter of used cooking oil, 200 g of NaOH and 400 milligrams of warm water. The amount of chemicals can be amended based on the volume of used oil.

The pH of the soap can be monitored by using pH papers to prevent the soap from becoming too alkaline due to excess sodium hydroxide.

After shaking, test tube A (oil + water + soap) formed an emulsion while test tube B (oil + water) separates into two layers (oil and water). This demonstrates that soap made from used oil can emulsify oil. Used oil in restaurants can be used in soap-making useful for cleaning purpose.
(ii) Making biodiesel

Biodiesel is a diesel fuel made by reacting vegetable oil (cooking oil) with other common chemicals. Biodiesel may be used in any diesel automotive engine in its pure form or blended with a petroleum-based diesel. No modifications are required, and the result is a less-expensive, renewable, clean-burning fuel. In the experiment, we tried to convert used oil to biodiesel.

- **Method - Transesterification**

Used oil is heated to a temperature of 50°C with continuous stirring. While heating, mix sodium hydroxide (as a catalyst) with the methanol until the solid sodium hydroxide dissolves. Pour the sodium hydroxide solution (mentioned above) into the heating oil. Continue heating for 40 minutes. Triglyceride from lipids reacts with methanol to form biodiesel after settling for a few days. The glycerol produced is a raw material necessary for the production of other useful chemicals.

A separating funnel is used to hold the reaction mixture for several days. The used oil could not be ignited even with the help of a wick. The biodiesel could be ignited. The flame is orange in colour and produced a small amount of soot.

The biodiesel produced can be used by restaurants (e.g. transportation).
(II) Carbohydrates and vegetables

(i) Carbohydrates

Carbohydrates is a common food waste, especially rice and bread rich in starch, and soft drinks rich in sugar. Many of these are prepared for daily meals by Hong Kong people but cannot be consumed. In fact, these foods can be collected and left to ferment to produce ethanol.

• Method – Fermentation

Polysaccharides have to be converted to simpler sugar before fermentation in the presence of yeast.

\[ C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(l) + 2CO_2(g) \]

Amylase is required to convert starch present in rice and bread to glucose. We then added the chemicals into a sealed conical flask allowing the yeast to undergo anaerobic respiration. The set up was left to stand for a few days. Later, fractional distillation was carried out at around 80°C to increase the concentration of ethanol.

The optimum conditions for yeast fermentation are as follows:
1) Absence of oxygen.
2) Temperature range of 20° to 30°C
3) pH range of 4 to 4.5
4) Sugar content of less than 40%

Fermentation Time line involving yeast

<table>
<thead>
<tr>
<th>Stage</th>
<th>Time required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag phase</td>
<td>3-15 hours after pitching yeast</td>
</tr>
<tr>
<td>Exponential growth phase</td>
<td>1-4 days</td>
</tr>
<tr>
<td>Stationary phase</td>
<td>3-10 days</td>
</tr>
</tbody>
</table>

Acidified potassium dichromate solution can test the presence of ethanol by oxidation. The ethanol produced reduced the acidified potassium dichromate solution turning it from orange to green.

\[ 3CH_3CH_2OH(aq) + 2Cr_2O_7^{2-}(aq) + 16H^+(aq) \rightarrow 3CH_3COOH(aq) + 4Cr^{3+}(aq) + 11H_2O(l) \]
(ii) Vegetables (Cellulose)

Vegetables are a rich source of cellulose. A large amount of uneaten vegetables are dumped every day, which can be used to make ethanol.

However, in order to obtain ethanol from vegetables, lignin must be first removed from it. Lignin, present in plant cell walls, hinders the breakdown of cellulose in cell walls into simple sugars, and the conversion of these sugars to ethanol (Jing-Ke, 2008).

Lignin can react with hydrogen peroxide in an alkaline medium to form products of low molecular weight. Once the bonding between lignin and cellulose breaks down, it converts to sugar with ease (C. Maes et al., 2000).

Cellulose is then hydrolyzed in an acidic medium to produce glucose, followed by fermentation.

![Cellulose and glucose](http://www.rsc.org/ejga/GC/2008/b808471h-ga.gif)

(iii) Direct ethanol fuel cell

Ethanol produced from the above process can be used in a direct ethanol fuel cell. Ethanol undergoes oxidation to produce water, carbon dioxide and hydrogen ions in the presence of a catalyst (e.g. Pt). Hydrogen ions pass through a proton exchange membrane to the cathode and react with oxygen to produce water. Electrons move from anode to cathode through the external circuit.

Anode: \[ C_2H_5OH(l) + 3H_2O(l) \rightarrow 12H^+(aq) + 12e^- + 2CO_2(g) \]

Cathode: \[ 3O_2(g) + 12H^+ + 12e^- \rightarrow 6H_2O(l) \]

Overall: \[ C_2H_5OH(l) + 3O_2(g) \rightarrow 3H_2O(l) + 2CO_2 \]

![Direct ethanol fuel cell](http://by.genie.uottawa.ca/~baranova/Nano_files/image002.gif)
Discussion

From the fermentation of carbohydrates and conversion of cellulose to ethanol, the fuel cell created can be used directly to generate electricity. The food waste can be collected from buildings and energy can be generated immediately on site where it is produced. This saves energy used in transportation, thus saving fossil fuels. It is recommended that every building has such a system to generate energy from food waste. The energy can be used for lighting purposes and heat supply during winter.

A direct ethanol fuel cell uses ethanol instead of the more toxic methanol. Ethanol is a hydrogen-rich liquid with a higher energy density (8.0 kWh/kg) compared to methanol (6.1 kWh/kg), which has a higher energy efficiency.

However, extracting ethanol through fermentation requires distillation. This process uses much energy, making it an expensive option. Research has been conducted by students from Fudan University, in Shanghai, on separating alcohol-water mixture through silicalite-filled silicone rubber membranes by pervaporation. The membrane produced can save much energy for the separation of ethanol and water compared to distillation.

Red and white meat food waste can be used as organic fertilizers. It is recommended that protein be extracted from meat in the future for other uses like nutrient supplement or added to milk powder to increase protein content.

The government can invite restaurants to join the food waste recycling scheme by reducing taxes or offering subsidies, as incentives. A labeling scheme to designate ‘green restaurants’ can be set up to encourage visits from ‘green activists’ and attract restaurant owners to join the recycling scheme. This would increase the income and popularity of restaurants which join the scheme.

TV commercials can be used as a medium to educate the public, as well as organizing talks and workshops on the recycling of food waste. It is encouraging to see that the topic of food waste is mentioned in Liberal Studies. This would educate the younger generation about the mounting problem of food waste in Hong Kong and the importance of recycling.

Finally, we hope that in the near future, every housing estate has food waste separation bins to encourage the separation of different food waste for different treatment.
Conclusion

By using various methods, food waste can be treated and reused exactly where it is produced. This would help save fuel required for transportation, which is far more eco-friendly. Most importantly, the amount of food waste dumped in landfills and incineration will decrease. Therefore, it is possible that Hong Kong’s dire food waste problem can be reduced.

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23. Fermentation Time Line Christopher White, Ph.D.
Comment:
In this project, students did their research on converting food wastes into other useful resources. It is impressive that the students could identify that the conversion from food wastes to fertilizers may not be the best solution for Hong Kong as agriculture is not popular. The experiments were carefully designed and different food components in food wastes, such as oils and carbohydrates were included in the investigations. The principles of converting food wastes to different useful products were also well studied. It is suggested that student may investigate methods to treat the food wastes which are difficult to be separated into different food components as those components are usually mixed in Chinese cuisine.
Oasis in the City

Tsuen Wan Government Secondary School
Student: Leung Sau Yu, Hung Hon Kit,
Tsang Hin Yung, Wong Cheuk Pang,
Leung Yick Yin

Preface
In Hong Kong, the temperature in urban areas can reach 35°C or above. Sometimes citizens may even die of heatstroke.

Thus, a system to cool its surroundings in the urban area can be beneficial to citizens during hot days. This is not only for pleasure but also help reduce the chance of people suffering from heatstroke. Citizens can take a comfortable rest under the Oasis in the City.

Scientific Knowledge Used – Endothermic Reaction
Endothermic reactions are reactions that absorb energy in form of heat. It is obvious that endothermic reactions can cool the surroundings.

Atoms in molecules are held together by an electrical attractive force. This force gives rise to the bond energies, which are involved in making or breaking the bonds of a molecule. During a chemical reaction, molecules in the reactants are first broken down; the bond energies are released to the surroundings. When forming the products, other bonds are formed; energies are needed and absorbed.

The difference in the types of bonds will result in a difference of energies input and output. In an endothermic reaction, the products have higher bond energies than the reactants. Thus, a net flow of energy into the system occurs. This explains why endothermic reactions absorb heat from the surroundings.

Scientific Knowledge Used – Transpiration in plants
Plants will carry out transpiration all day. This is a process where water evaporates from the
plants’ surface. The water takes away latent heat of vaporization from the surroundings. Therefore, it produces a cooling effect.

Many countries plant Crassulaceae on rooftops to cool them down. It has a waxy surface and concaved stomata. It is widely chosen because it can survive from extreme weather conditions including droughts. It has fast growth and asexual propagation. Research found that a greenery rooftop can cool it down by 8°C and a greenery cover of 4 m2 has the same effect of that of air-conditioning for 12 hours. Moreover, it’s colourful appearance can beautify the city. Therefore we use Crassulaceae in our design.

**Citric Acid and Baking Soda**

There are many different endothermic reactions. In our design, we choose the reaction between citric acid and baking soda (sodium bicarbonate). The reaction formula is shown as the follows:

\[
H_3C_6H_5O_7(aq) + 3 NaHCO_3(s) \rightarrow 3 CO_2(g) + 3 H_2O(l) + Na_3C_6H_5O_7(aq)
\]

We choose this reaction because of 2 reasons. Firstly, the reactants and products involved are safe while other endothermic reactions may involve toxic chemicals.

Secondly, the reactants can be obtained easily. Citric acids are commonly found in fruits and vegetables, while baking soda can easily be obtained by mining and inexpensive Solvay process.

**Our Design – Reaction System**

Citric acid solution is placed in a tank at the bottom of the setup. The solution will be pumped to the bottom of the sodium bicarbonate container. The container has filter paper on the top and bottom to hold solid sodium bicarbonate in between. An electrical pump will be placed underground for not blocking pedestrians along the street.

When the citric acid solution flows through the bottom filter, undissolved citric acid is filtered out. The citric acid solution will dissolve some sodium bicarbonate before
leaving the top filter paper and reaction starts to take place. Undissolved sodium bicarbonate remains inside the container. The mixed solution is further pumped into the reaction chamber. Reaction continues to take place. The reaction absorbs heat from the shelter to cool it down.

Furthermore, we will plant Crassulaceae on the top of the shelter to enhance its cooling effect.

**Our Design - Handling the products**

During the endothermic reaction, sodium citrate, water and carbon dioxide are produced. There are some holes on the top of the reaction chamber to allow carbon dioxide to escape to the soil above. The gas will be absorbed by the plants at the roof in photosynthesis.

Sodium citrate, which will dissolve in water from aqueous citric acid, will also be produced in the reaction. It will flow down to the solution collection chamber. The cool solution will run down the shelter, acting like cooling coils. It will be collected and brought away regularly. Sodium citrate can be used as a buffering agent and ingredient of medicines.

In conclusion, this shelter doesn’t produce toxic materials. It does no harm to the environment and fits sustainable development.

**Our Design - Physical Features**

The shelter has a dimension of 3m (L) x 3m (W) x 4m(H) and will be placed on the ground. We will use glass as the main material because it has a comparatively high specific heat capacity (840 J kg\(^{-1}\) °C\(^{-1}\)), resulting in a slower rise in temperature. We will paint shiny colour on the shelter to reflect heat radiation from the surroundings. We will place the shelter in crowded urban areas like Mong Kok, where it is highly demanded because of the high temperatures.
Experimental Report

Date: 6th March 2012

Objective: Show the effect on cooling when mixing citric acid and baking soda

Principle: It is known that mixing citric acid and baking soda absorbs heat from the surroundings. This can be a great help in creating an “Oasis in the City”.

It is assumed that other factors remain constant. The independent variable is the ratio of the amount of substances being mixed. The dependent variable is the temperature changed (dropped) in the reaction. The controlled variable is the temperature of the substances, water added and surroundings.

Materials:

<table>
<thead>
<tr>
<th>Material</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baking soda</td>
<td>30g</td>
</tr>
<tr>
<td>Citric acid crystals</td>
<td>30g</td>
</tr>
<tr>
<td>Distilled water</td>
<td>50ml</td>
</tr>
</tbody>
</table>

Apparatus:

<table>
<thead>
<tr>
<th>Apparatus</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaker (100 cm³)</td>
<td>2 pcs</td>
</tr>
<tr>
<td>Thermometer (-10 - 100°C)</td>
<td>2 pcs</td>
</tr>
<tr>
<td>Glass rod</td>
<td>2 pcs</td>
</tr>
<tr>
<td>Spatula</td>
<td>2 pcs</td>
</tr>
<tr>
<td>Measuring cylinder (50 cm³)</td>
<td>1 pc</td>
</tr>
<tr>
<td>Electronic balance</td>
<td>1 pc</td>
</tr>
</tbody>
</table>

Procedure:

1. 7ml of distilled water was prepared in a beaker.
2. A certain amount of reactant is prepared for a complete reaction.

From the chemical equation (3NaHCO₃ + C₆H₈O₇ → Na₃C₆H₅O₇ + 3CO₂ + 3H₂O), 3 moles of baking soda and 1 mole of citric acid are needed in the reaction.

Simplify the ratio to a rational amount.

\[
\frac{3}{1} \rightarrow \frac{0.06}{0.02}
\]

Mass of baking soda needed = 0.06 mol x 84 g mol⁻¹ = 5.04g
Mass of citric acid needed = 0.02 mol x 192 g mol⁻¹ = 3.84g

5.04g of baking soda and 3.84g of citric acid were prepared for the reaction.

3. The temperature of the tap water was recorded.
4. Baking soda and citric acid crystals were added to the beaker of tap water by using a spatula.
5. The final temperature was recorded and the temperature change in the mixture was calculated.
6. Experiments on different ratios of the reactants were tested.

Precautions:
1. When citric acid crystals dissolve in water, they dissociate and show acidic properties. They should be handled with care.

Results:
The results of different attempts are tabulated as follows:

<table>
<thead>
<tr>
<th>Attempt</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of baking soda [A]</td>
<td>5.03</td>
<td>4.2</td>
<td>3.75</td>
</tr>
<tr>
<td>Amount of citric acid crystals [B]</td>
<td>3.87</td>
<td>3.2</td>
<td>2.86</td>
</tr>
<tr>
<td>Ratio of A:B</td>
<td>≈13:10</td>
<td>21:16</td>
<td>≈13:10</td>
</tr>
<tr>
<td>The mixture</td>
<td>Initial temperature</td>
<td>23°C</td>
<td>23°C</td>
</tr>
<tr>
<td></td>
<td>Final temperature</td>
<td>10°C</td>
<td>12°C</td>
</tr>
<tr>
<td></td>
<td>Temperature change</td>
<td>-13°C</td>
<td>-11°C</td>
</tr>
<tr>
<td>The surroundings</td>
<td>Initial temperature</td>
<td>28°C</td>
<td>28°C</td>
</tr>
<tr>
<td></td>
<td>Final temperature</td>
<td>18°C</td>
<td>21°C</td>
</tr>
<tr>
<td></td>
<td>Temperature change</td>
<td>-10°C</td>
<td>-7°C</td>
</tr>
</tbody>
</table>

Lasting time of the cooling effect:

![Lasting time of the mixtures' temperature](image)

Conclusion:
According to the above experiment, the mixing of baking soda and citric acid causes a drop in temperature, which is favourable for the “Oasis in the City”. It has proven that a ratio of 13 portions of baking soda to 10 portions of citric acid crystals is the most effective for the cooling.
Photos:

Baking soda used in attempt 1

Citric acid used in attempt 3

Initial room temperature

Initial temperature of the mixture

Lowest temperature reached in attempt 1

Lowest temperature reached in attempt 2

Lowest temperature reached in attempt 3

Temperature of the surrounding when reacting
Conclusion

In conclusion, the system inside our shelter absorbs heat energy from the surrounding area. The reactants, citric acids and baking soda, are safe and can be easily obtained. We have also discussed the way to deal with the products of the reaction. We specially design the materials and the physical features of the shelter to maximize its cooling effects. Moreover, according to the experimental results, the endothermic reaction is effective in cooling. It proves the ability of the reaction in the shelter to cool its surroundings.

