

香港環境輻射監測技術報告第 34 號  
**Technical Report No. 34 on  
Environmental Radiation Monitoring in Hong Kong**

香港環境輻射監測摘要  
**Summary of  
Environmental Radiation Monitoring  
in Hong Kong**  
**2013**

呂振文  
C.M. Lui

翁忠海  
C.H. Yung

香港天文台  
**Hong Kong Observatory**

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Prepared by:  
Hong Kong Observatory  
134A Nathan Road  
Kowloon, Hong Kong

## 摘要

香港天文台環境輻射監測計劃在二零一三年踏入第二十七年。本年報收錄了監測計劃在二零一三年的主要工作內容、測量方法及結果。年報亦介紹了新的工作項目和轉變。

在二零一三年，天文台的輻射監測網絡錄得的環境輻射水平俱在正常本底變化範圍之內。天文台在不同的環境及食物樣本中測量到微量的人工放射性核素，包括銫-137、氙、銥-90及釷-239，分析結果與多年來的結果並沒有顯著分別。相信這些放射性核素主要來自一九四五至一九八零年間的大氣核武試驗。

至於新的工作項目，天文台在二零一三年開始運作新的空中輻射監測系統，取代自一九九八年起沿用的系統。新系統擁有較先進軟件及硬件，方便運作。

為了加強對海水的輻射監測，自二零一三年第四季度起，天文台由每年一次抽取海水樣本作輻射測量，加密至每季一次。

二零一一年三月發生於日本福島的核事故，距今已超逾三年。受這事故影響，天文台在二零一一年三月底至四月底曾於空氣樣本中檢測出微量的人工放射性核素碘及銫；此外，福島核事故對本港的環境輻射水平並沒有造成長遠影響。

二零一三年的測量結果顯示，自廣東核電站及嶺澳核電站運作以來，香港的環境輻射水平、環境樣本及市民日常食用的食品中的人工放射性核素活度並沒有可測量到的變化。

## ABSTRACT

The Environmental Radiation Monitoring Programme of the Hong Kong Observatory entered its twenty-seventh year in 2013. This annual report incorporates salient features of the work of the programme during 2013, including a brief report on measurement methods and results, highlights of relevant new work and changes.

In 2013, the ambient radiation levels in Hong Kong as measured by the Observatory's radiation monitoring network were within the normal background range. Traces of artificial radionuclides, namely caesium-137, tritium, strontium-90 and plutonium-239, were detected in various environmental and food samples. The levels of all these radionuclides were not significantly different from those recorded in past years. Their presences were primarily attributed to the atmospheric nuclear weapon tests between 1945 and 1980.

As to new work, the Observatory commenced the operation of a new Aerial Radiation Monitoring System (ARMS) in 2013, replacing the one that had been in use since 1998. The new system features more advanced hardware and software to facilitate operation.

In order to strengthen the radiation monitoring of sea water, the Observatory has increased the sampling and measurement frequency for sea water from once every year to once every quarter since the fourth quarter of 2013.

Three years have passed since the occurrence of the Fukushima nuclear accident in March 2011. Due to the impact of the accident, minute amounts of artificial radionuclides, namely radioactive iodine and caesium, were detected in some air samples collected by the Observatory between late March and late April 2011. Apart from that, the Fukushima nuclear accident did not bring any long-term effect to the ambient radiation levels in Hong Kong.

Based on the measurement results in 2013, it is concluded that there was no measurable change in the ambient radiation levels in Hong Kong, activities of artificial radionuclides in the Hong Kong environment and foodstuffs consumed by Hong Kong people, as compared with those before the operations of the Guangdong and Lingao nuclear power stations.

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## 1. 引言

香港天文台早於一九六一年開始監測香港的環境輻射水平，並參與由國際原子能機構(IAEA)和世界氣象組織(WMO)舉辦的國際性環境輻射監測計劃。由於興建廣東大亞灣核電站，天文台於一九八三年開展了一項全面的計劃，以監測核電站運作前後香港的環境輻射水平。

該計劃名為「環境輻射監測計劃」(ERMP)，分兩個階段進行。ERMP 第一個階段為期五年，稱為「本底輻射監測計劃」(BRMP)，於一九八七年至一九九一年進行，務求在一九九四年廣東核電站（位置見圖 1）投產之前，確定香港的本底輻射水平，作為基準線，以判別核電站運作後可能為香港輻射水平帶來的影響。監測結果可參考 BRMP 的報告（香港天文台，1992）。

ERMP 的第二階段由一九九二年開始運作至今，內容涵蓋 BRMP 內的所有重要項目，並因應累積的經驗來修訂採樣及測量工作。ERMP 是一項持續進行的計劃，目標是監測香港環境輻射水平的長期變化，尤其是廣東核電站與嶺澳核電站分別在一九九四年及二零零二年運作後可能出現的任何變化。

ERMP 的監測結果在計劃的年報和摘要中發表（<http://www.hko.gov.hk/publica/pubrmc.htm>）。讀者可參閱有關報告，以瞭解計劃的採樣、測量及質量保證工作的詳情。自二零零三年開始，監測計劃的年報實行精簡化，年報只收錄計劃的重點，包括測量方法和結果的總結，及該年工作的摘要、轉變或新措施。。

本報告的第 2 章介紹監測計劃的取樣工作、環境輻射水平、食物和環境樣本放射性的測量方法及儀器，以及質量保證。第 3 章則臚列二零一三年的測量結果及所得的結論。



## 2. 取樣、測量及質量保證

ERMP 的焦點集中在大氣、地面和水體三個主要照射途徑。測量工作主要包括兩個部份。第一部份是直接測量香港的環境輻射水平，第二部份是測量香港的環境樣本及市民日常食物中的人工放射性物質。圖 1 顯示二零一三年實時測量環境輻射的地點，圖 2 所示為二零一三年其他環境伽馬輻射的測量地點及環境樣本的收集點。表 1 列載二零一三年的取樣及分析概要。

### 2.1 環境輻射水平的直接測量

#### 2.1.1 輻射監測網絡

天文台的輻射監測網絡包含分佈全港各區的十二個監測站(圖 1)，全面地測量香港境內的環境伽馬輻射水平。

每個輻射監測站均裝設一個高壓電離室(Reuter-Stokes Model RSS-131/RSS-131-ER environmental radiation monitor)，不斷測量環境伽馬輻射劑量率，並每一分鐘將數據傳送至天文台總部。

天文台在互聯網上發放各監測站錄得的每小時平均環境伽馬輻射劑量率數據，供市民參考，網址為：

[http://www.weather.gov.hk/radiation/ermp/rmn/applet/map/rmn\\_hourly\\_c.htm](http://www.weather.gov.hk/radiation/ermp/rmn/applet/map/rmn_hourly_c.htm)

#### 2.1.2 熱釋光劑量計網絡

香港天文台於一九八零年代末開始使用熱釋光劑量計，測量長時間累積的環境伽馬輻射劑量。在二零一三年，熱釋光劑量計網絡包括二十九個位於香港各區的固定監測點(圖 2)。這個網絡使用 Harshaw 8807 型號的氟化鋰(LiF:Mg,Ti)及氟化鈣(CaF<sub>2</sub>:Dy)熱釋光劑量計。為確保數據的統計精確度，每

個監測點均設有五個一組的劑量計。熱釋光劑量計每季更換及取讀數據一次。

天文台在二零一二年於新建之鶴咀輻射監測站增設熱釋光劑量計監測點，準備以此取代原本位於鶴咀無線電發射站的監測點。經過一整年時間兩站並行，設置於鶴咀輻射監測站之熱釋光劑量計監測點於二零一三年正式取代鶴咀無線電發射站的監測點。

此外，由於設置於吉澳漁業研究站的監測點之設施有所改動，吉澳之熱釋光劑量計監測點在二零一三年七月遷移至同位於漁業研究站內的吉澳輻射監測站。

### 2.1.3 空中輻射監測系統

香港天文台在二零一三年開始運作新的空中輻射監測系統，取代自一九九八年起沿用的系統。新系統由Pico Envirotec公司製造，設有四個約2.5公升碘化鈉(NaI)探測器，可安裝在政府飛行服務隊的直升機上，以進行測量。新探測器總容量較舊系統大，令探測人工放射性核素的靈敏度增加。新系統亦擁有較先進的軟件及硬件，方便運作。

空中輻射監測系統能以輻射煙羽追蹤模式來測定香港上空有否出現輻射煙羽及鑑定其影響範圍。當輻射煙羽經過本港後，該系統可以轉為地面輻射污染測量模式運作，判別受輻射沉降物污染的地區。進行監測時，該系統可在直升機上即時顯示探測位置、伽馬圖譜、譜法分析結果及伽馬劑量率等資料。新系統更能夠通過直升機上的數據傳輸系統將部份測量數據傳送至天文台總部。

空中輻射監測系統的優點是它可以在偏遠、陸上交通難以到達的地點進行輻射巡測。每年天文台均會利用空中輻射監測系統作常規測量，收集環境輻射水平資料及監測輻射水平隨高度的變化。

#### 2.1.4 自動伽馬譜法系統

自一九九六年起，香港天文台在大鵬灣平洲上設置了一套自動伽馬譜法系統(圖 1)，以便及早測量核電站可能排放的人工放射性核素。該系統由一個鍍上硫化鋅(ZnS)的塑膠閃爍器、一個高純度鍺(HPGe)探測器和一個碘化鈉探測器組成。系統分別利用一個迴轉空氣濾紙鼓和一個碳濾盒不斷地收集大氣飄塵及氣態碘，空氣濾紙鼓和碳濾盒的流量分別為約每小時 30 立方米及 4 立方米。碳濾盒每週自動更換一次。硫化鋅閃爍器負責測量大氣飄塵中的總阿爾法及貝他活度；鍺探測器利用伽馬譜法自動分析大氣飄塵釋出的伽馬射線；碘化鈉探測器則量度碳濾盒的碘-131 活度。

系統會每五至十五分鐘將阿爾法和貝他的活度、碘 - 131 的活度及伽馬譜法分析結果等數據傳送至天文台總部。

#### 2.1.5 流動輻射監測站

流動輻射監測站設於一部輻射巡測車內，站內配備多款便攜式及經特別設計的測量儀器，用作常規及應急輻射測量。主要儀器見下表：

儀器	位置	用途
Hi-Q Environmental Products 高容量空氣取樣器 (流量約 54 m <sup>3</sup> h <sup>-1</sup> )	安裝於車內	通過車頂的氣管入口抽取外間的空氣樣本。
Hi-Q Environmental Products 放射性碘取樣器 (流量約 4.8 m <sup>3</sup> h <sup>-1</sup> )		
Seibersdorf SSM1-07 伽馬劑量率探測器	安裝於車頂	探測器可連接至車內的便攜式巡測儀，讓車內的工作人員可以連續不斷地讀取站外的伽馬劑量率。

儀器	位置	用途
Seibersdorf SSM-1 便攜式巡測儀	置於車內，有需要時利用巡測車移至測量地點使用	配備蓋革彌勒管，可以測量環境伽馬輻射劑量率
Reuter-Stokes RSS-131 / RSS-131-ER 便攜式 高壓電離室		測量環境伽馬輻射水平。在每個測量地點，工作人員會把高壓電離室的感應器安置在離地面一米高進行測量。
Berthold Technologies LB-124 表面污染掃描儀		配備硫化鋅閃爍器，工作人員利用掃描儀在離表面一厘米的位置量度阿爾法、貝他及伽馬表面污染。
便攜式伽馬譜法儀 (Canberra ISOCS 刻度系統/高 純度鍍探測器)		在測量地點對環境放射性核素作伽馬譜法分析。

此外，車頂亦裝置了氣象儀器收集風速、氣溫及濕度等天氣數據。

流動輻射監測站日常用於常規巡測、收集樣本及應急演練，並定期到本港指定地點收取環境輻射數據。

#### 2.1.6 高空輻射探測

天文台利用氣球攜帶 Vaisala RS92 型號探空儀及附帶的輻射探測組件在京士柏進行高空輻射探測工作。每個輻射探測組件(Vaisala NSS921 型號)含有兩支蓋革彌勒(Geiger Müller)管，一支是只量度伽馬輻射的伽馬管，另一支是量度伽馬及高於 0.25 兆電子伏(MeV)貝他輻射的伽馬及貝他管。輻射探空儀傳回地面的數據經地面站的一台高空探測系統接收和處理。