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Comment:

Students aimed at reducing the temperature in the urban area by using shelters which can absorb heat by both chemical reaction and transpiration of plants. The cooling method is innovative with the use of an endothermic reaction in addition to the use of plants on the rooftop apart from reflecting the sunlight. The design of the shelter also provides fresh air for the city when plants photosynthesize. It is suggested that students may investigate a method for replenishing the used chemicals after they are consumed. In addition, it would be better to use solar energy to provide electricity for the pump in order to be even more environmental friendly.
2012-13
Winning Proposals
Hong Kong Budding Scientists Award
2012-13年香港科學青苗獎比賽題目
「未來世界難題/現實難題」

1. 香港的海洋污染

新聞不時報導有關本港海洋污染問題，引起市民的關注。香港的天然資源有限，香港特別行政區政府應竭力避免海洋環境受到任何污染。試建議一個或以上的方案以避免或處理其中一種香港的海洋污染問題。解決方案必須實用、具經濟效益，符合科學原則，並有證據支持。

2. 辦公室健康

不少在職人士每天都要在辦公室內上班，整天長時間坐著使用電腦及電話等通訊工具工作。可是很多員工未能正視正確的坐姿、調教電腦螢幕和鍵盤的位置及定時讓眼睛和肌肉休息的重要性。另外，辦公室的空氣質素、溫度及燈光的調節等設施，如果不妥善處理，都會逐漸影響身體健康及工作效率。試想出有效的方法和 / 或發明新產品去改善上述情況。你的建議或發明必須實用、具經濟效益、符合人體構造或物理等科學概念，並有證據支持。

3. 其他

試描述一個發生在香港，並和科學及科技相關的現實難題。你須要說明難題的重要性及提出解決方法。你的解難方案應把重點放在科學和科技層面上。另外，你的建議必須實用、具經濟效益、符合科學原則，並有證據支持。
例一：使用鎢絲燈引發的問題；

例二：利用科學方法探究一些電視或電影中曾經出現的情節是否在真實世界存在。例如：電影中主角向門鎖射擊，破壞門鎖及開門。此情節已被另一電視節目（Mythbuster）以科學角度證實不可能。
1. Marine Pollution in Hong Kong

From time to time news about marine pollution in Hong Kong concern Hong Kong people. The natural resources in Hong Kong are limited and the Hong Kong Government should strive to avoid its environment from any marine pollution. Suggest in your proposal way(s) to avoid and / handle one kind of marine pollution in Hong Kong. The suggestions in your proposal are required to be practical, cost-effective, scientific and evidence-based.

2. Health in Offices

Many employees are required to work in an office environment. They have to spend the whole day sitting there and using different communication tools, such as computers and telephones. However, they rarely recognize the importance of correct sitting posture, proper locations of computer screens and keyboards and regular relaxation of eyes and muscles. Moreover, if the air quality, room temperature and light intensity in offices are not suitable, the health and working efficiency of the employees would also be gradually affected.

Please suggest an effective method and/or a new invention to improve the above situation. Your suggestion/ invention should be practical, cost-effective, well supported with science concepts, such as human physiology, physics etc. and evidence based.

3. Others

Describe an authentic problem in Hong Kong which is related to science and technology. Justify its importance and then suggest some solutions to solve the problem. Your proposal should focus on the scientific and technological aspects. Besides, the solutions should also be practical, cost-effective, scientific and evidence based.
Example 1: The problem of using tungsten lamps;

Example 2: Examine the scenes in TV programmes or movies through scientific investigations and check the possibility in a real world. For example, characters in movies successfully break in a room by breaking the lock with gun fires. This scene has been “busted” from science in another TV programme “Mythbuster” through scientific evidences.
The pH value of seawater in Aberdeen Typhoon Shelter and its solution

St. Paul's Co-educational College Primary School
Students: Lam Cheuk Wang, Luk Ethan Joshua, Chiu Tsun Fung, Kam Chun Kei Wong Penelope Wynne
Teacher: Mr. Law Chun Yu, Ms. Kong Jennifer Hoi Ying

Introduction

The maintenance of pH value is very important to marine life because it can greatly affect marine ecology. Many marine organisms are sensitive to the change in pH value. The shells of many marine animals are softened by lower pH value and become more vulnerable to the attack from their predators. According to the Environmental Protection Department, the pH value of seawater in Hong Kong should be kept between 6.5 and 8.5. However, the pH value of the seawater has been highly affected by the human activities including domestic sewage disposal and trace of the additives of the fuel used by water vehicles. The acid rain caused by industrial exhaust would further decrease the pH value of the seawater indirectly.

Aberdeen Typhoon Shelter

Aberdeen Typhoon Shelter is located in the Southern District of Hong Kong. It is about 5 minute trip from our school.
Characteristics of Aberdeen Typhoon Shelter

1) Hundreds of fishing boats anchor there. Many fishermen and their families live on the boats. Domestic sewage including food leftover, bathing soap and shampoo from the boats may be discharged directly to the typhoon shelter.

2) The typhoon shelter is long and narrow. Water flow is slow and so sewage may stay in the typhoon shelter for a long time.

3) There are residents at both sides of the typhoon shelter. Sewage from residential areas may also be discharged to the typhoon shelter directly.

According to the Environmental Protection Department, the pH value of seawater in Aberdeen Typhoon Shelter has been dropping in the recent 20 years due to sewage discharge and CO2 discharge by burning fossil fuels.

In this experiment, seawater is obtained from Aberdeen Typhoon Shelter and its pH value is measured.

Calcium carbonate

Calcium carbonate is an alkali which can neutralize acid. It is a main component of rocks and egg shells. At school, the main source of calcium carbonate is chalk, so we can obtain calcium carbonate directly using chalks in the classroom.

Experiment

Equipment used:
1. Digital pH meter
2. pH 4.0 and 6.8 buffer (for calibrating the pH meter)
3. 250mL beakers
4. Facial masks and gloves (As a safety issue to prevent inhalation of chalk powder and allergy)
Materials
1. Chalk
2. Different samples of water
3. Shampoo

Procedure:
1. Calibrate the pH meter with the buffer solutions.
2. Measure the pH value of sea water, tap water and distilled water for 3 times respectively and take the average of the readings.
3. Mix a little bit of shampoo with 200 mL pure water, measure the pH value for 3 times and take the average of the readings.
4. Grind a piece of chalk until it becomes powder.
5. Weigh 2 g of chalk powder and put it in 200mL seawater, stir well and wait for 30 minutes.
6. Put the pH meter into the mixture and wait until the reading of the pH meter becomes steady.
7. Repeat the procedures for 3 times and take the average of the readings.

Result

<table>
<thead>
<tr>
<th></th>
<th>Sea water</th>
<th>Seawater with calcium carbonate</th>
<th>Tap water</th>
<th>Tap water with calcium carbonate</th>
<th>Distilled water</th>
<th>Distilled water with calcium carbonate</th>
<th>Shampoo</th>
<th>Shampoo with calcium carbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average reading</td>
<td>5.9</td>
<td>7.4</td>
<td>6.5</td>
<td>7.6</td>
<td>6.9</td>
<td>7.5</td>
<td>6.0</td>
<td>6.8</td>
</tr>
</tbody>
</table>

It is found that calcium carbonate is effective in increasing the pH value of the seawater and shampoo mixture.
Design of the device

In order to reduce the impact of the sewage from the fishing boats to the water in Aberdeen harbour, we have designed a portable device to serve as a preliminary sewage treatment pack for treating the domestic sewage from the fishing families. As lots of the bathing soap and shampoo are mildly acidic, the purpose of the domestic sewage treatment pack is to serve as a pH balancer to reduce the pH difference between the sewage and the seawater.

The design is based on the materials which are reused from the domestic waste, such as the plastic bottles, together with the calcium carbonate and the nylon bag which are easily accessible with a relatively low cost.

1. The tube should be placed at 30°– 45° so that the sewage flows smoothly along the tube, yet limiting the speed of the flow. This allows sufficient time for the reaction between the sewage and the calcium carbonate.
2. There is a gate at the exit of the device. This controls the flow of the sewage and allows sufficient time for the reaction between the sewage and the calcium carbonate.
3. A nylon bag acts like a ‘teabag’ to hold calcium carbonate and it can be replaced easily.
Limitations and further investigations

In our experiment, we have investigated on the effect of calcium carbonate on the pH value of seawater. To investigate the effect of calcium carbonate to the pH value of the sewage, we could further conduct a number of trials on using a different amount of calcium carbonate powder. Moreover, the time for the treatment should also be compared for finding out the best time for keeping the sewage before discharging.

The experimental result shows an increase in the pH value of the seawater, and thus should conduct further experiments to investigate the effect of the insoluble calcium carbonate from the chalk on marine plants and animals. It is important for us to make sure that the treated sewage is not harmful to the marine organisms in any means.

Conclusion

The device is simple and user-friendly as it can be used in neutralizing acid in domestic sewage. Calcium carbonate is easy to obtain, environmental friendly and effective. We hope that this device would help protect the marine environment in Hong Kong.

Reference


Acknowledgement

Special thanks to Ms Siu Mei Yuk, Mr Tang Wai Cheong and Ms Yue Chor Man for their valuable advice.
Comment

Students were able to point out the importance of the maintenance of pH of seawater to marine ecology. They considered the reaction between calcium carbonate and acid and investigated the effect of calcium carbonate on the pH value of seawater. A portable device was also designed using this concept and effectively increased the pH of seawater. However, it would be much better if the students could investigate more on the optimum time for keeping the sewage before discharging and also the optimum concentration of calcium carbonate required for each reaction.
Interview with a Scientist

An Interview with Professor Chan Lung Sang: His Way as a Geology Expert

St. Paul’s Co-educational College Primary School
Students: Lam Cheuk Wang, Luk Ethan Joshua, Chiu Tsun Fung, Kam Chun Kei, Wong Penelope Wynne
Teacher: Mr. Law Chun Yu, Ms. Kong Jennifer Hoi Ying

Profile of the Interviewee

Professor Chan Lung Sang is a professor in the Department of Earth Science in University of Hong Kong. His specialized research interests are in Geophysics and applied geophysics, geology and tectonics of Hong Kong Region (http://web.hku.hk/~chanls/).

As Professor Chan has profound knowledge and lots of experiences in studying the geological activities, he has been frequently exposed in the mass media to explain the effect and the impacts of the natural disasters such as earthquakes and tsunami.

Interview Background

We have invited Professor Chan for our scientist interview because of two reasons. Firstly, we are really curious about the life of a geological scientist and the preparation work in becoming an expert in this area. Moreover, we would like to ask for comments and suggestions on our project of the water treatment kit for the fish boats.

Professor. Chan’s Road to a Geology Expert

Start from self-interest, continue in life experience

Professor Chan loves observing different kinds of rocks since his teen age because he does not like ever-changing objects. It leads him to get on the road of geology. However, he could hardly find any experts of geology in Hong Kong at that time, he acquired the knowledge from self-reading.
In his 40 years work on geology and geophysics, Professor Chan claimed that everything was an interesting experience to him. He mainly focuses his work on disasters and he is fond of finding out the cause of the land plate movements so as to eliminate the harm to us.

**Inspiration from everybody: A scientist never works alone.**

Great scientists come only once in a while, but Professor Chan was inspired by the scientists from their work but not their fame. He also said a monumental scientific breakthrough or achievement doesn’t only include one great scientist’s work, but the cooperation of millions of other scientists. The discoveries of famous Galileo, Newton and Einstein were just discoveries based on many different theories from scientists from the past.

“A scientist doesn’t have to wear a pair of nerdy glasses, a white robe and be single,” Professor Chan stated. Those mentioned are all just stereotypes of our perspectives on scientists. It can be a man who plays with his children, and can also be a woman who stays at home. Scientists can have different personalities and can definitely be diverse, but the most important qualities a scientist must have are never-ending passion, enduring commitment, willingness to explore and focus.

**Work hard, play hard: this is the way of a scientist.**

In his 18 years in the University of Hong Kong, Professor Chan said he really enjoys it. He thought it was not hard to be a scientist but when he was facing obstacles in his career, he always keeps trying and keeps a mind open to think of counter proposals.

We all know scientists usually have a hectic lifestyle. They sacrifice their private time by constantly conducting experiments and studying. Professor Chan said that when he is tired from work, he will go hiking, watch movies or spend quality time with his family. But at the end of the day, he still finds being at work fun and interesting because of his passion for his field, Geology. Therefore, sometimes he needs his family’s consideration for not showing up at dinners or gatherings. A quote from Professor Chan, ‘Once you truly like something, you will never think it is boring or feel busy at all.’
Professor Chan thinks that being a scientist should be fun but not hard. Scientists are neither lonely nor boring. He told us to accept that the finishing product might not be what was expected from the starting point, but it is the most interesting part in any scientific research.

**Suggestions and advice on our device**

(Below is a diagram of our prototype)

After a thorough discussion with Professor Chan, we have come to a consensus on how to improve our device that increases the pH value of the sea.

1) Instead of just having a simple nylon bag, Professor Chan suggested considering adding three more sand layers. The purpose is to purify the water and elevate the water quality.

2) The nylon bag contains one main ingredient, chalk (calcium carbonate).

Professor Chan suggested adding activated charcoal or carbon and Zeolite into the nylon bag (three materials are at a relatively low cost, zeolite can be found in fish aquariums)
Conclusion

Everyone has ups and downs during their scientific career, hence, we asked Professor Chan why or what has made him continue to pursue his career. He said there are three main keys to succeeding: luck, passion and determination. The most important one is passion. ‘When you enjoy what you are doing, you can’t feel any pressure,’ he said. Through interviewing Professor Chan, not only has his advice inspired us to enhance our water pollution device, we have also learned essential morals on how to be a successful scientist or innovator.

Appendix

Pictures taken during the interview.

Busily jotting down notes.

Prof. Chan is showing his drawings to us.

We felt honored to interview Prof. Chan.
We were so excited to check out Prof. Chan’s office!

**Acknowledgement**

First of all, we are grateful to the Hong Kong Federation of Youth Groups for establishing Hong Kong Budding Scientists Award so that we have a chance in participating in this meaningful event.

We wish to express our sincere thanks to Ms. Leung, the Principal of St. Paul’s Co-educational College Primary School, for providing us support with all the necessary facilities.

We are extremely grateful to Professor Chan for his expert, sincere and valuable advice and suggestions given to us.

We take this opportunity to record our sincere thanks to Mr. Law Chun Yu, Mr. Tang Wai Cheong, Ms. Yue Chor Man and Ms. Kong Hoi Ying for their unceasing encouragement, time and valuable guidance to us.

We also place on record, our sense of gratitude to one and all who, directly or indirectly, lent their helping hands in this activity.
CAN FRUIT PEELS ABSORB OIL SPILLS?

Diocesan Boys’ School Primary Division
Students: Jaden Tsui, Lester Ho,
        Adrian Wong, Adrian Lee
Teacher:  Hau Wing Leong Louis

INTRODUCTION

Oil spills have occurred all over the planet. This has caused terrible damage to the marine life in the ocean and the surrounding habitats. Oil and grease also frequently appear in Victoria Harbor\(^1\). After examining a website about using dried lemon peels to purify and clean ocean oil spills\(^2\), we wanted to know if applying other natural items could improve the result. We decided to test other different kinds of fruit peels to observe which kind of fruit skin may be best suited to absorb excess oil. As fruit peels are usually discarded, if we succeed, this idea may not only be a benefit to cleaning oil spills, but also to reduce waste. Therefore we have put the following experiment to the test.

SOLUTION

Aim

To test whether various fruit peels would absorb oil and which fruit peel is the most effective in absorbing oil to improve the cleaning of oil spills. We would also like to investigate if the peels absorb more when they are fresh or dried.

Hypothesis

We think that the banana peel will have most effect on absorbing the oil because it contains the most amount of fiber among the different fruits\(^3\). We also assumed that dried peels would absorb more because the absence of moisture may allow for greater absorption of the diesel.
Materials and Apparatus
- Orange peels
- Lime peels
- Lemon peels
- Pomelo peels
- Banana peels
- Knife
- Ruler
- Toothpicks
- Diesel
- Tap water
- Beakers
- Labels
- Markers
- Measuring cylinder

Procedure
1) Cut the fruit peels into equal pieces (Approximately 1cm x 1cm on the peel surface)

2) Dry half of the fruit peels.
3) Measure approximately 1 g of dried peel and 2 g of fresh peel from each fruit.
4) Add 100 ml tapwater 50 ml of diesel in 10 beakers respectively.
5) Put fresh and dried fruit peels into the beakers.
6) Wait for 2 days.
7) Remove fruit peels using toothpicks.
8) Measure remaining diesel and water in measuring cylinders to determine Which peel soaked the most oil.
Measurements of Equal Weight (in grams)

<table>
<thead>
<tr>
<th></th>
<th>Orange</th>
<th>Lime</th>
<th>Lemon</th>
<th>Pomelo</th>
<th>Banana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried</td>
<td>0.96</td>
<td>0.99</td>
<td>0.97</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>Fresh</td>
<td>2.04</td>
<td>1.97</td>
<td>2.02</td>
<td>1.99</td>
<td>2.04</td>
</tr>
</tbody>
</table>

Data Collection and Interpretation

A beaker is not precise enough for the measurement in our experiment. Therefore, we used a measuring cylinder instead. However, during the transfer of the mixture from a beaker to the measuring cylinder, a thick layer of emulsion (A mixture of oil and water) formed between the oil and the water. Taking it as oil will make our results unreasonable while taking it all as water will exaggerate the amount of oil absorbed by the peels. So we have made the following assumption:

We assume that the emulsion is 50% water and 50% oil.