天文台每年定期在不同的天氣情況下進行高空輻射探測，以收集輻射水平隨高度變化的數據。

## 2.2 食物及環境樣本取樣安排

### 2.2.1 大氣樣本

ERMP 所收集的大氣樣本包括大氣飄塵、濕沉積物(降雨)、總沉積物(濕沉積物加上乾沉積物)、氣態碘及水蒸氣。各取樣器及取樣方法見下表：

大氣樣本	取樣器	流量	取樣方法
大氣飄塵	Hi-Q Environmental Products 4200 AFC-BRL-KIT/230 及 Hi-Q Environmental Products BRL-3000M 高容量空氣取樣器	一般設置為 $17 \text{ m}^3\text{h}^{-1}$	透過高容量空氣取樣器內的濾紙收集大氣飄塵樣本
濕沉積物	頂部設有漏斗的容器之濕沉積物取樣器	-	在乾燥季節期內各收集點都會放置三個漏斗容器，以收集足夠雨水作測量。
總沉積物	直徑 260 毫米，盛有蒸餾水的不銹鋼圓盆之總沉積物取樣器	-	樣本每週收集一次。
氣態碘	裝有浸滲銀沸石濾盒之 Hi-Q Environmental Products CMP-0523CV/230 放射性碘取樣器	一般設置為 $2.5 \text{ m}^3\text{h}^{-1}$	濾盒每週收集和更換一次。
水蒸氣	裝有燥石膏濾盒之 Pylon Electronics Inc. VFP-20 氣態流出物取樣器	一般設置為 $0.12 \text{ m}^3\text{h}^{-1}$	每月隨機選擇一個星期間歇地收集樣本，直至取樣總時數達三十六小時為止。

天文台每週定期在京士柏、沙頭角和元五墳(圖 2)收集一次大氣飄塵和濕沉積物樣本。此外，在其他九個輻射監測站亦裝置有這些儀器，以便在應急時收集大氣樣本。天文台亦在京士柏收集總沉積物、氣態碘及水蒸氣樣本。

### 2.2.2 食物樣本

香港天文台從主要食物分銷點、批發市場和供應商收集各類市民日常食用的陸生和水生食物樣本，並特別著眼於本港和深圳出產的食物。

### 2.2.3 飲用水、地下水及海水

經處理的飲用水樣本，是從九龍和屯門配水管，以及沙田、屯門和油柑頭濾水廠(圖 2)收集的。未經處理的飲用水，則從萬宜水庫、船灣淡水湖、木湖 B 抽水站，以及沙田、屯門和油柑頭濾水廠(圖 2)收集。水務署的工作人員每三個月抽取飲用水樣本一次，交香港天文台作輻射測量。

油柑頭濾水廠在二零一三年四月至七月進行維修，而荃灣濾水廠於上述期間代替油柑頭濾水廠供應飲用水給當區用戶。因此，水務署的工作人員於二零一三年四月及七月這兩個季度在荃灣濾水廠取樣，以代替來自油柑頭濾水廠所抽取之飲用水樣本。

在房屋署職員、屋邨管理員及寺院人員等協助下，天文台於以下六個地點(圖 2)抽取地下水樣本：長康邨(青衣)、鈞樂新村(元朗)、環翠邨(港島東)、華富邨(薄扶林)、富山邨(東九龍)及清涼法苑(屯門)。

因應福島核事故發展及公眾對海水輻射監測之關注，天文台於二零一三年加強對海水的輻射監測。在環境保護署協助下，在二零一三年八月額外採集海水樣本作輻射測量。另外，自二零一三年第四季度起，天文台更增加海水樣本取樣及測量頻率，由每年一次在四個地點取樣，增至每季一次交替在其中兩個地點取樣。取樣地點均位於香港東部沿岸(圖 2)，分別為橫瀾島、火石洲、大浪灣及赤洲附近的海域。海水會從三個不同深度抽取：上層(水面下2.5米)、中層(與水面及海床等距)和低層(海床上2.5米)。海水中的懸浮粒子樣本是經由薄膜過濾海水樣本後收集。

## 2.2.4 土壤及沉澱物樣本

天文台在香港境內三十九個指定地點抽取土壤樣本，每一地點取樣周期為五年。每個地點抽取的土壤樣本均來自兩個不同的深度：上層由地面至 15 厘米深，下層則由 15 至 30 厘米深。二零一三年的取樣地點為東涌、石壁水塘、大澳、白泥、塔門、吉澳、平洲及跑馬地(圖 2)。

潮間帶土樣本每季在白沙灣、尖鼻咀和沙頭角三處沿岸地區(圖2)收集。樣本從兩個不同深度層抽取，上層從表面至 15 厘米深，下層則自 15 至 30 厘米深。另外，土木工程拓展署每年在大灘海、龍蝦灣、索罟灣和西區碇泊處四個地點(圖 2)協助收取海床沉澱物樣本。

表 1 及表 2 列載二零一三年樣本取樣概要。

## 2.3 食物及環境樣本的實驗室測量

食物及環境樣本的放射性分析均於京士柏的輻射實驗室進行。表 1 列出監測的主要人工放射性核素。每個樣本按照不同樣本類別及測量目的，經過下列一項或多項程序分析：

- (a) 以伽馬譜法測量伽馬放射性核素的活度；
- (b) 以液體閃爍計數法測量氚<sup>+</sup>的放射性活度；
- (c) 以低本底總貝他計數法測量銥-90 的放射性活度；及
- (d) 以阿爾法譜法測量釷-239 的放射性活度。

[<sup>+</sup>氚主要是在宇宙射線進入大氣層時自然地形成，或在一九四五至一九八零年間大氣核武試驗中產生，而少量亦可能來自核電站運作 (UNSCEAR 2008)。]

有關各種量度參數的概要，例如樣本大小、計數時間及探測下限等，載列於表 3。

## 2.4 本底輻射監測計劃(BRMP)及 環境輻射監測計劃(ERMP)的測量值比較

在 2.1 至 2.3 節所敘述的輻射測量中，部份環境伽馬輻射監測站、自動伽馬譜法系統及部分環境及食物樣本的輻射測量在 BRMP 進行的五年間尚未開始運作，所以本報告中有關這些系統或樣本的輻射測量結果並沒有相應的 BRMP 範圍作為本底輻射比對。

雖然如此，自一九九二年 ERMP 第二階段開始運作多年來，所有 BRMP 已包含的輻射測量項目的測量值均顯示香港的環境輻射水平及樣本中的人工放射性核素活度均沒有因核電廠的運作而產生實質的變化。在這個基礎上，本報告中凡沒有 BRMP 範圍的測量項目(即在 ERMP 第二階段運作後才開始測量的項目)均以該項目首五年測量值的變化範圍作為參考。此參考值的測量時段與 BRMP 最接近，因此在沒有其他可見的變素影響下，也可以被視為該測量項目的近似本底數值範圍。

## 2.5 質量保證

自一九八九年開始，天文台已參與國際及中國內地機構舉辦的測量比對及能力測試(許建忠等，2007)，當中包括國際原子能機構(IAEA)、英國國家物理實驗室(NPL)、世界衛生組織(WHO)及中國輻射防護研究院(CIRP)。

在二零一三年九月天文台參加了 CIRP 安排就水樣本進行之鋇-90 活度測量的實驗室能力測試。同年十月，天文台亦參加了 NPL 所籌劃的測量能力測試，量度由 NPL 提供的一個水體樣本內所含的伽馬放射性核素。天文台這兩次測試的測量結果均在 CIRP 及 NPL 公佈的可接受範圍之內。詳情見 3.1.8 段。



除了參加測量比對及能力測試外，天文台亦透過內部質量保證程序，確保香港環境輻射監測結果的可靠性。為了提升輻射測量工作的管理效能及品質，天文台輻射實驗室的工作程序是依據國際標準化組織所訂下的 ISO 9001:2008 標準運作和提供輻射測量服務，並於二零零九年初成功獲得認證。

其後認證機構會定期對輻射實驗室作跟進審查，核實其輻射測量服務可繼續獲得 ISO 9001:2008 認證。天文台輻射實驗室於二零一三年二月順利通過年度審查，標誌著輻射實驗室所提供的優質輻射測量服務再一次得到認可。

### 3. 測量結果及結論

#### 3.1 測量結果

##### 3.1.1 輻射監測網絡

輻射監測網絡於二零一三年所錄得的年平均環境伽馬劑量率及一分鐘平均數據的變幅載於表 4a。測量結果均在本底輻射範圍之內。

自輻射監測網絡運作以來，各監測站錄得的輻射水平一般會隨著季節轉變而出現數個百分點的變化。在下雨或當熱帶氣旋影響香港的情況下，變化會明顯較大，甚至高於平時水平的一倍。

二零一三年環境伽馬劑量率的最大變幅於九月二十三日錄得。當日香港受到與熱帶氣旋天兔相關的狂風大驟雨影響，在平洲錄得的一分鐘平均劑量率較該年的平均值高出約百分之七十五，但仍在本底輻射範圍之內。

### 3.1.2 熱釋光劑量計網絡

二零一三年各熱釋光劑量計站錄得的伽馬輻射劑量率的年平均値、標準差及變幅載於表 4b。所有監測站錄得的劑量率均在 BRMP 範圍之內。

### 3.1.3 空中輻射監測系統

天文台於二零一三年一月使用新的空中輻射監測系統以地面輻射污染測量模式在平洲進行環境輻射測量，測量高度按地勢而改變，並保持着距離地面約一百米。測量過程中並沒有探測到人工放射性核素。圖 3 為測量當天該區的環境輻射計數率數據。

天文台於七月使用新的空中輻射監測系統在大鵬灣及西貢地區以輻射煙羽追蹤模式進行測量。直升機由海拔約一千米降至約一百米，測量海面及地面上的輻射水平隨高度的變化。測量過程中並沒有探測到人工放射性核素。圖 4 及圖 5 分別顯示在大鵬灣和西貢地區所錄得的垂直輻射水平分佈數據。

新系統的探測器總容量比舊系統稍大，因此新系統的探測效率相對較高。但同時新系統所採用的探測器厚度較小，所以整體而言由能量較高的宇宙輻射所產生的計數率會較少，令新系統的本底計數率數值普遍低於舊系統，可更有效地測量到本底以外的輻射量。

圖 3 至圖 5 顯示新系統與舊系統觀測所得的結果類同，在陸地上量度到的計數率明顯比海面上的水平高，主要是由於岩石及土壤比海水含有較多放射性物質所致。至於隨高度的變化方面，在海面上所量度到的計數率並沒有明顯變化，基本上為本底輻射水平。而計數率自地面隨高度迅速遞減，直至達到與海面上所量度到的水平相若。

### 3.1.4 自動伽馬譜法系統

二零一三年平洲自動伽馬譜法系統錄得的數據載於表 5。全年並沒有探測到人工放射性核素，而所有測量結果均在環境輻射範圍內。

### 3.1.5 流動輻射監測站

二零一三年天文台在船灣淡水湖共進行了四次宇宙輻射測量，平均伽馬劑量率為每小時 0.029 至 0.037 微戈(見表 6)，與往年所得的數據相近。

### 3.1.6 高空輻射探測

天文台在二零一三年進行了共七次高空輻射探測，以收集質量較好的數據。進行探測時的天氣情況如下：三月七日天晴，地面吹輕微西北風。八月二十一日多雲，地面吹輕微西風。九月二十六日多雲，地面吹和緩東風。十月十日天晴，地面吹輕微東南風。十一月七日天晴，地面吹輕微東南風。十二月五日天晴，地面吹輕微東南風。十二月十九日天晴，地面吹輕微東北風。

圖 6 顯示二零一三年高空輻射探測的平均大氣放射性垂直廓線。由於二零一三年高空輻射探測數據質量參差，探測高度未能超過 20 公里。儘管如此，所得的數據分析結果與以往大致相若(李新偉等，2007)。

### 3.1.7 食物及環境樣本

二零一三年天文台共收集了 409 個食物和環境樣本。表 7、8、9 和 10 分別列載樣本的伽馬譜法分析、氡、鋁-90 及鈾-239 測量結果。

放射性活度數據均按照取樣日期進行衰變修正。倘若取樣工作持續進行了一段較長的時間(例如一週或一月)，衰變

修正便會以取樣期間的中間日期作為依據。

各表中只列出有關人工放射性核素的可測量活度結果。為方便參考，表 11 按不同的照射途徑臚列了二零一三年各主要樣本類別的測量結果。

(a) 伽馬譜法分析

二零一三年在部份土壤及沉澱物樣本中發現微量的人工伽馬放射性核素銫-137，活度均在 BRMP 範圍之內。樣本包括土壤、潮間帶土及海床沉澱物，在 BRMP 期間及過往 ERMP 的監測工作中也曾在這幾類樣本中發現銫-137（黃明松等，2003），相信主要是與一九四五至一九八零年間大氣核武試驗的沉降物殘餘有關(UNSCEAR 2008)。