Therefore, the formula for dried fruit is:

\[ \text{DIESEL ABSORBED} = 50 \text{ ml} - (\text{DIESEL volume} + \frac{\text{EMULSION Volume}}{2}) \]

Since the original weight of fresh fruit was doubled of the dried fruit, the formula for fresh fruit is:

\[ \text{DIESEL ABSORBED} = \frac{(50 \text{ ml} - (\text{DIESEL volume} + \frac{\text{EMULSION Volume}}{2}))}{2} \]

Data Analysis

We made a comparison among all fruit peels and compare the dried and fresh ones.
We discovered that dried lime peels absorbed the most amount of oil of all the dried fruit peels. The fresh lime peels were likewise absorbing the most amount of oil amongst the fresh peels. Our hypothesis that bananas would absorb the most amount of oil is not supported by our results.

Most of the fruits peels we tested, the dried peels absorbed more oil (Lime, orange and lemon), but one of them has no significant difference between the dried and fresh peels (banana) and one of dried peel actually absorbed less oil (Pomelo). Our hypothesis of dried peels absorbing more oil is not well supported by our results. We may further our research on this aspect.
EXTENSION

Background and Aim

During our interview with the scientist, Dr. Tsang and our team discussed about the difference between ‘absorption’—oil being taken into the peels, and ‘adsorption’—oil being stuck on the peels. The amount of oil that can be removed by the former one depends on the mass of the peels, while the oil can be removed by the later one depends on the surface area on the peels. By cutting the same amount of peels into smaller pieces, the surface area is increased. We also talked about the salinity and pH in sea water, which may affect the results. Therefore, we extended our research on whether surface area will affect the amount of oil removed using salt and vinegar to mimic seawater.

Hypothesis

We predict that the peels with bigger surface areas will do better in removing the diesel if a significant amount of the diesel removed by adsorption.

Additional materials & apparatus

- pH paper
- Vinegar
- Salt

Procedures

1. We chopped the peels into 1.5cm x 1.5cm, 2.0cm x 2.0 cm and 2.5 cm x 2.5 cm sizes.

2. After that, we mixed water with vinegar to adjust the pH and checked it with pH paper.
3. We then mixed in the salt and stirred it until the salt had dissolved. Then we add in the layer of oil.

4. We put in 2g of orange and lime peels of different sizes.

5. After 2 days, we took the peels out and collected the following data.

Data analysis

<table>
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<tr>
<th>(volume in ml)</th>
<th>Emulsion</th>
<th>Diesel</th>
<th>Diesel Absorbed</th>
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</thead>
<tbody>
<tr>
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<td>5.0</td>
<td>46.0</td>
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<tr>
<td>Orange 2.0 x 2.0 cm</td>
<td>6.0</td>
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<td>1.0</td>
</tr>
<tr>
<td>Orange 2.5 x 2.5 cm</td>
<td>17.0</td>
<td>40.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Lime 1.5 x 1.5 cm</td>
<td>5.0</td>
<td>40.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Lime 2.0 x 2.0 cm</td>
<td>4.0</td>
<td>45.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Lime 2.5 x 2.5 cm</td>
<td>7.0</td>
<td>44.0</td>
<td>2.5</td>
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<table>
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<tr>
<th>Fruit Type</th>
<th>1.5 x 1.5 cm</th>
<th>2.0 x 2.0 cm</th>
<th>2.5 x 2.5 cm</th>
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<tbody>
<tr>
<td>Orange</td>
<td>1.5</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Lime</td>
<td>3.8</td>
<td>3.0</td>
<td>2.5</td>
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</table>

From our results, the 1.5cm x 1.5 cm lime peels have removed the most oil. It supported our hypothesis that there is a significant amount of oil is removed by adsorption. It is also comparable to the result of our original experiment, showing that our results are valid. This can also explain why the fresh pomelo peels removed more oil than the dried ones. The thick fresh pomelo peels has much larger surface area than the dried ones. Its oil removing ability is therefore much enhanced, which may have outweighed the oil removing ability enhanced by drying the peel.
CONCLUSION AND SUGGESTION

There is a large amount of fruit peels thrown away when people consume fruits. This waste can be reused to treat oil spills. It is not only a cheaper way to help clean oil spills, but also reduce the amount of solid waste and relieve the need for facilities to treat them.

However, the peels are not very effective in absorbing oil. Relying on this method alone cannot clean all the oil spills. In addition, it will be rather difficult to collect the peels from domestic use. Finally, there is the issue of how best to treat the combined collection of fruit peels and oil in an environmentally responsible and economically sound manner.

We had proven that the surface area of the peels enhance the amount of oil removed. It may be helpful to increase the efficiency of oil removal by chopping the peels into smaller pieces to increase surface area by unit mass of peels. In all, the fruits are more suitable for domestic use in a smaller scale.

References:


Comment:

Students conducted investigations on the use of fruit peels to improve the cleaning of oil spills by absorbing oil. It was a good idea to reuse waste to solve our daily life problem. Also, it was highly appreciated that students could recognize the difference between absorption and adsorption, and did a more in-depth investigation on the effect of the surface area on removing oil in their revised proposal. However, students are advised to repeat their experiments so as to get more accurate results. Finally, students could think more on how to implement their idea into domestic use.
An Investigation on Office Ergonomics

Diocesan Girls’ Junior School
Students: Divina Yung, Fion Tse
           Chan Pui Yung, Ng Sze Mai
Teacher:  Ms. Ella Yu, Miss Veronica Tang

Introduction

Computer is an important tool in our daily lives but it affects our physical health and our work performance if not used properly. Many people suffer from wrist pain and eye strain after using computer for a long time. The Budding Scientists of Diocesan Girls’ Junior School wants to investigate the following:

1. Does having a wrist rest help reduce the tiredness of your wrist?
2. Does the brightness of the monitor affect the working efficiency of people, particularly in proofreading?

Background Research

Having correct posture is essential when working in front of computers for long hours. According to the UCLA Ergonomics website, there are 4 important aspects when setting up the workstation.

They are:
1. Chair
2. Keyboard
3. Monitor
4. Pauses and Breaks: Wrist, finger and hand exercises are recommended after long periods of working at the computer.

For the brightness of a computer monitor, while most people have personal preferences, research shows that if you do not need to squint, and do not notice the light or the absence of it, the brightness of your monitor is suitable. In general, the brightness of the monitor
should match the ambient lighting. Unsuitable monitor brightness can lead to eye strain. The common symptoms of eye strain include eye pain and tension, eye dryness, and blurred vision.

**Hypothesis**

**Wrist Test**

We thought that using a wrist rest would be better while typing with the keyboard at the flattest setting since your wrists will be level with the keyboard, which, according to our research, is ideal for your posture.

**Brightness Test**

We agreed that if the brightness of the monitor is about the same as the surrounding light, it will be better for the working efficiency of people when proofreading, since it’s very uncomfortable if you’re working on a computer which has a bright computer monitor in a dim room, and vice versa.

**Experiment**

**Wrist Test**

We have extended the time of typing for the wrist test from 30 minutes to 45 minutes so that we can tire out the subjects’ wrist more in order to see a bigger difference from before typing and after typing.

**Materials**

- Computers (with internet access, keyboards, headphones, word processor)
- Chairs
- English books
- Keyboard wrist rests
- A dynamometer
**Procedures**

1. Set the keyboard at the flattest position and place the wrist rest (if needed) right beneath the keyboard.
2. Instruct subjects of the proper posture. Make sure the subjects without wrist rest have their wrists on the desk while subjects with wrist rest have their wrist on the wrist rest in a relaxed position.
3. Measure the handgrip strength on the subject’s right hand using the dynamometer by asking them to squeeze as hard as possible.
4. Immediately after measuring, have the subject start typing from an English story book on Microsoft Word for 45 minutes.
5. After 45 minutes of typing, measure the handgrip strength on the subject’s right hand again.

**Brightness Test**

We have changed the procedure for the brightness test after our interview with Dr. Leung. He suggested that we ask each subject to repeat the test for the brightness of 0, 50 and 100 so that we are comparing the score difference of the same person. He also suggested that we give subject a chance to relax their eyes in between by asking them to look at green and far things.

**Materials**

- Tables and chairs
- Desktop computers with LCD monitors
- 1 timer
- A word document with three paragraphs for proofreading
Procedures

1. Set all the monitors to a brightness setting of 0.

2. Remind subjects of proper posture and instruct subjects to identify any misspelled words found in the Word document using the highlighting tool.  

3. Time for 1 minute and 30 seconds, then ask the subjects to stop highlighting.

4. Ask the subjects to save the file and follow the teacher on a walk around the school, mainly looking at faraway green objects.

5. During the subjects' walk, change all the brightness settings to 50, then open another passage.

6. When the subjects come back, repeat steps 2-5, but change the brightness levels to 100 instead.

7. Count the number of misspelled words each subject found and record the data.

Results (Refer to Appendix 1 and 2)

Wrist Test

From the results we see that using a wrist rest and not using a wrist rest will not significantly make a difference between the tiredness of your wrists.

Brightness Test

Using the brightness of 50 or 100 on the monitor is more efficient in proofreading.

1 We picked proofreading as the task to do on the computer for the brightness test because people often have to proofread for their mistakes on the computer screen and it requires them to look at the computer screen for a long time.
Factors Affecting our Results

Factors affecting Wrist Rest Test

We think that the subjects’ regular typing habits and preference, such as whether they use a wrist rest and the angle of the keyboard, might affect the way they use the wrist rest in the experiment and affect our results. Also, because of time limitation, we were only able to have our subjects typing for 45 minutes which might still not be long enough to tire out their wrists enough to make a difference. However, we do feel that normally people would not type for 45 minutes straight so our procedure is quite valid. Another limitation is that we can only run this experiment with three classes in our school due to time constraint, which is a limited sample size with limited age group and gender.

Factors Affecting Brightness Test

While we check the posture of our subjects during the test, the Budding Scientists team couldn’t watch everyone at the same time and some subjects’ wrong posture might affect the results. Also, the screen brightness in the experiment might not be the level the subjects regularly use, which might also affect their proofreading abilities. We have tried to increase the sample size by asking for volunteers from 3 grades; however, if we can increase the sample size even more, we can have more valid results.

We only did this experiment with the Philips brand monitor, but different monitors will have different brightness settings. If resources allow, we would like to use a lux meter to measure the light intensity of our monitor, so the results can be applied to different monitors.

Conclusion

The Budding Scientist team of DGJS recommends that the brightness setting of the Philips monitor be set to 50 or 100 and it does not make a difference whether you use a wrist rest or not. However, if you type for more than 30 minutes, it is important to take a break for your eyes and your wrists.
Further Exploration

Further Exploration for Wrist Test

We can test whether different keyboard angles with the use of wrist rest will have the same effect. We would also try different brands of wrist rest as the softness, thickness and shape of different wrist rests might be different. We would also test whether the use of wrist rest affects the posture and tiredness of different parts of the body.

Further Exploration for Brightness Test

We would test if different eye conditions, such as with or without glasses, or after laser surgery, will affect the brightness preferences of the monitor of people and also test whether the colour and brightness of the light in the environment will affect how efficient people can be in proofreading using our recommended brightness setting.
Appendix 1

Consolidated Result Data Tables

Results of Wrist Test

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<tr>
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<th>Strength of Wrist</th>
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Results of Brightness Test

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<th>No. of Words Found</th>
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<td>18</td>
<td></td>
</tr>
</tbody>
</table>

|                      | Changes of No. of Mistakes Found |                      |                      |                      |
|----------------------|----------------------------------|----------------------|----------------------|                      |
| Brightness           | 100 – 50                         | 50 – 0               | 100 – 0              |
| Average              | -0.08                            | 3.30                 | 3.23                 |
| Median               | 0                                | 3                    | 3                    |
## Appendix 2

### Detail Result Data Tables

### Results of Wrist Test

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## Strength of Wrist (without Wrist Rest)

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Comment:

Students focused their investigations on the proper use of computer and did two experiments, the wrist test and brightness test, in their proposal. It was quite interesting that they could think of using the efficiency of people in proofreading to determine the suitable brightness of a monitor. Besides, since the sampling size has been increased quite a lot in the revised proposal, their effort was highly appreciated. However, students are advised to think more on their experimental designs so that more convincing data or conclusion could be drawn.
「香港海洋污染問題解決方案」專題報告

大埔循道衛理小學
參賽學生：何祖鍵  胡碧文  李汝望
崔詠兒  呂珮琪
老 師：黃倩婷  潘慕齡

引言：
香港的海洋污染主要來自家居、工商業和農業污水，其中以農業污水最嚴重，主因是農場的設備簡陋，沒有徹底過濾污水便排放。

我們發現台灣透過生態池污水淨化系統有效地過濾農業污水，而我校正擁有此系統，觸發我們就地取材，探討如何再作改良。

我們得知本校的生態池污水淨化系統所使用的珊瑚骨和蠔殼，當遇上酸水便會被分解，失去讓硝化細菌寄生及去除的功效，故須定時更換。我們建議加入無需更換的生物環，以解決此問題，因而設計了本實驗。

目的把不同的生物環加入此系統，比較寄生在它們表面的硝化細菌數量，分析哪種較適合。

實驗（一）

實驗（一）假設
1. 在相同形狀、重量和物料的情況下，寄生在兩種大小不同的生物環表面上的硝化細菌之數量不同。
實驗（一）步驟

1. 把兩種由玻璃粉製成而形狀相同的生物環(20g)用繩串起來。

2. 放進生態池污水淨化系統。

3. 五天後取出實驗品，測試透光度及用電子顯微鏡來觀察結果。
實驗（二）

實驗（二）假設
在相同形狀和重量的情況下，寄生在五種大小和物質不同的生物環表面上的硝化細菌之數量不同。

實驗（二）步驟

1. 把五種形狀和重量（20g）相同，但大小和物質不同的生物環用繩串起來。
2. 放進生態池污水淨化系統。

3. 五天後取出實驗品，測試透光度及用電子顯微鏡來觀察結果。
實驗原理
原理一：建設生態池污水淨化系統的設計圖。
比較題一和二，得出生物環的接觸面越多，表面面積就會越大。

結果：
先把實驗品分別放進280毫升的蒸餾水中，各瓶子相隔1分鐘以同一個人的右手大力搖晃1分鐘，目的讓硝化細菌溶入水中，然後利用電筒照射各瓶子的同一點，比較水的透光度，透光度越弱即顯示水中的細菌濃度越高。最後再用電子顯微鏡來觀察細菌之數量，令結果更準確。
先把實驗品分別放在 280 毫升的蒸溜水中，短時間後，抽出 2 毫升的溶液，再放入離心機以每分鐘 13500 轉的速度沉澱溶液中的細菌，之後抽走 1.8 毫升的液體，利用餘下沉在底部高濃度的 0.2 毫升作測試。最後仔細地只抽出 0.2 毫升中的十一萬份之一，透過理工大學的專業電子顯微鏡來觀察。

在公平測試的原則下，實驗(一)中的生物環(B)和(D)都是同形狀、物料和重量，結果(D)較好，因為體積越小，所需的數量就會越多，加上有較多凹凸面，能增加讓硝化細菌寄生的表面積(實驗原理二)。

而實驗(二)用了相同形狀和重量的生物環(A)至(E)做測試，雖然五種的大小不同，但因實驗(一)已有印證，所以實驗(二)只需比較物質方面，結果以活性碳製成的(A)，能產生最多硝化細菌。

綜合以上結果，我們建議加入體積較小且有較多凹凸面，並由活性碳製成的生物環，果效最好。

感想：

經過研究，我們明白到氨是農業肥料的重要成分，但它具有毒性及腐蝕性，影響水中生物生長，但利用硝化細菌就可分解氨，我們建議加入的生物環則有效讓更多硝化細菌寄生，加大了淨化污水的效能。

既然生態池污水淨化系統成效高又環保，亦可美化環境，希望政府多建設此系統以解決香港農業污水的問題。

最後，組員在整個過程中能發揮永不放棄的合作精神，真是難能可貴！
參考資料：

網頁
淨化海港計劃：
http://www.cleanharbour.gov.hk/chinese/g4_2_1.html

香港水質污染的原因：
http://hk.knowledge.yahoo.com/question/question?qid=7006111702433

《農村72變系列報導之39》太麻里金針山青山農場生態淨化池：
http://tw.myblog.yahoo.com/jw!TGA3Oii2CFQWBkZ_hwYNXaFonkzdR/article?mid=1828

《硝化細菌與水產養殖的關係如何？》：

水草造景專用硝化細菌DIY過程解析：

魚缸水為何會變酸？：

生物環問題：
http://blog.yahoo.com/_AHIO2NYRODMN35USTCUPTQWGUE/articles/311552

書籍
《科學探究資料冊》（2011）：教育出版社、主編：李揚津博士。
《科學活動資料冊》（2011）：教育出版社、顧問：李揚津博士。
《香港科學青苗獎資料匯編(2005-2008)》（2008）：教育局課程發展處資優教育組。
評語：
同學們在事前做了大量的資料搜集，包括台灣的生態池淨化系統和各種生物環的功用，嘗試應用生態池淨化系統和生物環，解決農業污水排放的問題，當中的努力實值得加許。他們設計了一系列的實驗，以比較不同的生物環對寄生在其表面的硝化細菌的數量的影響。假如同學可更嚴謹地設計其實驗，控制當中的變因，使各個實驗均在公平測試下進行，相信實驗結果會更具科學理據及更有說服力。
Electricity from Wastewater in Hong Kong

The Chinese Foundation Secondary School
Team Members: Chak Man Him, Fung Hing Lun
Li Yik Hin Nigel, Leung Lok Ming Arnold
Teacher: Chan Pik Ying, Ho Chun Man

For the past decades, the accelerated consumption of fossil fuels has not only speeded up global warming and formation of acid rain, but also triggered the global energy crisis. The innovative Microbial Fuel Cell (MFC) is viewed as an ideal candidate for energy supply. MFC can be employed to harvest the “hidden” energy in raw wastewater to generate electricity while treating wastewater by reducing its oxygen-depletion contents. Recently, Shizas et al. reported that the energy hidden in wastewater could exceed the electricity required in the treatment process by a factor of 9.3.