(b) 氙

二零一三年在部份大氣、水及食物樣本中發現微量的氙，活度均在本底輻射範圍之內。樣本包括大氣水蒸氣、濕沉積物、總沉積物、地下水、海水、飲用水、樽裝水、水果、食米、牛奶、蔬菜、家禽、肉類、海產及海藻。所偵測到的氙相信主要是因宇宙射線自然產生，而小部份則是以往大氣核武試驗的殘餘(UNSCEAR 2008)。

(c) 鋰-90

二零一三年在部份大氣、食物及土壤樣本中發現微量的鋰-90，活度均在本底輻射範圍之內。這些樣本包括大氣飄塵、濕沉積物、總沉積物、土壤、食米、牛奶、蔬菜、水果、家禽、海產、海藻及海水中懸浮粒子。在 BRMP 期間及過往 ERMP 的監測工作中，這些樣本中也曾發現鋰-90，相信主要也是來自以往大氣核武試驗(UNSCEAR 2008)。

(d) 鈾-239

二零一三年在部份海藻、潮間帶土及海床沉澱物樣本中發現微量的鈾-239，活度均在 BRMP 範圍之內。鈾-239 主要

也是來自以往大氣核武試驗的沉降物(UNSCEAR 2008)。

### 3.1.8 實驗室測量比對結果

在二零一三年九月天文台參加了 CIRP 安排就水樣本進行之鋇-90 活度測量的實驗室能力測試，表 12 為天文台之測量結果。CIRP 於二零一四年三月公佈有關測試結果。天文台的測量結果均在 CIRP 所公佈的可接受範圍之內。

天文台在二零一三年十月參加了 NPL 所籌劃的實驗室測量能力測試，量度由 NPL 提供的一個水樣本內所含的四種伽馬放射性核素的活度，表 13 為天文台之測量結果。NPL 於二零一四年七月公佈了測試結果。天文台的測量結果均在 NPL 公佈的可接受範圍之內。

## 3.2 結論

二零一三年在香港境內不同地點錄得的環境伽馬劑量率均在本底輻射範圍之內。與過去的情況相若，天文台在不同的環境及食物樣本中測量到微量的人工放射性核素，包括銻-137、氡、鋇-90 及釷-239。它們的水平與在廣東核電站及嶺澳核電站運作之前所收集的樣本並沒有顯著分別。

從以上結果可推論日本福島核事故並未對本港的環境輻射水平造成長遠影響。而世界衛生組織的有關報告亦顯示日本福島核事故不會在日本以外導致健康風險明顯增加 (World Health Organization 2013)。

以此總結，二零一三年香港的環境輻射水平及在環境和食物樣本中的人工放射性核素活度並沒有可測量到的變化。

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## 1. INTRODUCTION

Since 1961, the Hong Kong Observatory (HKO) has been monitoring environmental radiation levels in Hong Kong and participating in international programmes on environmental radiation monitoring organised by the International Atomic Energy Agency (IAEA) and the World Meteorological Organization (WMO). In response to the construction of nuclear power stations at Daya Bay in Guangdong, the HKO embarked in 1983 on a comprehensive programme to monitor the environmental radiation levels in Hong Kong before and after the power plants commenced operation.

The programme was named the “Environmental Radiation Monitoring Programme (ERMP)”. It comprises two phases. The first phase is known as the “Background Radiation Monitoring Programme (BRMP)” and was conducted from 1987 to 1991 to establish the baseline radiation levels in Hong Kong prior to the operation of the Guangdong Nuclear Power Station (GNPS) in 1994 (see Figure 1 for location). These baseline levels would help to reflect any changes arising from the operation of GNPS. The monitoring results can be found in the report on the BRMP (*Hong Kong Observatory, 1992*).

The second phase of the ERMP, implemented since 1992, contains all the essential features of the BRMP and with adjustments in sampling and measurement to take advantage of the experience gained. The ERMP is an on-going programme to detect long-term changes in environmental radiation levels in Hong Kong, if any, particularly those arising from the operation of the GNPS and the Lingao Nuclear Power Station (LNPS) since 1994 and 2002 respectively.

The monitoring results of the ERMP can be found in the respective annual reports and summaries (<http://www.weather.gov.hk/publica/pubrm.htm>). Readers may refer to the relevant reports for details of the sampling, measurement and quality assurance work. From 2003 onwards, the annual reports only contain the most salient features of the programme, including summaries of measurement methods and results, highlights of new work, changes or measures introduced during the year.

Chapter 2 of this report describes the sampling schedule, the instruments and methods used for measuring ambient radiation levels, radioactivity in food and environmental samples as well as quality assurance. Measurement results of 2013 and conclusions are presented in Chapter 3.

## 2. SAMPLING, MEASUREMENT AND QUALITY ASSURANCE

The emphasis of the ERMP is to monitor three major exposure pathways, namely the atmospheric pathway, the terrestrial pathway and the aquatic pathway. In respect of measurement, there are two major components. The first component is the direct measurement of ambient radiation levels in Hong Kong. The second is the detection of artificial radioactive material in the environment of Hong Kong and in the foodstuff commonly consumed by Hong Kong people. The locations for real-time measurement of ambient radiation in 2013 are shown in Figure 1. The other locations for measurement of ambient gamma radiation and collection of environmental samples in 2013 are shown in Figure 2. A summary of the sampling and analysis programme in 2013 is given in Table 1.

### 2.1 Direct measurement of ambient radiation level

#### 2.1.1 *Radiation Monitoring Network*

The radiation monitoring network (RMN) of the Hong Kong Observatory comprises 12 monitoring stations distributed over the territory. The network provides a comprehensive coverage for measurement of ambient gamma radiation level in Hong Kong.

The dose rates are measured at each station continuously by a high pressure ionization chamber (HPIC) (Reuter-Stokes Model RSS-131/RSS-131-ER environmental radiation monitor). Data are transmitted to the Observatory Headquarters every minute.

The hourly average ambient gamma dose rate data recorded by the radiation monitoring stations are made available on the Internet for reference by the public. The address of the website is:

[http://www.weather.gov.hk/radiation/ermp/rmn/applet/map/rmn\\_hourly\\_e.htm](http://www.weather.gov.hk/radiation/ermp/rmn/applet/map/rmn_hourly_e.htm)

#### 2.1.2 *Thermoluminescent Dosimeter Network*

A thermoluminescent dosimeter (TLD) network has been in operation since the late 1980s to measure ambient gamma doses accumulated over a long period. In 2013, the network comprises 29 fixed monitoring points over the territory (Figure 2). The TLDs are of the lithium fluoride (LiF:Mg,Ti) and calcium fluoride (CaF<sub>2</sub>:Dy) type (Harshaw 8807). A batch of five TLDs is placed at each site to ensure statistical accuracy. The TLDs are replaced and read on a quarterly basis.

In 2012, an additional TLD monitoring point was established at the new Cape D'Aguilar Radiation Monitoring Station with a view to replacing the TLD monitoring point originally located at the Cape D'Aguilar Radio Transmitting Station. After a whole year's parallel run, the TLD monitoring point located at Cape D'Aguilar Radiation Monitoring Station officially replaced that located at Cape D'Aguilar Radio Transmitting Station in 2013.

In addition, since the facilities of Kat O Fisheries Research Station were altered, the original TLD monitoring point at the Fisheries Research Station was moved to Kat O Radiation Monitoring Station, which is also situated inside the Fisheries Research Station, in July 2013.

### *2.1.3 Aerial Radiation Monitoring System*

In 2013, the Observatory commenced the operation of a new Aerial Radiation Monitoring System (ARMS), replacing the one which had been put into operation since 1998. The new system was manufactured by Pico Envirotec Inc. It consists of four 2.5 litres sodium iodide (NaI) detectors that can be mounted on board a helicopter of the Government Flying Service for measurement. The total volume of the detectors in the new ARMS is larger than that of the old system, resulting in an increased sensitivity in detecting artificial radionuclides. The new system is also equipped with more advanced hardware and software to facilitate operation.

The new ARMS can operate in the plume tracking mode, which has the capability to determine the existence and extent of any radioactive plume over Hong Kong. After the passage of the plume, the system, operated in the ground contamination measurement mode, can be used to identify surface areas contaminated by deposited radionuclides. Real-time location information, gamma spectra, spectroscopic analysis results and gamma dose rates are displayed on board the helicopter during monitoring operation. The new system can also transmit some of the real-time measurement data to the Observatory Headquarters through the data transmission system of the helicopter.

The merit of ARMS is that it can be used to detect radiation levels over remote areas and over regions inaccessible to land transportation. Every year, routine measurements are made using ARMS to collect data of environmental radiation level as well as radiation levels at various altitudes.

### *2.1.4 Automatic Gamma Spectrometry System*

Hong Kong Observatory has been operating the Automatic Gamma Spectrometry System (AGSS) at Ping Chau, Mirs Bay since 1996 (Figure 1) for providing early alert of any releases of artificial radionuclides from the nuclear power stations. The system consists of a zinc sulphide (ZnS) coated plastic scintillator, a high purity germanium (HPGe) detector and a NaI detector. It continuously collects airborne particulates on a rotating filter drum and gaseous iodine in a carbon cartridge. The flow rates of the filter drum and carbon cartridge are around 30 and 4 m<sup>3</sup>/hour respectively. The carbon cartridge is replaced automatically at weekly intervals. The ZnS scintillator measures the gross alpha and beta activities of the particulates collected. The HPGe detector measures gamma rays emitted by the particulates and gamma spectrometry analysis is carried out automatically. The NaI detector measures the iodine-131 activity in the carbon cartridge.

Data of alpha and beta activities, iodine-131 activity, as well as results of gamma spectrometry analysis are transmitted to the Observatory Headquarters every 5 to 15 minutes.

### 2.1.5 Mobile Radiation Monitoring Station

The Mobile Radiation Monitoring Station (MRMS) is set up inside a radiological survey vehicle. It is equipped with portable and specially designed instruments for use in routine and emergency radiological surveys. Major instruments are listed below:

Instrument	Location	Usage
High Volume Air Sampler (Hi-Q Environmental Products) (flow rate at about 54 m <sup>3</sup> h <sup>-1</sup> )	Installed inside the vehicle	Air is drawn from outside into the samplers through an inlet on the vehicle roof.
Radioiodine Sampler (Hi-Q Environmental Products) (flow rate at about 4.8 m <sup>3</sup> h <sup>-1</sup> )		
Gamma Dose Rate Probe (Seibersdorf SSM1-07)	Installed on the vehicle roof	The probe is connected to a portable survey meter inside the vehicle so that staff inside the vehicle can continuously take readings of the ambient gamma dose rate outside the station.
Portable Survey Meter (Seibersdorf SSM-1)	The instruments are stored inside the vehicle and will be transported to survey site for measurements.	Equipped with Geiger Müller tube to measure ambient gamma dose rate.
Portable High Pressure Ionization Chamber (HPIC) (Reuter-Stokes RSS-131/RSS-131-ER)		To measure the ambient gamma radiation level. At each measurement location, staff will mount the sensor of the HPIC at 1 metre above ground for measurement.
Surface Contamination Monitor (Berthold Technologies LB-124)		Equipped with a ZnS scintillator. Staff uses the Surface Contamination Monitor to take alpha, beta and gamma surface contamination measurements at 1 cm above the surface.
Portable Gamma Spectrometric Analysis Module (Canberra In-Situ Object Calibration System/HPGe)		For ambient gamma spectrometric analysis at survey location.

In addition, meteorological instruments are also installed on the vehicle roof to collect weather data like wind speed, temperature and humidity.

The radiological survey vehicle is deployed for routine radiological survey, collection of samples and emergency drills. It also pays regular visits to selected locations in Hong Kong to collect environmental radiation data.

### 2.1.6 Upper-air Radioactivity Soundings

Radioactivity in the upper atmosphere is measured at King's Park by radioactivity sensors attached to balloon-borne radiosondes (Model Vaisala RS92). The radioactivity sensor (Model Vaisala NSS921) comprises two Geiger-Müller (GM) tubes: a gamma-only tube, which measures only gamma radiation, and a gamma-plus-beta tube, which measures gamma as well as beta radiation of energy higher than 0.25 MeV. Data from the radioactivity sensor is transmitted back and processed by the upper-air sounding system at the ground station.

The Observatory carried out regular radioactivity soundings under different weather conditions each year to collect data of the variation of radiation levels with altitudes.