In Hong Kong, an average of 2.68 million cubic metres of wastewater was produced per day in 2010-2011. Hong Kong is one of the very few places in the world using seawater for flushing. Hence, wastewater in Hong Kong is partly composed of seawater. This is different from most of the other places.

However, it seems there is not much research on the application of the MFC in harvesting energy from “saline” wastewater. Hence, in our project, we aim to investigate the feasibility of using “saline” wastewater to generate electricity using MFC in Hong Kong. To achieve this, we construct an “environmental friendly” MFC using “saline” wastewater as fuel and study its efficiency by measuring the electromotive force.
In the anodic compartment shown above, micro-organisms (e.g. E. coli) already present in wastewater undergo anaerobic respiration to biodegrade the organic waste (e.g. carbohydrates). Glucose is taken as a representative of carbohydrates here.

Under anaerobic condition, glucose undergoes oxidation with water to form carbon dioxide, proton and electrons.

Anodic reaction:

\[ \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} \rightarrow 6\text{CO}_2 + 24\text{H}^+ + 24\text{e}^- \]

Electrons produced flows through the external circuit to the cathodic compartment and combine with oxygen to undergo reduction to form water. Therefore, electricity is generated.

Cathodic reaction:

\[ 6\text{O}_2 + 24\text{H}^+ + 24\text{e}^- \rightarrow 12\text{H}_2\text{O} \]
Experimental details

Section 1
Seawater Quality Assessment

Objective
To find out the quality of seawater in different places within the Victoria Harbor

Procedure
1. Seawater from different sites in Victoria Harbor was collected.
2. Different sensors were used to assess the seawater quality.

Results and Discussion

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<td>6.4</td>
<td>6.5</td>
<td>6.2</td>
</tr>
<tr>
<td>Total dissolve oxygen (ppm)</td>
<td>9.3</td>
<td>6.2</td>
<td>6.3</td>
<td>9.4</td>
</tr>
</tbody>
</table>

Table 1 – pH and Total dissolved oxygen of seawater collected at different sites on 26 Jan 2013
From the findings, the pH of wastewater collected at Causeway Bay, Siu Sai Wan and North Point is less than the optimal value of 6.5. Wastewater collected at Siu Sai Wan has the lowest dissolved oxygen (6.2 ppm). This implies that Siu Sai Wan has relatively high oxygen-depletion content, which suggests a “good” fuel for the MFC. In order to have a deeper insight in the seawater in Siu Sai Wan, we did 3 more individual water quality assessments.

<table>
<thead>
<tr>
<th>Test</th>
<th>1&lt;sup&gt;st&lt;/sup&gt;</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt;</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt;</th>
<th>4&lt;sup&gt;th&lt;/sup&gt;</th>
<th>Mean</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>26/1</td>
<td>30/1</td>
<td>4/2</td>
<td>18/2</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>11:15</td>
<td>13:15</td>
<td>13:15</td>
<td>16:30</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.40</td>
<td>6.20</td>
<td>6.35</td>
<td>6.21</td>
<td>6.29</td>
<td>To be in the range 6.5 - 8.5</td>
</tr>
<tr>
<td>Dissolved Oxygen (ppm)</td>
<td>6.2</td>
<td>5.6</td>
<td>6.2</td>
<td>6.2</td>
<td>6.1</td>
<td>Not less than 4mg/L</td>
</tr>
<tr>
<td>Electrical Conductivity (ppm)</td>
<td>15,310</td>
<td>15,612</td>
<td>14,960</td>
<td>15,262</td>
<td>15,286</td>
<td></td>
</tr>
<tr>
<td>E. coli (per 100 mL)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Annual geometric mean not to exceed 610 cfu/100mL</td>
</tr>
<tr>
<td>Salinity (ppm)</td>
<td>/</td>
<td>/</td>
<td>30,474</td>
<td>16,262</td>
<td>23,368</td>
<td>Highly saline: 10000 – 35000 ppm</td>
</tr>
</tbody>
</table>

Table 2 – Parameters of seawater collected at Siu Sai Wan on different dates

The seawater collected in Siu Sai Wan is highly saline (23,368 ppm) and its electrical conductivity is quite good (15,286 ppm). Hence, seawater can act as an electrolyte in MFC to help conduct electricity. Its average pH is still lower than the optimal value 6.5. However, it is still suitable for E. coli to grow. In the seawater, no E. coli was found. This is because the wastewater has already been treated in wastewater treatment plant before discharge. Actually, before the wastewater treatment, the E. coli concentration in Hong Kong wastewater is always greater than 107 per 100 mL. In treatment plant, the oxygen-depletion content is also reduced sharply.
For hygienic reasons, we cannot directly use the “untreated” wastewater for our MFC study. Hence, we need to use “artificial” wastewater instead. In order to achieve this, we add E. coli and glucose solutions (to simulate the oxygen-depletion content) to the “already treated” seawater. This mixture acts as the Hong Kong “saline” wastewater and is used in our MFC experiments.

Section 2
Determinination of E. coli concentration

Objective
To determine the E. coli concentration by Plate Count Method and UV-Vis spectroscopic measurement

Procedure

Part A - Plate Count Method
1. The number of colonies per mL (concentration) of different E. coli solutions was found using plate count method.

Part B - UV-Vis Spectroscopic Measurement
1. The absorbances of different E. coli solutions prepared in Part A were measured at 350 nm.
2. A calibration curve for E. coli solution was produced.
3. Absorbance of solution of unknown E. coli concentration (such as those prepared in Section 3 – Part C) was measured and its concentration determined.
Results and Discussion

Figure 1 - Calibration curve for determination of E. coli concentration

The curve fitting is very satisfactory and the calibration curve can be used to determine the concentration of E. coli in a solution.

<table>
<thead>
<tr>
<th>E. coli solution (prepared in Section 3 – Part C)</th>
<th>Absorbance</th>
<th>Concentration of E. coli (x 10^6 / mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.43</td>
<td>1.87</td>
<td></td>
</tr>
</tbody>
</table>

Table 3 shows the absorbance and the concentration of an E. coli sample prepared in Section 3 – Part C

From the calibration curve, the E. coli concentration of a sample prepared in Section 3 – Part C is 1.87 x 10^6 / mL.
Section 3
Building MFC and Measuring MFC efficiency

Objective
To construct a simple MFC and measure its electromotive force

Safety Precaution
1. Clean the bench and hands with 75% ethanol.
2. Work near a Bunsen flame when handling E. coli.

Procedure
Part A - Preparation of salt bridge
1. 0.4g agar and 8.08g potassium nitrate was boiled in 40 cm³ distilled water.
2. The agar solution was added into each autoclaved U-tube.
3. The tube was closed and cooled in a water bath for 15 minutes.
Part B - Preparation of Cathodic solution

EITHER
Potassium hexacyanoferrate(III) solution (Mediator for Cathode)
1. 8.25 g potassium hexacyanoferrate(III) solids was added into 250 mL volumetric flask.
2. The autoclaved seawater was added into the volumetric flask until the fixed volume was obtained at the graduation mark.

OR

Preparation of algae solution
1. 0.4 g (wet mass) of algae was weighed and added into 13 mL of fresh water.

Part C – Preparation of solutions for making “saline” wastewater

Autoclaved seawater
1. The seawater collected at Siu Sai Wan in Section 1 was autoclaved at 121 °C for 30 minutes before use.

Standard glucose solution
1. 8 grams of glucose were added into 100 mL volumetric flask and then autoclaved seawater was added until graduation mark.
2. The glucose solution was boiled and stoppered after boiling.

E. coli solution
1. The E. coli solution was incubated at 37°C in an incubator before use.
2. It was then diluted with autoclaved nutrient solution until its UV absorbance at 350 nm reached 0.43.

Methylene blue solution (Mediator for Anode)
1. 1.2 mL methylene blue solution was added into 100 mL volumetric flask.
2. The autoclaved seawater was added into the volumetric flask until the graduation mark.
Part D – Constructing the MFC and Measuring its MFC Efficiency

Model 1 – using potassium hexacyanoferrate(III) solution in cathodic compartment

1. The following MFC set-up was assembled.

   ![MFC set-up diagram]

   [Remarks: the mixture of glucose, E. coli and autoclaved seawater acts as the “saline” wastewater in our study]

2. The electromotive force (e.m.f.) of the MFC was measured for 12 hours.

3. Steps 1-2 were repeated.

4. Steps 1-2 were repeated using nutrients solution, as control, instead of the E. coli solution.
Model 2 - using algae solution in cathodic compartment

1. Steps 1-4 of Model 1 were repeated, but using algae solution instead of potassium hexacyanoferrate(III) solution.

2. The algae solution was illuminated with LED light during experiment.
Results and Discussion

Model 1 - using potassium hexacyanoferrate(III) solution in cathodic compartment

<table>
<thead>
<tr>
<th>Concentration of E. coli Solution (x 10^6 / mL)</th>
<th>e.m.f.max (V)</th>
<th>e.m.f.max (V)</th>
<th>Average e.m.f.max (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>1.00</td>
<td>0.117</td>
<td>0.130</td>
</tr>
</tbody>
</table>

Table 4 – e.m.f.max for Model 1

Our findings show that the maximum electromotive force (e.m.f.max) for the MFC Model 1 is 0.124 V on average. This shows that the “saline” seawater can act as a fuel in the MFC to generate electricity.

In this fuel cell, the potassium hexacyanoferrate(III) solution acts as a catalyst to speed up the reduction of oxygen. However, potassium hexacyanoferrate (III) is irritant and even releases toxic gas hydrogen cyanide when reacting with strong acid, which is commonly found in industrial wastewater. Hence, we modified this Model 1 to Model 2 in which the algae solution is used instead of potassium hexacyanoferrate (III) solution. The algae releases oxygen during photosynthesis and so can help speed up the rate of reduction of oxygen. It is also worth to note that algae is not only harmless to environment compared with potassium hexacyanoferrate (III) solution, but algae can also help remove pollutants.
Model 2 - using algae solution in cathodic compartment

The figure above shows that the algae releases colourless gas bubbles when it is illuminated with LED light. This indicates algae undergoing photosynthesis to product oxygen gas.
Model 2 - using algae solution in cathodic compartment

<table>
<thead>
<tr>
<th>Sample</th>
<th>Concentration of E. coli Solution (x 10^6 / mL)</th>
<th>e.m.f.max (V)</th>
<th>e.m.f.max (V)</th>
<th>Average e.m.f.max (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.00</td>
<td>0.458</td>
<td>0.386</td>
<td>0.422</td>
</tr>
</tbody>
</table>

Table 5 – e.m.f.max for Model 2

It was found that the e.m.f.max for Model 2 is 0.422 V on average. This again shows that the “saline” seawater is feasible to generate electricity even the solution used in cathodic compartment is changed.

Figure 1 – MFC efficiency comparison for Models 1 and 2

Our findings show that the e.m.f.max for Model 2 has much higher efficiency than that of Model 1. This implies that the use of algae solution in MFC is a much better choice for electricity generation than use of potassium hexacyanoferrate (III) solution from both points of view of environmental protection and MFC efficiency.
Conclusion

Our experiments have indicated that MFC is feasible to generate electricity using the “saline” wastewater, such as the Hong Kong wastewater, as fuel. Also, a MFC composed of “saline” wastewater and “environmental friendly” algae solution is successfully constructed, which can generate electricity of 0.422 V.

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cathode</strong></td>
<td>Reduction of potassium hexacyanoferrate (III)</td>
<td>Reductive photosynthesis by algae</td>
</tr>
<tr>
<td><strong>Anode</strong></td>
<td>Oxidative respiration process by E-Coli</td>
<td>Oxidative respiration process by E-Coli</td>
</tr>
<tr>
<td><strong>Electrolytes</strong></td>
<td>Wastewater (saline)</td>
<td>Wastewater (saline)</td>
</tr>
<tr>
<td><strong>E.m.f. max</strong></td>
<td>0.124 V</td>
<td>0.422 V</td>
</tr>
<tr>
<td><strong>Sustainability</strong></td>
<td>Low (involving non-renewable, toxic cathodic solution)</td>
<td>High (renewable cathodic matrix)</td>
</tr>
<tr>
<td><strong>Scalable</strong></td>
<td>Low (involving toxic cathodic solution)</td>
<td>High (non-toxic, greener cathodic system)</td>
</tr>
</tbody>
</table>

To conclude, MFC is a promising technology to generate electricity by harvesting the “hidden energy” in wastewater. We truly believe that MFC is an ideal alternative for energy source.


**Suggestion**

In the wastewater treatment plant, no facilities such as aerobic and anaerobic tanks actually need remove if MFC system is applied. However, wastewater should flow through the anaerobic tank instead of aerobic tank as shown in the figure below while algae are added to the aerobic tank. Then, electricity is generated.

The following model shows the small-scale treatment plant using MFC system.
Appendix - List of References

Journals/Articles

- Kim et al., Continuous electricity production from artificial wastewater using a mediator-less microbial fuel cell. Bioresource Technology 97 (2006) 621–627
- Meehl et al., Chap. 10: Global Climate Projections, Sec. 10.ES: Mean Temperature, in IPCC AR4 WG1 2007

Websites

Marine Water Quality Monitoring in Hong Kong

The annual E. coli (depth-averaged) levels (cfu/100mL) at 17 marine monitoring stations in Victoria Harbour and vicinity, 2000 – 2011

Summary of Water Quality Objectives for Marine Waters of Hong Kong

Total dissolved solids
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Marine Water Quality

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Water Quality Criteria

Calculating Geometric Means
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http://en.wikipedia.org/wiki/Escherichia_coli

Salinity
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Algae
http://en.wikipedia.org/wiki/Algae

Potassium hexacyanoferrate(III)
http://en.wikipedia.org/wiki/Potassium_ferricyanide

BOD test
http://en.wikipedia.org/wiki/Biochemical_oxygen_demand

通識教材套 - 防洪淨流

香港利用海水沖廁的實踐
Seawater for Flushing

A pioneer in large-scale seawater flushing

Information Paper on Provision of Sea Water for Flushing Purposes

Sidebar: Using Seawater Directly for Flushing Toilets

The impact of sea water flushing on biological nitrification-denitrification activated sludge sewage treatment process.