## 2.2 Collection of food and environmental samples

### 2.2.1 Atmospheric Samples

Atmospheric samples, including airborne particulates, wet deposition (precipitation), total deposition (wet plus dry deposition), gaseous iodine and water vapour, are collected under ERMP. The sampling equipment and method are listed below:

Atmospheric Samples	Sampling Equipment	Flow Rate	Sampling Method
Airborne Particulates	High Volume Air Sampler (Hi-Q Environmental Products Model 4200 AFC-BRL-KIT/230 and Hi-Q Environmental Products Model BRL-3000M)	Typically set at $17 \text{ m}^3\text{h}^{-1}$	Airborne particulates are collected from a filter paper installed inside the High Volume Air Sampler.
Wet Deposition	A carboy fitted with a top funnel.	-	During the dry season, three sets of carboys and funnels are used at each location for collection of sufficient amount of rain for measurement.
Total Deposition	A stainless-steel pan of 260 mm diameter filled with distilled water.	-	Samples are collected at weekly interval.
Gaseous Iodine	Sampled through a silver impregnated zeolite cartridge fitted inside a radioiodine sampler (Hi-Q Environmental Products Model CMP-0523CV/230).	Typically set at $2.5 \text{ m}^3\text{h}^{-1}$	The cartridge is collected and replaced weekly.
Water Vapour	Collected using a gaseous effluent sampler (Pylon Electronics Inc. Model VFP-20) with a drierite cartridge.	Typically set at $0.12 \text{ m}^3\text{h}^{-1}$	Sampling is done intermittently during a week-long period randomly selected in each calendar month, until the overall collection time reaches 36 hours.

Airborne particulates and wet depositions are regularly collected at King's Park, Sha Tau Kok and Yuen Ng Fan (Figure 2) at weekly intervals. In addition, equipment is also installed at the other nine radiation monitoring stations for collecting atmospheric samples during emergency. Total deposition, gaseous iodine and water vapour are also collected at King's Park.

### *2.2.2 Food Samples*

Terrestrial and aquatic food samples typical of the diet of the local population are collected at main distribution points, wholesale markets and from enlisted suppliers. Particular attention has been given to food produced locally and in Shenzhen.

### *2.2.3 Drinking Water, Underground Water and Sea Water*

Treated drinking water is collected from distribution taps at Kowloon and Tuen Mun as well as the treatment works at Shatin, Tuen Mun and Yau Kom Tau (Figure 2). Untreated or raw drinking water is collected from the High Island Reservoir, the Plover Cove Reservoir, the Muk Wu B Pumping Station and the treatment works at Shatin, Tuen Mun and Yau Kom Tau (Figure 2). Both treated and untreated drinking water samples are collected once every three months by staff of the Water Supplies Department. The drinking water samples are passed to the Observatory for radiological measurements.

Yau Kom Tau Treatment Works was under maintenance during the period from April to July of 2013. Tsuen Wan Treatment Works, as a replacement, provided drinking water to the concerned area during the maintenance period. As such, staff of the Water Supplies Department collected drinking water samples from Tsuen Wan Treatment Works to replace those from Yau Kom Tau Treatment Works during the quarters April and July of 2013.

Underground water is collected at six locations (Figure 2), namely Cheung Hong Estate (Tsing Yi), Kwan Lok San Tsuen (Yuen Long), Wan Tsui Estate (East Hong Kong Island), Wah Fu Estate (Pokfulam), Fu Shan Estate (East Kowloon) and Ching Leung Nunnery (Tuen Mun) with assistance from the Housing Department, the respective estate management and the nunnery personnel.

In response to the development of the Fukushima nuclear accident and public's concern about radiation monitoring of sea water, the Observatory enhanced radiation monitoring of sea water in 2013. With the assistance from the Environmental Protection Department, additional sea water samples were collected in August 2013 for radiation measurement. Furthermore, the Observatory has increased its sea water sampling and radiation measurement frequency since the fourth quarter of 2013. Sampling frequency increases from yearly collection of sea water samples at four locations to quarterly collection at two locations alternately. The sampling locations are over the eastern part of the coastal waters of Hong Kong (Figure 2), namely waters off Waglan Island, Basalt Island, Tai Long Wan and Port Island. At each location, samples are collected at three depths - the upper level (2.5 metres underneath the surface), the middle level (equidistant from the surface and the seabed) and the lower level (2.5 metres above the seabed). Suspended particulates in sea water are collected by filtering the sea water samples through a membrane filter.

### 2.2.4 Land Soil and Sediments

Land soil is sampled at 39 designated sites throughout the territory. Each site is sampled once every five years. At each site, samples were collected from two layers, the upper layer from the surface to 15 cm deep and the lower layer from 15 cm to 30 cm deep. In 2013, land soil samples were collected from Tung Chung, Shek Pik Reservoir, Tai O, Pak Nai, Tap Mun, Kat O, Ping Chau and Happy Valley (Figure 2).

Intertidal sediments are sampled quarterly at three locations along the coast of Hong Kong (Figure 2), namely Pak Sha Wan, Tsim Bei Tsui and Sha Tau Kok. Two layers are taken at each sampling point, the upper layer from the surface to 15 cm deep and the lower layer from 15 cm to 30 cm deep. Sampling of seabed sediments is carried out annually with the assistance of the Civil Engineering and Development Department at four locations (Figure 2), namely Tai Tan Hoi, Lung Ha Wan, Picnic Bay and Western Anchorage.

The sampling and analysis programme in 2013 is summarized in Table 1 and 2.

### 2.3 Measurement of food and environmental samples in laboratory

All radioactivity measurements of food and environmental samples are carried out in the Radiation Laboratory at King's Park. A list of the major artificial radionuclides routinely monitored is given in Table 1. Each sample, depending on the sample type and measurement objective, will go through one or more of the following analyses:

- (a) gamma spectrometry analysis to determine the activities of gamma-emitting radionuclides;
- (b) liquid scintillation counting to determine the activity of tritium<sup>†</sup>;
- (c) low-level gross beta counting to determine the activity of strontium-90; and
- (d) alpha spectrometry analysis to determine the activity of plutonium-239.

[<sup>†</sup>Tritium is primarily produced naturally by cosmic rays entering the atmosphere or generated during atmospheric nuclear weapon tests conducted from 1945 to 1980. A small amount is also produced during the operation of nuclear power stations (*UNSCEAR 2008*).]

A summary of key measurement parameters, including sample size, counting time and detection limits, are given in Table 3.

### 2.4 Comparison between BRMP and ERMP measurement results

Among the radiation measurement works described in Section 2.1 to 2.3, some of the radiation monitoring stations, the Automatic Gamma Spectrometry System as well as radiological measurements of some of the environmental and food samples had not yet started operation during the BRMP 5-year period. Hence for the measurement results from these systems or samples, no corresponding BRMP ranges are available as background reference.