Comment:
The innovative Microbial Fuel Cell (MFC) is a state-of-art invention - the sewage is used to generate electricity. Students performed well in the field trip and laboratory work. Supported by a real model and plenty of literature reviews the data was presented logically and the results were convincing and evidence-based. In order to put the invention to practical applications, students are advised to increase the scale of the experiment and carry out further research on the optimal efficiency of MFC.
Interview with a Scientist

An Interview with
Professor Nora Tam Fung Yee
A chair Professor of the Department of Biology and Chemistry,
City University of Hong Kong

Background

Professor Nora Tam Fung Yee is a chair Professor of the Department of Biology and Chemistry, the City University of Hong Kong. Influenced by her teacher, Professor Tam was enchanted with biology. She thinks biology has a special fascination. “Different from other subjects, biology is more practical and more related to our daily lives, also, taking biology one has more chance to go out for fieldtrips,” said Professor Tam. After graduating from Chinese University of Hong Kong in 1979, she further studied in England and acquired her MSc and PhD from Universities of Sheffield and York respectively in the fields of Environmental Biology/ Applied Ecology. Over 30 years, Professor Tam has been active in the education field. She has supervised more than 100 student projects in environmental biology up to PhD level and held many important posts, such as a visiting Professor of many universities in China. Professor Tam has contributed to society by spending most of her career investigating mangrove ecology and its application on filtering pollutants. Professor Tam is also dedicated in nurturing future generations to sustain environmental protection.

To recognize Professor Tam’s achievements in environmental protection, she was awarded the Excellent Product Award on the project entitled “ Constructed mangrove wetland as an alternate sewage treatment technology” in The 13th China Hi-Tech Fair, the largest and most influential scientific and technological fair in China. Recently,
she was awarded the Bronze Bauhinia Star for her valuable contributions to promoting scientific research, education and environmental conservation.

**Professor Tam’s Research**

“We should not see trash as trash; we should not see sewage as sewage. Instead, we should see them as resources.” Although this is what Professor Tam has always in mind, her investigation of mangrove starts with a coincidence.

Once when Professor Tam was on a fieldtrip, waiting beside the shore for examining the mangrove in low tide. She observed that the plants next to a primitive washroom were much more flourishing. Curious about the reasons behind, she started investigating the mechanism how mangroves turn waste into their own nutrients. Her recent studies focus on creating a man-made mangrove with mixed species that can act as a wastewater filter to remove up to 90% of pollutants, such as suspended solids, nitrogen and phosphorous compounds. The mangrove acts as the liver and kidney of nature in a win-win situation where mangrove filters out the pollutants in wastewater to enhance its own growth.

**Contribution to society**

With her knowledge and experience in wetland, Professor Tam was frequently invited to participate in related projects in China, such as restoring the ecological system at a destroyed wetland. Two years ago, she collaborated with Xiamen University to build a wastewater treatment system at an artificially constructed wetland in Shenzhen for treating wastewater and greening the local environment.

Professor Tam is one of the environmental protection pioneers in Hong Kong. “When I started my environmental cause, the government hasn’t even set up the Department of
Environmental Protection!” said Professor Tam. Between 1997 and 2000, she led a team to investigate the few remaining local mangroves and published books to raise public concern on mangrove conservation. Now, almost all schools will use her book in studying mangrove ecology. “But that’s not what makes me feel most successful”, said Professor Tam. “Once in a fieldtrip, I heard a couple talk about mangrove. They knew the importance of mangrove in nature and the need for its conservation.” She felt rewarded that her hard work has influenced the public the way they think and raise their concern towards environmental protection.

Qualities to be a successful scientist

When asked for the essential qualities of a good scientist, Professor Tam gave the following advices:

Clear minded

Scientists must have a clear mind since they have to be firm on what they are doing. They must clearly know the aim of the experiment and the purpose of each step. They also have to be clear of the procedures and minimize error.

Not afraid of failure

Result of a science project does not often turn out to be what was expected. Scientists must always be prepared to accept failure. However, just accepting is not enough. They should not give up easily. Instead, they should face the problem, find out the causes and tackle them.

Able to endure hardship

Science projects require repeating the same step numerous times to obtain an accurate and convincing result. This is surely a demanding process. Therefore, scientists must
have the ability to endure hardship. “This quality is particularly important for a scientist doing similar things as I do.” said Professor Tam. “Environmental projects require frequent fieldtrips to monitor the growth of organisms in an area. This is especially difficult for scientists who have different engagement.”

**Careful observation**

Science is about asking questions and explaining. With careful observation, one may observe a pattern in what other think is random. With careful observation, Professor Tam discovered the special groups of mangrove that led to her success and fame.

**Environmental cause in Hong Kong**

“Hong Kong started environmental measures way before Singapore and Taiwan. However, our progress was really too slow.” commented Professor Tam. While some activists have a strong environmental concept, others still focus on the economic development. This causes disputes within society and slows down the overall progress in Hong Kong.

To tackle the problem, Professor Tam emphasizes on education. “To raise environmental awareness is not just about giving people the knowledge; it is to change the way they think and the way they act.” In other cities, trash bins are rare in streets. People there take their rubbish home. They know their responsibility to get rid of the rubbish they produce. This is their lifestyle. However, Hong Kong people would complain if there are not enough trash bins in the streets. “They even complain about rubbish bin shortage in the country parks. We are not supposed to create rubbish in country parks! This is the problem with Hong Kong people.” lamented Professor Tam. Through education, Professor Tam hopes to influence the next generation and change their mindset. Environmental protection is not just talking verbally but doing physically. “Looking to the bright side, although the pace of environmental cause in Hong Kong is slow, there is still progress. There is still hope.” said Professor Tam.
**Support from government**

Funding is a very important for a large scale research. However, according to Professor Tam, Hong Kong government’s support for scientific research is inadequate. “Comparing to the past, scientists nowadays can apply funding from different departments of the government. However, as a whole, there is still great room for improvement.” said Professor Tam.

**Words for teenagers**

Professor Tam finally gave the following advices to our teenagers: Do not be afraid of hardship!

Professor Tam found teenagers nowadays would not endure hardship. She attributed this to the material prosperity. Teenagers nowadays do not have to pay much effort to get what they want. This leads to the situation that they are afraid of failure. When facing failure, Professor Tam suggests that instead of running away from the problem, teenagers should find the root of the problem and fix it.

“For most science projects, you are doomed to fail at the very beginning. What brings you success is to stand up at where you fall, thought clearly where the problem is and tackle it. That’s the only way to success”

**Reflection**

It is our honour to have an opportunity to learn from Professor Tam. It was really nice of her to share her experiences and stories with us. We were much impressed by her great contributions in the last 30 years in promoting scientific research and education as well as environmental conservation, such as the project of artificially constructed wetland to remove pollutants in wastewater. Her work really benefits our society.

“The mangroves in Hong Kong are getting fewer and fewer during the last few decades.” Professor Tam told us with a sigh that the environment is always damaged when economy is developing quickly. It is therefore important to get a balance between
environment preservation and economy growth. We agree her advices to have an awareness in sustaining the environment.

Being a successful scientist, Professor Tam still works hard and self-motivated to do many tough studies even facing challenges and failures. She insists to go to mangrove at 5 a.m. and wait until the low tide for conducting her researches. In order to verify results, she is patient to repeat the experiments many times. We learned from Professor Tam that “persistence”, “enduring hardship” and “not afraid of failure” are crucial factors to be a scientist. She also inspired us to become persons who will not regret for their life.

Regarding environmental protection, just as Professor Tam said “many Hong Kong people just talk about it but do not take action”. We actually can “act” in our daily lives, but did not. Professor Tam’s words have inspired us and we will take action from now on rather than just talking. It is also important that we should treat everything as a hidden resource instead of waste, just like Professor Tam’s work, treating wastewater as resources.

From left to right:
Leung Lok Ming, Li Yik Hin, Professor Nora Tam Fung Yee, Chak Man Him, Fung Hing Lun
Reference

Personal Information of Prof. Nora Tam Fung Yee
http://personal.cityu.edu.hk/~bhntam/

紅樹林專家- 譚鳳儀

紅樹林人工濕地廢水處理系統

研究與開發紅樹林濕地與再植技術中心

China Hi-Tech Fair
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Cityu’S Wetland System Removes 90% of Wastewater Pollutants

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Country and Marine Parks Board - Brief Background of Non-Official Members

Honours Awarded to Members of Cityu Community
Park Celebrates World Wetlands Day

Council for Sustainable Development

Wetland Project Study Competition

Wetland System for Wastewater Treatment

Mangrove Plant Diversity
http://unepscs.org/Mangrove-Training/05-Mangrove-Plant-Diversity-South-China-Sea.pdf
Science Investigation -
Absorption of Heavy Mental Ions By Tea Waste

St. Paul’s Co-educational College
Teacher: Tsang Kwok Ying, Tse Wai Tak
Student: Ng Wai Chung, Xiao Hantong Tony
Fung Chi Ying Natalie, Chan King Fung Kelvin
Siu Ting Chi Sienna

Introduction

Rapid urbanization and industrialization lead to increased level of metal ions in our wastewater. Heavy metal ions, an important source of pollutants in the marine water, are introduced into the ocean from a variety of sources such as urban drainage and industrial runoff. According to the Chinese Ministry of Health, industrial pollution has made cancer China’s leading cause of death. It has caused adverse impacts on the ecosystem and water quality. The heavy metal pollution in Hong Kong is not exceptionally serious, but pollutants emitted by vehicles and other urban sources along with the wastewater from the heavily industrialized Pearl River Delta still pose health risks to Hong Kong residents, and harm the aquatic life.

As heavy metal ions accumulate in the environment, they enter the human body through breathing, drinking, and skin absorption. Exposure to these metal ions may lead to serious health issues such as growth inhibition, organ and nervous system damages, and even cancer. High heavy metal content in the environment also causes adverse effects on the environment. The effects of heavy metal poisoning on aquatic lives are: reduction of the developmental growth, increase of developmental anomalies, reduction of fish survival—especially at the beginning of exogenous feeding or even cause extinction of entire fish population in polluted reservoirs. Therefore the removal of heavy metal ions from natural water is of great importance.

There are a huge collection of chemical methods to remove heavy metal ions from water, but some of them involve high costs while some of them may lead to the contamination of water by other harmful chemicals.
Another method is using readily available natural absorbents to remove the heavy metal ions. Our group decided to test the ability of domestic wastes such as tea waste to reduce the concentration of heavy metal ions in water, and design filters that can remove heavy metal ions effectively.

**Proposed Heavy Metal Ions to be Tested**

**Chromium (Cr³⁺)**

Chromium compounds are discharged into the environment by various industries such as refinery and alloy industries. Chromium can cause health problems such as damage to nervous system and cancer. There has been chromium-related environmental catastrophes reported, such as chromium wastes deposited near the Ganga in India.

The level of Chromium is high in Causeway Bay at 61mg/kg (dry weight).

**Copper (Cu²⁺)**

Copper is found in industrial wastewater as it is a major metal used in the electroplating and printed circuit board industries. Household drainage also contains copper from domestic use of copper containing chemicals and corrosion of household copper pipes. High concentration of copper ions is toxic to aquatic life including fish, invertebrate and amphibian.

Copper is commonly found in marine sediments, highest in central Victoria Harbour (160 - 170 mg/kg dry weight).

**Nickel (Ni²⁺)**

Nickel is used in the production of batteries and fertilizers. It is discharged into the environment through industrial and agricultural wastewater. Excessive nickel is toxic and may cause cancer.

Nickel content is high at Deep Bay at 37mg/kg (dry weight).
**Cobalt (Co2+)**

Sources of cobalt in the environment are mainly industrial wastes. Cobalt is toxic both to human and to aquatic animals. It is cancer-causing and is harmful to the nervous system.

**Experiment**

**Objective**

To investigate the effect of tea leaves on the concentration of heavy metal ions listed above in water.

**Principle**

Insoluble cell walls of tea leaves are largely made up of cellulose and hemicelluloses, lignin, condensed tannins and structural proteins. These make it a good absorbent of heavy metal ions as they contain functional groups with higher affinity for heavy metal ions than that of water. Therefore ions are attracted to the tea leaves.

**Materials**

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tea waste</td>
<td>300 g</td>
</tr>
<tr>
<td>0.03M NaOH solution</td>
<td>500 mL</td>
</tr>
<tr>
<td>0.1M Cr3+solution</td>
<td>100 mL</td>
</tr>
<tr>
<td>0.1M Ni2+solution</td>
<td>100 mL</td>
</tr>
<tr>
<td>0.1M Cu2+solution</td>
<td>100 mL</td>
</tr>
<tr>
<td>0.1M Co2+solution</td>
<td>100 mL</td>
</tr>
<tr>
<td>Distilled or deionised water</td>
<td>2000 mL</td>
</tr>
<tr>
<td>Filter paper</td>
<td>x10</td>
</tr>
<tr>
<td>Teabags</td>
<td>x16</td>
</tr>
</tbody>
</table>
**Apparatus**

<table>
<thead>
<tr>
<th>Apparatus</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volumetric flask (250cm³)</td>
<td>x20</td>
</tr>
<tr>
<td>Beaker (250cm³)</td>
<td>x16</td>
</tr>
<tr>
<td>Pipette (2.5mL)</td>
<td>x1</td>
</tr>
<tr>
<td>Pipette (5mL)</td>
<td>x1</td>
</tr>
<tr>
<td>Pipette (10mL)</td>
<td>x1</td>
</tr>
<tr>
<td>Pipette (20mL)</td>
<td>x1</td>
</tr>
<tr>
<td>Pipette filler</td>
<td>x1</td>
</tr>
<tr>
<td>Measuring cylinder (50cm³)</td>
<td>x4</td>
</tr>
<tr>
<td>Blender</td>
<td>x1</td>
</tr>
<tr>
<td>Spatula</td>
<td>x4</td>
</tr>
<tr>
<td>Filter funnel</td>
<td>x2</td>
</tr>
<tr>
<td>Electronic weight</td>
<td>x1</td>
</tr>
<tr>
<td>Colorimeter</td>
<td>x1</td>
</tr>
<tr>
<td>Colorimeter bottle</td>
<td>x4</td>
</tr>
</tbody>
</table>

**Experimental Set-up and Procedure**

**Calibration Procedure of the colorimeter**

1. 5mL of distilled water was added into the colorimeter bottle and inserted into a colorimeter. Before the insertion, the colorimeter bottle was shaken thoroughly and its surface dried with a filter paper to ensure even distribution of sample and to prevent water droplets on the surface from affecting the result.

2. The colorimeter was calibrated by clicking the calibration button.

**Control set-up procedure**

1. 5mL of 0.00125M Cr³⁺-solution was added into the colorimeter bottle and inserted into a colorimeter.
2. The values representing the absorption of a suitable wavelength (red light rays is used for Cr³⁺) as shown on the readout screen were recorded.

3. The procedure was repeated with different metal ion solutions of different

**Experimental set-up procedure**

1. 2g of tea waste treated with merely hot water was weighed with an electronic balance and then added into a teabag.

2. The teabag containing the tea waste was added into 50 mL of distilled water in a beaker.

3. The solution was covered with plastic wrap to prevent the solution from having its concentration altered by the evaporation of water.

4. The beaker containing the sample solution was left overnight in order to let all particles of tea leaves come out.

5. The colorimeter was calibrated. 5mL of the sample solution was added into a colorimeter bottle and the bottle was inserted into the colorimeter to take the initial reading.

6. The values representing the absorption suitable wavelength as shown on the readout screen were recorded. The same procedure was repeated three times to ensure the reliability of the value.

7. 50cm³ of ion solution was added to the beaker and it was left overnight in order to let the tea waste absorb the metal ions.

8. 5mL of the sample solution was added into a colorimeter bottle and the bottle was inserted into the colorimeter again and the values for absorption of red light rays and green light rays were recorded.

9. By comparing the above values with the value obtained in the control set-up, the percentage decrease in the absorption of light rays was obtained. Since the absorption of light rays represents the concentration of coloured ions in the solution, the percentage decrease in the concentration of metal ions in the solution was obtained.

Other experiments were designed using similar procedure with small amendments on the independent variable in order to investigate on the following factors affecting the absorption of metal ion of tea wastes.
A. Initial metal ions molarity
B. Type of tea leaves
C. Time allowed for tea leaves to absorb metal ions
D. Weight of the tea leaves
E. Surface area of the tea leaves
F. Treatments of tea leaves beforehand (NaOH and NaHCO3)

**Assumption:**

It is assumed that the change in value of absorption of light rays is only due to the change in metal ion concentration.

**Results and Discussion**

**A. Different metal ions and different type of teas**

In the early stage of the study, four different tea leaves’, green, black, flower, Pu er tea, were used to study their effectiveness in absorbing four different heavy metal ions, Co2+, Cu2+, Cr3+, and Ni2+, each of concentration of 0.0025M. It was assumed that different types of tea may have different absorption towards heavy metal ions. 16 beakers of 4 types of tea leaves soaked in different solutions were prepared and the final concentration of metal ions of each beaker was measured after 24 hours of contact time.
The results are shown in the following graph:

According to the graph above, different tea leaves vary in amount of absorption, yet the differences are not very significant. From the graphs, the percentage decrease of Cr3+ metal ion is the highest when it is put in green tea (50%), while that of Cu2+ ion is the highest in black tea (52%), and that of Co2+ ion is the highest in flower tea (79%). However, there is no particular kind of tea leaves that will have significant difference in absorption of these four ions. This suggested that the type of tea is not the major factor affecting the absorption of heavy metal ions.

Results of the experiment also indicate that all tea leaves are effective in absorbing chromium(III) ions, copper(II) ions and cobalt(II) ions, while no significant absorption of Nickel(II) ions was determined.

Concentration of Nickel(II) ions was found to have increased after 24 hours of contact time with tea leaves for most of the tea types except Pu er. It had been found that there is on average 14.84μg of Nickel in one gram of tea leaves. The increase in concentration of nickel(II) ions may be attributed to the release of nickel(II) ions from tea leaves in the solution, and the non-optimum pH level for absorption, as no control of the pH value of the solution was done. (The optimum pH for the best absorption for is 4)
B. Different initial metal ions concentration

Since the effectiveness in absorption of different metal ions are similar, one of the metal ions, Cu$^{2+}$, is chosen to study the effect of different initial metal ions concentration.

Pu Er tea leaves was used to absorb the copper(II) ions. Tea’s ability to absorb copper(II) ions decreases with the initial molarities of copper(II) solution. The percentage decrease in copper(II) ions concentration decreases from over 35% for initial molarity of 0.00125M to 5% for initial molarity of 0.02M, while it was found that tea leaves is not effective to remove copper(II) ions of concentration greater than 0.025M (1587.5mg/kg). Since common water pollutant only contains 160-170mg of copper(II) ions per kilogram. Tea leaves is very effective in removing these concentration of copper(II) ions. Past researchers had also found that copper(II) ion removal percentage increased when the initial ion concentration decreased. The fact that the ratio of surface active sites to the total Copper(II) ions in the solution is negatively related to the initial molarity of the solution, may explain the above experiment result.
C. Optimum Time for Highest Percentage Decrease of Heavy Metal Ion Concentration

In this experiment, 0.005M of Cr\textsuperscript{3+} ions solution was added to Pu er tea with time as independent variable. During every recess and lunch time, a small amount of solution was taken out and the concentration of the Cr\textsuperscript{3+} ions was measured. A time depending graph was plotted in order to find out the rate of absorption over time and to obtain the optimum time for heavy metal ion to have the highest percentage decrease of concentration.

From the graph, it was found that the concentration of the Cr\textsuperscript{3+} ions decreased in a decreasing rate, with the initial rate of the percentage decrease as 0.15\% per minute. When the ions were soaked in Pu er tea leaves for 320 minutes, the highest percentage decrease (41.1\%) is measured. After 320 minutes, the percentage decrease in concentration of Cr\textsuperscript{3+} ions has slightly dropped. Therefore, the optimum time for heavy metal ions to be soaked in tea leaves is 320 minutes. As the metal ions may not be adhered to the tea leaves firmly, they may fall out easily as time goes, which explain the drop of percentage decrease in concentration of ions after 320 minutes.
D. Optimum mass of tea leaves for the highest percentage decrease of heavy metal ion concentration

In this experiment, 0.005M of Cr\(^{3+}\) ion solution was added to Pu er tea leaves of different masses as the independent variables. Tea leaves of different masses were weighed with electronic balance and packed into tea bags. The concentrations of Cr\(^{3+}\) ions were measured after 7 hours. A mass-dependent graph was plotted in order to find out the concentration decrease with varying masses of tea leaves and to obtain the optimum mass for the metal ions to have the highest percentage decrease of concentration.

From the graph, it was found that the concentration of Cr\(^{3+}\) ions decreased in greater extent with larger mass of tea leaves, with the least percentage decrease of 14.8% at mass of 1g. When the mass of tea leaves reaches 5.5g, the highest percentage decrease (62.9%) was measured. At mass of 6g onwards, the percentage decrease in concentration of Cr\(^{3+}\) ions has significantly dropped by 16.5%, in which a percentage decrease of 46.4% was measured.

This phenomenon can be explained that when all active sites of tea leaves (ie. Cellulose) are occupied with Cr\(^{3+}\) ions as mass used increases, further increasing the tea leaves
mass cannot increase the absorption. Mass of tea leaves is no longer the limiting factor. Thus the curve flattens off.

Therefore, the optimum mass of tea leaves for removing 0.005M (260mg / kg) of chromium(III) ions is 5.5g. As common water pollutant only contains around 61 mg of chromium(III) ions per kilogram, around 1.3g of tea leaves is needed.

**E. Surface Area**

In this experiment, 0.005M Cr3+ions solution was added to Pu’er tea leaves with different surface areas as independent variable. A set of tea leaves was ground into powder with an electronic grinder and another set was left as leaves. The concentrations of Cr3+ions were then measured after 7 hours. A comparing bar chart of surface area against the concentration decrease of metal ions was plotted in order to find out whether powder or leaf form could lead to better absorption.

From the graph, it was found that at powder form results in higher percentage decrease in Cr3+ion concentration (65.3%) comparing to the significantly lower decrease of leaves form (37.5%). Therefore, larger total surface area of tea leaves contribute to the better absorption of metal ions.
It can be explained that with larger surface area, the total active sites of tea leaves (i.e., Cellulose) is increased to which more metal ions can be attached.

**F. Different treatment of tea leaves:**

In order to enhance the effectiveness of the tea leaves, different treatment was done before the absorption. Three Pu'er tea bags were soaked with the same volumes of NaOH solution, NaHCO₃ solution, and distilled water for 24 hours beforehand respectively.

The results are as follows:

![Bar graph showing percentage decrease in concentration of copper ions soaked in Pu Er tea of different treatment methods]

Comparing the three treatments used, it is shown that tea leaves soaked with NaOH gives a significantly better absorption performance on Cu²⁺ ions. The decrease in concentration is as high as 79.4%.

NaOH is more efficient than Hot water to remove soluble and colored components in tea leaves. Also NaOH can neutralize the tannic acid from the tea leaves. Thus, soaking the tea leaves in NaOH in advance can further facilitate metal ion absorption.
Conclusions
1. All tea leaves are effective in absorbing chromium(III) ions, copper(II) ions and cobalt(II) ions.
2. The lower the initial copper(II) ion concentration, the higher is the amount of ions absorbed by tea leaves.
3. The larger the total surface area of tea leaves, the better is the absorption of heavy metal ions.
4. The most appropriate soaking time of tea leaves is 320 minutes.
5. The most appropriate mass of tea leaves to be used is 1.3g for each litre of water pollutants.

Research significance
Teawaste is a cheap material so its utilizing in industrial wastewater treatment plants would be convenient. Meanwhile it is possible to increase the treatment efficiency by pretreatment with some chemicals such as NaOH. Finally we recommend to evaluate the effect of pretreatment processes for this type of treatment and to investigate the probable changes of adsorption.

In view of the severe pollution in the mainland at present, this investigation brings light to the effectiveness of tea leaves, promoted under specified conditions, on absorbing heavy metal ions. It is hoped that tea leaf wastes, as an environmentally-friendly resources, can be recycled and used in metal ion absorption for industrial sewage treatment in mainland China in the near future.

Limitations
As experiments on lead(II) ions and mercury ions produce precipitates which would mask the colour change of the solutions, these important heavy metal ions could not be used in this investigation. In addition, since mercury ions could not be obtained in a sufficiently large amount, no experiments could be performed with mercury ions under test.
Due to the nickel-containing nature (on average 14.84μg of nickel per gram) of tea leaves, this attributed to the release of Ni2+ ions from tea leaves into the solutions tested, causing experiments on Ni2+ ion to be inaccurately performed.

**Suggestion for further researches**

Further researches can investigate on whether the tea wastes are re-usable in absorbing metal ions. Other factors such as the pH value and temperature of solution can also be studied in order to find the optimum pH and temperature of the tea wastes solution for treating water with metal ions. Moreover, further researches can design a suitable method to measure other metal ions in water including lead and mercury.

**Reference**


**Comment:**

Students investigated the optimal efficiency of the absorption of heavy metal ions by tea waste comprehensively. The time and effort students spent on the investigations are highly appreciated. Their evaluation on the exceptional cases and the limitation of the experiments was sensible. The conclusion drawn was evidence-based and the suggestions for further studies were appropriate. It is suggested that the methodology could be revised in more detail in order to consolidate their conclusions.
Magic Pepper – Cleaning Ocean Oil Spills

St. Stephen’s Girls’ College
Teacher: Kwan Pui Shan
Student: 3C Au Ying Heung, 3E Poon Wing Kei, 3E Wu Hoi Kei
4D Ling Cheuk Kwan, 4E Lai Yan Ling

Introduction

Reasons for investigation

One of the main harmful marine pollutants is oil, which usually comes from oil spills. Spilt oil penetrates into the feathers of birds and the fur of mammals, reducing their insulating ability and buoyancy in water. Therefore, our group decided to investigate in the ways of the treatment of oil spills.

Present situation

Presently, the methods used for cleaning ocean oil spills take weeks, months or even years. They involve burning off the oil or applying detergents. These methods have their own detrimental environmental effects. Magic sand (hydrophobic sand) is a better alternative substance which works by attracting and sinking oil into the bottom of the ocean without causing the same harmful environmental effects. However, due to the high cost involved in production, it is not yet being used extensively.

Our choice of materials

We tried out different substances which is cheap and can be easily obtained in our homes to replace hydrophobic sand. They included salt, white pepper, bread, hair etc. and they were tested about their abilities to absorb oil. We found white pepper, surprisingly, formed lumps with oil and sank. It might be the material and we made further investigations on the oil absorbing properties of pepper.

In the following two experiments, we investigated

1. The oil-trapping ability of white pepper compared with hydrophobic sand and also how different sizes affect the results and

2. The recyclability of oily white pepper
Experiment 1:
Comparing the effectiveness of different sizes of white pepper and that of magic sand (hydrophobic sand) for cleaning an oil spill

1. Aim
After discovering the lipophilic property of white pepper, we decided to find out how size affects the oil-attracting ability. The effectiveness of commercial hydrophobic sand was also compared.

2. Materials and Apparatus
a. 3 separate portions of different sizes of white pepper (crushed by mortar and pestle) and 1 portion of commercial hydrophobic sand, 2 grams each

<table>
<thead>
<tr>
<th>Size</th>
<th>Whole</th>
<th>Large</th>
<th>Small</th>
<th>Hydrophobic Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4 to 1/2 of a whole white pepper</td>
<td>1/4 to 1/2 of a whole white pepper</td>
<td>Fine white pepper powder</td>
<td>Commercial hydrophobic sand</td>
<td></td>
</tr>
<tr>
<td>Amount</td>
<td>2 grams</td>
<td>2 grams</td>
<td>2 grams</td>
<td>2 grams</td>
</tr>
</tbody>
</table>

b. oil of 4 separate portions, 1 cm³ each
c. water of 4 separate portions, 6 cm³ each
d. an electronic balance
e. 4 measuring cylinders (10 cm³)
3. Procedures

a. Weigh 2 g of each of white pepper of different sizes and commercial hydrophobic sand with the electronic balance.

b. Pour water, oil, then white pepper of different sizes, or hydrophobic sand of their respective amount into each of the 4 measuring cylinders.

<table>
<thead>
<tr>
<th>Whole</th>
<th>Large</th>
<th>Small</th>
<th>Hydrophobic Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Whole" /></td>
<td><img src="image2.png" alt="Large" /></td>
<td><img src="image3.png" alt="Small" /></td>
<td><img src="image4.png" alt="Hydrophobic Sand" /></td>
</tr>
</tbody>
</table>

c. Time for 2 hours then observe the volume of oil remaining on the surface of water, the water quality and also calculate the ratio of amount of white pepper / commercial hydrophobic sand to the amount of oil trapped.

4. Results

In each measuring cylinder, 1 cm³ of oil floated on 6 cm³ of water. When white pepper / hydrophobic sand was added in, oil was absorbed and a mass sank. If the volume of remaining oil was small, the oil absorbing ability of the material was good. We also observed the quality of water to check if any resulting mass has dispersed around.
<table>
<thead>
<tr>
<th>Size of pepper/ hydrophobic sand</th>
<th>Whole</th>
<th>Large</th>
<th>Small</th>
<th>Hydrophobic Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of oil remaining</td>
<td>0.4 cm³</td>
<td>0 cm³</td>
<td>0 cm³</td>
<td>0.2 cm³</td>
</tr>
<tr>
<td>Ratio of mass of white pepper used to volume of oil trapped</td>
<td>~3.33:1</td>
<td>~2:1</td>
<td>~2:1</td>
<td>~2.5:1</td>
</tr>
<tr>
<td>Water quality</td>
<td>clear</td>
<td>clear</td>
<td>cloudy</td>
<td>clear</td>
</tr>
</tbody>
</table>

Comparison of effectiveness of different samples in trapping oil
5. Interpretations
The large-size crushed and small-size crushed pepper absorbed more oil than the other two samples. They had larger surface areas for lipophilic abilities. The crushing might also serve to expose the nonpolar constituents of pepper such as aromatic oil and crude fat that attracted the floating oil.

However, as the small-sized crushed pepper was very light, it dispersed around in the water instead of staying still after it sank with the oil absorbed. It might also be not big enough to hold the possibly larger oil droplets, and so some of the oil trapped inside escaped back to the water surface after some time.

6. Conclusion
The large-size crushed pepper is the most effective among pepper of different sizes and also hydrophobic sand in trapping oil on water surface.

Experiment 2:
Recycling methods for the oily pepper / hydrophobic sand

1. Aim
To find out the most effective way to remove oil from oil-trapping pepper / hydrophobic sand

2. Materials and Apparatus
a. Oil-trapping pepper and hydrophobic sand
b. Vinegar
c. Evaporating dish
d. Beaker
e. Glass rod
f. Tongs
3. Procedures:

a. Put the oil-trapping pepper into the evaporating dish.

b. Pour vinegar into the dish until all oil-trapping pepper is soaked in vinegar.

c. Slowly heat the dish with Bunsen flame until the mixture boils.

d. Put the boiled mass into a beaker and pour in tap water.

e. Pour water away after stirring.

f. Put the boiled mass into another clean evaporating dish.

g. Slowly heat the mass until dryness with Bunsen flame and stir to prevent burning.

h. Repeat experiment 1 using the recycled samples, with 1 cm³ oil used in each case.
4. Results

<table>
<thead>
<tr>
<th></th>
<th>Recycled pepper</th>
<th>Recycled Hydrophobic Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of oil remaining</td>
<td>0 cm³</td>
<td>~1 cm³</td>
</tr>
<tr>
<td>Ratio of mass of white pepper used to volume of oil trapped</td>
<td>~2:1</td>
<td>Undetermined (No oil trapped)</td>
</tr>
</tbody>
</table>

The pepper after recycling could trap oil in about the same degree as before in the ratio around 2:1. It was hard to recycle hydrophobic sand as they kept popping out during the heating process and much oil is left on the water surface when we tried to reuse it.

We tried to boil the materials with vinegar as we found from literature that hot acidic solutions could break down oil by hydrolysis.

5. Conclusion

Boiling oil-trapping pepper with vinegar and then drying it sufficiently is a feasible way of recycling the used, oily pepper. The recycling of hydrophobic sand is not as feasible and the recycled sand can hardly trap any oil again.

Negative results and Improvements

In experiment 1,
We first used beakers as containers for the set-ups. But we later found out the amount of oil trapped could not be seen and compared clearly or accurately. It was too subjective if we just judged whether there was any oil left with our naked eyes.
We tried to dye the oil in the sample by adding iodine in heptane, which was purple. However, the solutions didn’t blend completely with the oil. The results obtained would still be inaccurate and could not easily be compared.

We then thought of reading the change in volume of oil directly for more accurate data. Therefore, we used the measuring cylinders. The initial and final readings of the volumes of oil can be read clearly and the drop in volume of oil can be obtained.

In experiment 2, We have tried a few ways to recycle the oil-trapped pepper. We first tried to use the filter paper to separate oil from the pepper. However, the holes of the filter paper are too small that only water molecules, but not oil molecules could pass through. The oil and the pepper mass left on the filter paper as residue without separating.

We then tried to recycle the oil-trapped pepper directly instead of separating oil from pepper beforehand. We tried 2 methods:

1) Heat the pepper directly. However, the pepper was still oily and could not trap any more oil after recycling.

2) Boil the oil-trapped pepper with water. Although it seemed that some of the oil was removed, but the pepper could not trap oil in the same degree as before.

After some research, we found out that acidic solutions can breakdown oil. Therefore, we tried to combine the 2 methods above, but using vinegar instead of water: boil the pepper with vinegar, rinse it with water and heat it until dryness. The pepper obtained afterwards could work further.

And why we prefer using white pepper:

There are some other advantages of using pepper over hydrophobic sand:

1. Price

We have roughly calculated the cost of using hydrophobic sand in a real oil spill, which is approximately HKD$120,000,000. But for white pepper, taking its wholesale cost it would only cost HKD$38,000,000. Also, considering the reusable property of pepper, it should be a good alternative choice.
2. Biodegradable

Hydropobic sand is manufactured by spraying a layer of hydrophobic compound on normal sand, while white pepper are naturally planted, and would do less harm or even no harm to ocean. It also decomposes easier.

Future plans

There are still a few points that we are not yet able to make investigations on, because of both the lack of time and the constraints in technology and knowledge:

1. We have been thinking of making pepper bags for domestic use, such as to clean the oil stains left on eating tools and cooling utensils. However, wrapping the peppers with gauze is not practical as it would be soaked with both oil and water, and makes it hard to recognize whether the peppers or the cloth did the trapping, while tea bags’ holes are way too big to keep the peppers inside. We still haven’t found a perfect solution for this, and so the idea is being shelved for now.

2. In all the experiments the only kind of pepper we used is white pepper, and we know nothing about whether or not the other kinds of pepper, e.g. green pepper and black pepper, would give the same results.

3. We may investigate on the possibilities of using white pepper in sewage treating plants to trap any oil.

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**Thanks:**

We would like to give our special thanks to Ms. P.S. Kwan, our guiding teacher, who has been directing us throughout the whole project, and also to Mr. L.T. Po and the janitors for helping us with the apparatus and the cleaning up after experiment. Without them our investigations would have not been as smooth and successful.

**Comment:**

Using white peppers for the removal of oil in ocean is an innovative idea, which is raised from a fantastic observation in daily life. Much effort was put to improve the experimental set-up throughout the investigation and a neat protocol was finally reached. They demonstrated their trouble shoot and problem solving skills, which are definitely crucial to a scientist. Evaluation on the practical usages and the cost effectiveness of the project could enhance the accomplishment of this ground-breaking investigation.
Treatment and Recycling of Disposed Expanded Polystyrene

La Salle College
Teacher: Yau Lai Chu Irene
Student: Matthew Cheung Ka Long
        Benton Chung Poh Hei
        Brian Lam Ching Long
        Gabriel Wong Chun Hei
        Wong Tsz Him

1. Aim
The aim of this project is to investigate the effectiveness of using acetone in treating and recycling expanded polystyrene, so as to reduce the amount of polystyrene to be discarded in landfills.

2. Background
Polystyrene (PS) is a common packaging material made from non-renewable petroleum-based chemicals. Often in the form of Expanded Polystyrene (EPS), polystyrene is commonly used for disposable trays, plates, bowls and cups, and for building insulation and packing material. It is popular as it is chemically inert, light, hygienic and very convenient.

However, lots of problems arise when the polystyrene has to be discarded. Polystyrene is not recycled. It takes a lot of space in landfills and at least 500 years to decompose. In Hong Kong, about 135 tonnes of EPS waste is disposed at our landfills every day. Furthermore, EPS has become a major component of plastic debris in the ocean. It is hazardous to marine life, and could lead to accumulation of toxic chemicals in the food chain.
Australia has established a collection network to facilitate EPS recycling, by segregation, collection, reprocessing and export. During 2009/2010 over 3,000 tonnes of EPS was recycled throughout Australia. In Germany, manufacturers are required by law (Verpackungsverordnung) to take responsibility for recycling or disposing of any packaging material they sell which includes polystyrene. We must also find a solution to tackle this severe problem caused by polystyrene in Hong Kong.

3. Theory

3.1 Acetone

Acetone is the organic compound with the formula (CH3)2CO, and a kind of ketone. It is a colourless and flammable liquid, a good solvent for most plastics, including polystyrene. It can be found in nail polish removers. The hazardous nature of acetone includes high flammability, irritation of eyes, repeated exposure may cause skin dryness or cracking, and vapours may cause drowsiness and dizziness.

Nowadays, most of acetone is produced via the cumene process. In the process, benzene is alkylated with propylene to produce cumene, which is oxidized by air to produce phenol and acetone:

3.2 Polystyrene

Polystyrene is an artificial aromatic polymer produced from monomer styrene. It is a long chain hydrocarbon where alternating carbon centers are attached to phenyl group (benzene). Its chemical formula is (C8H8)n. It is one of the typical examples of plastics. It can be either hard or fragile, depending on its form. It is commonly used in protective packaging, CD and DVD cases, containers, lids, disposable bottles, and trays.
3.3 Expanded Polystyrene (EPS)

Expanded Polystyrene (EPS) is a rigid cellular plastic, produced by expanding polystyrene beads containing gas, which makes it tougher than other types of polystyrene. It is used for disposable containers, packing peanuts and packing cushions. EPS contains 98% air and is therefore light in weight.

(Note: forms of polystyrene include sheet or molded polystyrene, expanded polystyrene, extruded polystyrene etc.)

3.4 Theory

Instead of crowded with substance, there is actually a huge amount of air space in the polystyrene. Acetone breaks down the connection of the polystyrene molecule and air, and the air contained in the polystyrene are released to the atmosphere. As a result, the polystyrene is compressed and “dissolved” into acetone, like salt dissolved into water. Only a little amount of acetone is needed to compress a large amount of polystyrene. After the whole mixture is dried, the polystyrene formed is harder and denser than its original form.

4. Experiment

4.1 Objective

In order to investigate the effectiveness of acetone in recycling polystyrene, we carried out an experiment, in which we compared acetone with two other non-toxic polystyrene solvents, ethyl acetate and cyclohexanone. For 10mL of each solvent, we measured the percentage decrease in volume and the rate of compression.

(Note: most other solvents for acetone are toxic and not available in our school laboratory; please refer to the list of solvents for polystyrene at Appendix III)
4.2 Procedures

(Please refer to the laboratory manual at Appendix I)

The apparatus needed in the experiment

Dissolving a polystyrene strip into solvent

4.3 Findings

<table>
<thead>
<tr>
<th></th>
<th>Ethyl Acetate</th>
<th>Acetone</th>
<th>Cyclohexanone</th>
</tr>
</thead>
<tbody>
<tr>
<td>mass of 10mL solvent (g)</td>
<td>8.6</td>
<td>7.6</td>
<td>9</td>
</tr>
<tr>
<td>initial mass of polystyrene (g)</td>
<td>6.339</td>
<td>9.153</td>
<td>3.085</td>
</tr>
<tr>
<td>mass of beaker (g)</td>
<td>50.7</td>
<td>50.1</td>
<td>50.1</td>
</tr>
<tr>
<td>total initial mass (g)</td>
<td>65.639</td>
<td>66.853</td>
<td>52.185</td>
</tr>
<tr>
<td>final mass of mixture (g)</td>
<td>64.7</td>
<td>64.8</td>
<td>61.8</td>
</tr>
<tr>
<td>decrease in mass (g)</td>
<td>0.939</td>
<td>2.053</td>
<td>0.385</td>
</tr>
<tr>
<td>percentage decrease in mass (%)</td>
<td>1.431</td>
<td>3.071</td>
<td>0.619</td>
</tr>
<tr>
<td>volume of polystyrene dissolved (cm³)</td>
<td>374</td>
<td>540</td>
<td>182</td>
</tr>
<tr>
<td>volume of solvent (mL)</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>total initial volume (cm³)</td>
<td>384</td>
<td>550</td>
<td>192</td>
</tr>
<tr>
<td>final volume of mixture(cm³)</td>
<td>14</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>decrease in volume (cm³)</td>
<td>370</td>
<td>529</td>
<td>184</td>
</tr>
<tr>
<td>percentage decrease in volume(%)</td>
<td>96.35416667</td>
<td>96.18182</td>
<td>95.833333333</td>
</tr>
<tr>
<td>time taken (s)</td>
<td>605</td>
<td>143</td>
<td>425</td>
</tr>
<tr>
<td>dissolving rate (cm³/s)</td>
<td>0.618181818</td>
<td>3.776224</td>
<td>0.42835294</td>
</tr>
</tbody>
</table>

Resulted dissolved polystyrene using different solvents
In the experiment, we found that the volume of polystyrene can be greatly reduced by immersing polystyrene into organic solvents. The decrease in volume of polystyrene for ethyl acetate, acetone and cyclohexanone are 370cm³, 529cm³, and 184cm³ respectively. The percentage decrease in mass is also the greatest when using acetone. Moreover, acetone can compress the polystyrene at a rate of 3.78 cm³/s, more than 6 times the rate of the other two solvents.

### 4.4 Conclusion

As acetone can dissolve polystyrene at a faster rate and by a larger amount than the other two solvents, ethyl acetate and cyclohexanone, acetone is the most effective solvent in recycling acetone among the three solvents.

A: polystyrene dissolved in ethyl acetate  
B: polystyrene dissolved in acetone  
C: polystyrene dissolved in cyclohexanone

There are a lot of errors in the experiment, such as the inaccuracy in measuring the volume and mass of the polystyrene. To improve the experiment and increase the reliability, we can increase the sample size, test the effectiveness of more different kinds of solvents, be more accurate when cutting the polystyrene into strips, and perform the experiment in a sealed container to avoid errors. Moreover, we should repeat the experiment several more times in order to minimize mistakes during the experiment.

### 5. Design and Application

#### 5.1 Design

We designed an EPS recycling machine to compress and recycle polystyrene by using acetone on a large scale. It is a self-operating system. The whole process - putting in the waste EPS, adding acetone, compressing and taking out the compressed polystyrene, can be monitored by a computer program.
The machine is cylindrical, a cross-sectional diagram is provided below:

Its operation steps are:

1. Close the trap door; open the side door and put polystyrene basket in
2. Add acetone from above and lower the compressor to compress the polystyrene until all polystyrene are compressed
3. Open the trap door to let acetone flow back to the pump for reuse
4. Open the side door and take out basket to discharge the compressed polystyrene

As the machine is not a high-tech appliance and is made of mechanical parts only, its cost is rather low. Other than being automatic and highly-efficient, it also has the advantage of performing compression in a sealed container. The only chance of losing acetone by evaporation is when the side door is opened. About 80% of the acetone can therefore be recycled. If the machine is cooled with a cooler, or if the air pressure outside can be monitored to be higher than inside, loss of acetone due to evaporation can be prevented even when the side door is opened, and more acetone can be recycled, with only the acetone trapped in the polystyrene lost.
5.2 Application

The polystyrene, after being treated, could be reused to produce polystyrene products. Moreover, recycled EPS can be used in the construction of buildings as an insulator, or as foam packaging. Clothes’ hangers, park benches, flower pots, toys, rulers, picture frames etc. can also be made.

We suggest placing the EPS recycling machines in Hong Kong’s seven refuse transfer stations (see diagram below) where daily waste is collected and transported to strategic landfills (5 to 10 machines for each station, and Outlying Islands Transfer Facilities (OITF) can have 2 machines each):

Waste transportation is a high cost process. By compressing and recycling EPS before they are transported to landfills, instead of doing this process separately in different locations, the cost of transporting the large volume polystyrene waste can be minimized.

Also, in addition to Hong Kong’s three-colored recycling bins, a fourth purple bin for collection of polystyrene products and packaging can be added to make recycling of polystyrene waste more efficient and convenient. Citizens will be urged to clean the oil and grease on the EPS waste before recycling.

6. Comparison with other methods

<table>
<thead>
<tr>
<th></th>
<th>Combustion</th>
<th>Compression</th>
<th>Dissolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td>Polystyrene waste can be used as a fuel to generate energy</td>
<td>No harmful chemicals will be released to the environment</td>
<td>A very small amount of energy consumed as dissolving rate of acetone is high</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>Harmful carcinogenic and toxic products are produced</td>
<td>A large amount of energy is required as EPS can resist compression</td>
<td>A large amount of acetone is used which may cause harm to the environment</td>
</tr>
</tbody>
</table>
7. Conclusion and Recommendations

Our investigation proved the effectiveness of acetone as a solvent to compress and recycle polystyrene. We have also designed a possible way to recycle EPS on a large scale. We therefore suggest the Hong Kong society to put our idea into practice, in order to relieve the problem caused by polystyrene disposal. A new purple recycling bin should be introduced to encourage the public to recycle EPS and make collecting EPS waste more efficient.

Also, it is suggested to adapt other countries’ methods in recycling polystyrene such as the packaging law (Verpackungsverordnung) in Germany, which requires manufacturers to take responsibility for recycling or disposing of any packaging material they sell. This law is successful in Germany. A similar kind of law should also be enacted for the sake of our citizens.

On the other hand, while people are working hard to recycle polystyrene, we should think about the origin of the problem. People use polystyrene because it is light and hygienic, but if we want to solve the problems caused by polystyrene, we should tackle it from the origin - reduce the amount of disposed polystyrene produced in our daily life. Of course it will lead to inconvenience - but between our comfort and our Earth, what would you choose?

8. References

Appendix I

Lab Manual

Objective
To investigate the effectiveness of different solvents in reducing the volume of polystyrene.

Hypothesis
Acetone is more effective than ethyl acetate and cyclohexanone in dissolving polystyrene.

Apparatus

<table>
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<tr>
<th></th>
<th>Quantity</th>
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</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>10mL</td>
<td>Ethyl acetate</td>
<td>10mL</td>
<td></td>
</tr>
<tr>
<td>Cyclohexanone</td>
<td>10mL</td>
<td>Beaker</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Polystyrene waste</td>
<td>Abundant supply</td>
<td>Timer</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Measuring cylinder</td>
<td>6</td>
<td>Dropper</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Electronic Balance</td>
<td>1</td>
<td>Glass rod</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Safety Precautions
Perform the following experiment in a fume cupboard.
Wear safety goggles and gloves.
Be cautious of the hazardous nature of chemicals.

Procedures
1. Cut the polystyrene into strips of 2cm x 2cm x 20cm
2. Measure 10 mL of each solvent by a measuring cylinder and pour them into the beakers.
3. Start the timer and add polystyrene strips one by one into the beakers in each setup. Use a glass rod to compress the polystyrene and stir the mixture.
4. Continue to add polystyrene strips until the solution is saturated for each setup.
5. Record the time taken for the polystyrene to dissolve in each setup.
6. Record the number of strips dissolved in each setup.
7. Measure the final volume of polystyrene in each setup.
8. Calculate the volume of polystyrene dissolved for each solvent.
9. Analyze the experimental results and compare the effectiveness of the solvents.
Appendix II

<table>
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<tr>
<th>Budget (in HKD) Acetone</th>
<th>$16 per 1L</th>
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<tr>
<td>EPS Dumped</td>
<td>135 ton per day = 135000kg</td>
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<tr>
<td>Mass of EPS able to be dissolved by 1L of acetone</td>
<td>~1kg</td>
</tr>
<tr>
<td>Reusing rate of acetone</td>
<td>~95%</td>
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<tr>
<td>Acetone needed per day</td>
<td>6750 L</td>
</tr>
<tr>
<td>Cost (Acetone) per day</td>
<td>$108000</td>
</tr>
<tr>
<td>Cost (Acetone) per year</td>
<td>$39420000</td>
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</tbody>
</table>

Note: According to the HKSAR Government Budget 2013–2014, the government has injected $5 billion into the Environment and Conservation Fund to provide support for green projects initiated by the community. This only accounts for 0.8% of the total estimated amount.

Appendix III

Solvents that can dissolve acetone

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<tr>
<th>Aromatic Hydrocarbons</th>
<th>Chlorinated aliphatic hydrocarbons</th>
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<tr>
<td>Benzene</td>
<td>methylene chloride</td>
</tr>
<tr>
<td>Toluene</td>
<td>Chloroform</td>
</tr>
<tr>
<td>Xylene</td>
<td>carbon tetrachloride</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Pyridine</td>
<td>Acetone</td>
</tr>
<tr>
<td>Dioxane</td>
<td>Dimethylformamide</td>
</tr>
<tr>
<td>Methyl ethyl ketone</td>
<td>Diisopropyl ketone</td>
</tr>
<tr>
<td>Cyclohexanone</td>
<td>Tetrahydrofuran</td>
</tr>
<tr>
<td>n-butyl phthalate</td>
<td>Methyl phthalate</td>
</tr>
<tr>
<td>Ethyl phthalate</td>
<td>Tetrahydrofurfuryl alcohol</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>Butyl acetate</td>
</tr>
<tr>
<td>1-nitro-propane</td>
<td>Carbon disulfide</td>
</tr>
<tr>
<td>Tributyl phosphate</td>
<td>Cyclohexane</td>
</tr>
<tr>
<td>Methylcyclohexane</td>
<td>Ethylcyclohexane</td>
</tr>
</tbody>
</table>

**Comment:**

Students fully utilized the property of acetone and polystyrene and created an EPS recycling machine. This demonstrates how a new invention is raised from a long-established principle, which is easily overlooked usually. Together with the comprehensive research on the method of recycling EPS in different regions, they suggested practical ideas to solve the EPS problem faced in Hong Kong. It is suggested the design of the EPS could be fine-tuned and the operational details could be evaluated further.
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<tr>
<td>鍾凱文</td>
<td>天主教伍華小學</td>
</tr>
<tr>
<td>甄巧盈</td>
<td>保良局何壽南小學</td>
</tr>
<tr>
<td>陳希言</td>
<td>沙田官立小學</td>
</tr>
<tr>
<td>鄭桂恒</td>
<td>聖公會李兆強小學</td>
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<td>巫卓林</td>
<td>聖公會李兆強小學</td>
</tr>
<tr>
<td>黃子軒</td>
<td>聖公會李兆強小學</td>
</tr>
<tr>
<td>陳泰名</td>
<td>聖公會聖紀文小學</td>
</tr>
<tr>
<td>林樂熹</td>
<td>聖公會聖紀文小學</td>
</tr>
<tr>
<td>陳榮恩</td>
<td>聖公會聖紀文小學</td>
</tr>
<tr>
<td>黎濟森</td>
<td>天主教聖安德肋小學</td>
</tr>
<tr>
<td>甘浚祺</td>
<td>聖保羅男女中學附屬小學</td>
</tr>
<tr>
<td>林偉樂</td>
<td>順德聯誼總會李金小學</td>
</tr>
<tr>
<td>黃凱宏</td>
<td>大埔舊墟公立學校（寶湖道）</td>
</tr>
<tr>
<td>李希朗</td>
<td>大埔舊墟公立學校（寶湖道）</td>
</tr>
<tr>
<td>陳展朗</td>
<td>大埔舊墟公立學校</td>
</tr>
<tr>
<td>高涯澄</td>
<td>大埔舊墟公立學校</td>
</tr>
<tr>
<td>黎行健</td>
<td>德信學校</td>
</tr>
<tr>
<td>陳顥謙</td>
<td>油蔭地天主教小學</td>
</tr>
<tr>
<td>鄧禧泓</td>
<td>英華小學</td>
</tr>
</tbody>
</table>
「科學知識測驗」一等獎

中學組（排名不分先後）
文俊權  神召會康樂中學
翟梓峯  浸信會呂明才中學
梁俊灃  何明華會督銀禧中學
趙士傑  何明華會督銀禧中學
譚穎照  迦密唐賓南紀念中學
司徒灃麟 迦密柏雨中學
陳煒方  中華基督教會全完中學
羅琛明  基督教宣道會宣基中學
施昱坤  福建中學（小西灣）
梁家穎  優才（楊殷有娣）書院
黃  旭  優才（楊殷有娣）書院
黃一晉  優才（楊殷有娣）書院
胡嘉希  德望學校
余施煒  協恩中學
余錦森  香島中學
馮泰堯  香港教師會李興貴中學
阮文軒  香港浸會大學附屬學校王錦輝中小學
鍾焯儒  香港管理專業協會羅桂祥中學
林偉堃  香港四邑商工總會黃棣珊紀念中學
黃家裕  旅港開平商會中學
黃卓朗  旅港開平商會中學
區浩文  觀塘瑪利諾書院
黃俊希  喇沙書院
林靖朗  喇沙書院
鍾博熙  喇沙書院
潘文榮  基督教聖約教會堅樂中學
林銘進  保良局何蔭棠中學
任恩翃  香港培正中學
謝智健  皇仁舊生會中學
關  敏  皇仁舊生會中學
黃耀斌  荃灣公立何傳耀紀念中學
溫政培  東華三院盧幹庭紀念中學
鄭振聰  東華三院盧幹庭紀念中學
林寄寬  英華書院

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香港科學青苗獎
準決賽學校名單
(2012-13)
香港科學青苗獎準決賽學校名單(2012-13)

小學組準決賽隊伍名單
大埔循道衛理小學
拔萃女小學
英華小學
聖公會李兆強小學
聖保羅男女中學附屬小學
中華基督教會灣仔堂基道小學（九龍城）
拔萃男書院附屬小學
中華基督教會基慈小學
港澳信義會小學

中學組準決賽隊伍名單
聖保羅男女中學
中華基金中學
協恩中學
田家炳中學
喇沙書院
聖士提反女子中學
香港道教聯合會鄧顯紀念中學
神召會康樂中學
何明華會督銀禧中學
迦密柏雨中學
優才（楊殷有娣）書院
歷屆籌委會

比賽合辦團體

教育局資優教育組
香港數理教育學會
香港教育工作者聯會
香港資助小學校長會
香港中文大學教育學院校友會
行政長官卓越教學獎教師協會

教育局委託承辦『香港科學青苗獎2012/13』之機構

香港青年協會

2012-13香港科學青苗獎籌委名單

顧問團名單

譚鳳儀教授
吳基培教授
吳大琪教授
葉賜權先生
黃諾心女士
吳本韓博士
呂夢茹女士

香港城市大學
香港中文大學
香港科技大學
澳門科學館總館長
香港數理教育學會
香港中文大學
教育局科學教育組

關利平教授
鄭慕賢博士
陳龍生教授
吳 賓先生
黃永基先生
楊萬成先生
陳沛田先生

香港城市大學
香港教育學院
香港大學
香港數理教育學會
香港數理教育學會
資深教育工作者
教育局資優教育組

主席 副主席 祕書
杜家慶校長 黃群英女士 梁見德先生

委員

林威廉先生 谷裕峰先生 劉明基先生 葉國洪博士 吳 賓先生 劉國良校長
趙善衡先生 陳佩芳女士 周國良先生 樊文輝先生 蔡錦滔先生 蔡瑋庭先生
李家俊先生 馮新偉博士 黎育欣女士 莫明偉先生 梁偉明先生 羅玉婷女士
陳凱詩女士 吳勝文先生 關志賢先生 王子揚博士
歷屆評判

2011-12 香港科學青苗獎決賽評判

小學組
陳凱詩女士 香港科學青苗獎籌委
梁展鵬教授 香港理工大學
關志賢先生 香港科學青苗獎籌委
譚耀培校長 香港教育工作者聯會

中學組
江紹佳教授 香港中文大學
梁嘉聲教授 香港理工大學
吳賀先生 香港數理教育學會
鄭啟明博士 香港中文大學

2011-12香港科學青苗獎準決賽評判

小學組
羅玉婷女士 香港科學青苗獎籌委
蔡瑋庭先生 香港科學青苗獎籌委
陳凱詩女士 香港科學青苗獎籌委
葉國雄博士 香港科學青苗獎籌委
劉明基校長 香港科學青苗獎籌委

中學組
彭金滿博士 香港中文大學
劉善雅博士 香港中文大學
吳賀先生 香港科學青苗獎籌委
歴屆評判

2012-13 香港科學青苗奨決賽評判

小學組
麥嘉慧博士 香港浸會大學
吳勝文先生 香港科學青苗奨籌委
葉國洪博士 香港科學青苗奨籌委
陳曉雯女士 香港青年協會

中學組
陳永康教授 香港浸會大學
張肇堅博士 香港城市大學
劉國良校長 香港科學青苗奨籌委
盧家健先生 香港青年協會

2012-13 香港科學青苗奨準決賽評判

小學組
王子揚博士 香港科學青苗奨籌委
周國良先生 香港科學青苗奨籌委
吳 賓先生 香港科學青苗奨籌委
李家俊先生 香港科學青苗奨籌委
陳曉雯女士 香港青年協會

中學組
周祥明博士 香港中文大學
湯佩玲博士 香港大學
莫明偉先生 香港科學青苗奨籌委
盧家健先生 香港青年協會
曾參加香港科學青苗獎學校名單

小學組（排名不分先後）
九龍城浸信會禧年(恩平)小學
九龍婦女福利會李炳紀念學校
九龍塘學校
九龍塘學校(小學部)
上水宣道會小學
大埔循道衛理小學
大埔舊墟公立學校
大埔舊墟公立學校(寶湖道)
中西區聖安多尼學校
中華基督教會青年會小學
中華基督教會基法小學(油塘)
中華基督教會基華小學(九龍塘)
中華基督教會基慈小學
中華基督教會基慧小學
中華基督教會灣仔堂基道小學(九龍城)
五邑鄒振猷學校
天主教伍華小學校
天主教明德學校
天主教聖安德肋小學校
屯門官立小學校
北角官立小學校
北角循道學校
伊利沙伯中學舊生會小學校分校
西貢崇真天主教小學校
佐敦道官立小學校
佛教陳榮根紀念學校
佛教慈敬學校
佛教榮茵學校
沙田官立下午小學校
沙田官立小學校
沙田循道衛理小學校
秀茂坪天主教小學校
協和小學校
和富慈善基金李宗德小學校
拔萃女小學校
拔萃小學
拔萃男書院附屬小學校

孫方中小學
旅港開平商会學校
海壩街官立小學校
浸信宣道會呂明才小學校
浸信會沙田圍呂明才小學校
真鐸學校
祖堯天主教小學校
粉嶺公立學校
荃灣公立學校
荔枝角天主教小學校
軒尼詩道官立上午小學校
馬鞍山靈糧小學校
高主教書院小學校
國民學校
博愛醫院歷屆總理聯誼會梁省德學校
曾梅千禧學校
港大同學會小學校
港澳信義會小學校
華德學校
順德聯誼總李金小學校
順德聯誼總會伍冕端小學校
順德聯誼總會李金小學校
醍醐園主辦可立小學校
醍醐園主辦可銘小學校
愛秩序灣官立小學校
慈雲山聖文德天主教小學校
新加坡國際學校
聖士提反書院附屬小學校
聖公會主恩小學校
聖公會田灣始南小學校
聖公會李兆強小學校
聖公會偉倫小學校
聖公會聖紀文小學校
聖公會德田李兆強小學校
聖方濟各英文小學校
聖母無玷聖心小學校
聖保羅男女(堅尼地道)小學校

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東涌天主教學校
東倫同鄉會方樹泉學校
東華三院鄧肇堅小學
油蔴地天主教小學
保良局田家炳小學
保良局何壽南小學
保良局梁周順琴小學
保良局陳溢小學
保良局陸慶濤小學
保良局黃永樹小學
保良局錦泰小學
宣道會台山陳元喜小學
宣道會陳元喜小學
宣道會葉紹蔭紀念小學
紅磡官立小學
英華小學
迦密梁省德學校
香港九龍塘基督教中華宣道會陳元喜小學
香港浸信會聯會小學
香港普通話研習社科技創意小學
香港道教聯合會陳呂重德紀念小學
香港道教聯合會雲泉學校
聖保羅男女中學附屬小學
聖保羅書院小學
聖馬可小學
聖嘉祿學校
聖瑪加利男女英文中小學
路德會梁鉅鏐小學
農圃道官立小學
嘉諾撒聖家學校
嘉諾撒聖家學校(九龍塘)
瑪利曼小學
閩僑小學
鳳溪第一小學
鳳溪第二小學
鳳溪創新小學
德信學校
樂善堂小學
嶺南大學香港同學會小學
嶺南大學香港同學會直資小學
寶血會伍季明紀念學校上午校
寶血會思源學校
靈糧堂秀德小學
中學組（排名不分先後）
九龍真光中學
十八鄉鄉事委員會公益社中學
中華基金中學
中華基督教會全完中學
中華基督教會扶輪中學
中華基督教會協和書院
中華基督教會基完中學
中華基督教會基朗中學
中華基督教會馮梁結紀念中學
中華傳道會李賢堯紀念中學
中華傳道會劉永生中學
中華聖潔會靈風中學
五邑司徒浩中學
仁愛堂田家炳中學
元朗公立中學
屯門天主教中學
文理書院（香港）
可風中學
台山商會中學
田家炳中學
石籬天主教中學
伊利沙伯中學舊生會中學
伊利沙伯中學舊生會湯國華中學
西島學校
伯裘書院
何文田官立中學
何明華會督銀禧中學
余振強紀念第二中學
佛教沈香林紀念中學
佛教善德英文中學
佛教黃允畋中學
佛教葉紀南紀念中學
妙法寺劉金龍中學
李求恩紀念中學
沙田官立中學
沙田崇真中學
沙田培英中學
沙田循道衛理中學
沙田蘇浙公學
協恩中學
拔萃女書院
孫方中書院
旅港開平商會中學
浸信會呂明才中學
真光女書院
神召會康樂中學
粉嶺禮賢會中學
荃灣公立何傳耀紀念中學
荃灣官立中學
荔景天主教中學
馬鞍山聖若瑟中學
馬錦明慈善基金馬陳端喜紀念中學
高主教書院
高雷中學
培英中學
基督教女青年會丘佐榮中學
基督教宣道會宣基中學
基督教香港信義會信義中學
基督教聖約教會堅樂中學
救恩書院
陳樹渠紀念中學
喇沙書院
惠僑英文中學
智新書院
華仁書院（九龍）
順利天主教中學
順德聯誼總會李兆基中學
順德聯誼總會翁紹中學
匯知中學
匯基書院
匯基書院（東九龍）
新亞中學
獅子會中學
聖士提反女子中學
聖士提反堂中學
聖公會白約翰會督中學
聖公會李炳中學
聖公會李福慶中學
聖公會基孝中學
聖公會陳融中學
聖公會聖本德中學
聖公會鄧肇堅中學
明愛屯門馬登基金中學
東華三院李克寧灣中學
東華三院黃鳳翎中學
東華三院盧幹庭紀念中學
長沙灣天主教英文中學
保良局百周年李兆忠紀念中學
保良局何蔭棠中學
保良局姚連生中學
保良局胡忠中學
保良局唐乃勤中學
保良局唐乃勤初中書院
保良局第一張永慶中學
保良局董玉墀中學
保良局顏寶鈴書院
保良局羅氏基金中學
保祿六世書院
南屯門官立中學
宣道會陳朱素華紀念中學
皇仁書院
皇仁舊生生會中學
英皇書院
英華女學校
英華書院
迦密中學
迦密柏雨中學
迦密聖女南紀念中學
風采中學
香島中學
香海正覺蓮社佛教正覺中學
香海正覺蓮社佛教馬錦煇紀念英文中學
香海正覺蓮社佛教梁植偉中學
香港仔工業學校
香港四邑商工總會黃棣珊紀念中學
香港浸會大學附屬學校王錦輝中小學
香港浸會大學附屬學校王錦輝中學
香港培正中學
香港基督教服務處培愛學校
香港教師會李興賢中學
香港道教聯合會鄧顯紀念中學
香港管理專業協會李國寶中學
香港管理專業協會羅桂祥中學
香港孫鏡波書院
聖母玫瑰書院
聖母書院
聖母院書院
聖母無玷聖心書院
聖伯多祿中學
聖保祿學校(中學部)
聖保羅男女中學
聖保羅書院
聖若瑟英文書院
聖馬可中學
聖嘉勒女書院
聖瑪加利男女英文中小學
聖羅撒書院
裘錦秋中學(元朗)
路德會西門英才中學
路德會協同中學
嘉諾撒聖方濟各書院
寧波公學
廖寳珊紀念書院
瑪利曼中學
瑪利諾中學
福建中學（小西灣）
閩僑中學
鳳溪廖潤琛紀念學校
德信中學
德望學校
德愛中學
德蘭中學
樂善堂梁錦琚書院
樂道中學
鄧肇堅維多利亞官立中學
鄧鏡波學校
優才(楊殷有娣)書院
嶺南衡怡紀念中學
禮賢會彭學高紀念中學
寶安商會王少清中學
寶血會上智英文書院
鍾聲慈善社胡陳金枝中學
靈糧堂怡中文學
靈糧堂劉梅軒中學
觀塘瑪利諾書院
比賽花絮
準決賽2011-12
科學知識測驗(初賽)2012-13

準決賽2012-13
頒獎禮2012-13

頒獎禮司儀
教育局資優教育組課程發展主任
梁晃德先生

主禮嘉賓致詞
教育局前助理署理秘書長
(專業發展及培訓)梁兆強先生

致歡迎詞
教育局資優教育組總課程發展主任
陳沛田先生

頒獎禮嘉賓致詞
香港科學青年獎籌委
劉明基校長

小學組決賽評判分享
香港浸會大學
麥國傑博士

小學組冠軍
聖保羅男女中學附屬小學

小學組亞軍
拔萃男書院附屬小學

小學組季軍
拔萃女小學

小學組殿軍
大埔廈僑小學

小學組優異獎
港澳僑憲會小學

小學組優異獎
聖公會李兆強小學

中學組決賽評判分享
香港城市大學劉學堅博士(左)
香港浸會大學陳永康教授(右)

中學組冠軍
中華基督教會基長中學

中學組亞軍
聖保羅男女中學

中學組季軍
聖士提反女子中學

中學組殿軍
喇沙書院

中學組優異獎
香港道教聯合會鄧顯紀念中學

中學組優異獎
逾密伯爵中學