Despite this, during the years of operation since the start of the second phase of ERMP in 1992, results of BRMP-covered radiation measurement of ambient radiation levels and activities of artificial radionuclides suggested that there had been no material changes in the overall environmental radiation levels in Hong Kong as a result of the operation of the nuclear power plants. On this basis, for radiation measurement without BRMP reference values (i.e. measurement started after the second phase of ERMP), the range of values in the first five years of measurement were adopted as the reference range in this report. This reference range, being closest to the BRMP period in time, can effectively be taken as the approximate baseline level of that radiation measurement in the absence of visible influences from other variables.

## 2.5 Quality assurance

Since 1989, the Observatory has been participating in inter-laboratory comparison exercises and proficiency tests organized by international and national organizations (*Hui et al., 2007*), namely the International Atomic Energy Agency (IAEA), the National Physical Laboratory of the United Kingdom (NPL), the World Health Organization (WHO) and the China Institution for Radiation Protection (CIRP).

In September 2013, the Observatory participated in the laboratory proficiency test for the measurement of strontium-90 activity in water samples organized by CIRP. In October, the Observatory also took part in the proficiency test organized by NPL for the measurement of activity of gamma-emitting radionuclides in a water sample provided by NPL. The measurement results of the Observatory during these two tests were all within the acceptable ranges announced by CIRP and NPL. Details can be found in Section 3.1.8.

Other than inter-laboratory comparison exercises and proficiency tests, the quality of the environmental radiation monitoring results in Hong Kong is also assured through internal quality assurance procedures. To enhance the management efficiency and quality of its radiation measurement work, the Hong Kong Observatory Radiation Laboratory adheres to a high standard of radiation measurement services based on the International Organisation for Standardization ISO 9001:2008. Accreditation for the ISO 9001:2008 was obtained in early 2009.

The certification body will conduct annual surveillance audits of the Radiation Laboratory to ascertain that its radiation measurement services meet the requirements for the continuation of ISO 9001:2008 certification. The quality radiation measurement services provided by the Radiation Laboratory were reaffirmed upon successfully passing the Annual Surveillance Audit in February 2013.

### 3. RESULTS AND CONCLUSION

#### 3.1 Results

##### 3.1.1 *Radiation Monitoring Network*

The annual average ambient gamma dose rates and ranges of 1-minute averages recorded by the RMN in 2013 are tabulated in Table 4a. The measurement results were all within baseline radiation levels.

Since the operation of the RMN, temporal changes in the radiation level recorded at the stations are typically a few per cent in seasonal variations. During rainy condition or episodes of tropical cyclone affecting Hong Kong, the variations can be significantly larger and may even double the usual level.

The most significant change in the ambient gamma dose rate in 2013 was recorded on 23 September. Under the influence of heavy squally showers associated with tropical cyclone Usagi, the 1-minute average dose rate at Ping Chau rose to about 75% above the mean value of the year, but still within the baseline levels.

##### 3.1.2 *Thermoluminescent Dosimeter Network*

The annual average, standard deviation and variation of gamma dose rates measured at each of the TLD stations in 2013 are listed in Table 4b. The gamma dose rates recorded at all stations were found to be within the BRMP range.

##### 3.1.3 *Aerial Radiation Monitoring System*

In January 2013, the Observatory used the new ARMS in the ground contamination measurement mode to carry out measurements over Ping Chau. The measurement height followed terrain, maintained at a height of about 100 metres above the ground. No artificial radionuclides were detected. Figure 3 shows the ambient radioactivity count rates over the area on the day of measurement.

In July, the Observatory used the new ARMS in the plume tracking mode to carry out measurements over Mirs Bay and Sai Kung areas. The helicopter descended from about 1000 metres down to about 100 metres above sea level to measure the change of radiation levels against altitude over the sea surface and land surface. No artificial radionuclides were detected. Figures 4 and 5 depict the vertical radiation level profiles over Mirs Bay and Sai Kung area respectively.

The new ARMS is equipped with detectors having a larger total volume than those of the old system, resulting in a relatively higher detection efficiency. The detectors of the new system are also thinner compared to those of the old one. Thus, overall speaking, the count rates arising from high energy cosmic radiation are lesser such that the background count rates of the new system are generally lower than the old system, making the new system more efficient in detecting radiation level above background.

It can be seen from Figures 3 to 5 that observations made by the new ARMS were similar to those from the old system. The count rates measured near land surface were significantly higher than those measured over the sea surface, as rocks and soil contained more radioactive substances than sea water. As to changes in count rates with height, the variations over sea surface were not significant, reflecting basically the background radiation level, while the count rates over land decreased rapidly with height before reaching a level close to those measured over the sea.

#### *3.1.4 Automatic Gamma Spectrometry System*

Results obtained by the AGSS in 2013 are given in Table 5. No artificial radionuclides were detected in the year and all results were within ranges of environmental radiation levels.

#### *3.1.5 Mobile Radiation Monitoring System*

Four measurements of cosmic radiation were carried out at Plover Cove in 2013. The average gamma dose rates ranged from 0.029 to 0.037  $\mu\text{Gy h}^{-1}$  (Table 6), close to those measured in previous years.

#### *3.1.6 Upper-air Radioactivity Soundings*

Seven radioactivity soundings were made in 2013 to collect data of better quality. The weather conditions during these soundings were: fine with light northwesterly winds at the surface on 7 March; cloudy with light westerly winds at the surface on 21 August; cloudy with moderate easterly winds at the surface on 26 September; fine with light southeasterly winds at the surface on 10 October; fine with light southeasterly winds at the surface on 7 November; fine with light southeasterly winds at the surface on 5 December; fine with light northeasterly winds at the surface on 19 December.

Figure 6 shows the average vertical profiles of atmospheric radioactivity from the seven upper-air radioactivity soundings in 2013. The quality of radioactivity soundings made in 2013 varied and all measurements could not reach a height over 20 km. Despite this, the data analysis results obtained were similar to those in the past (*Li et al. 2007*).

#### *3.1.7 Food and Environmental Samples*

A total of 409 food and environmental samples were collected in 2013. The results of gamma spectrometry analyses, tritium measurements, strontium-90 measurements and plutonium-239 measurements are shown in Tables 7, 8, 9 and 10 respectively.

All radioactivity data are decay-corrected to the date of sampling. Where sampling is done over an extended period (for instance a week or a month), decay correction is made with reference to the mid-point of the sampling period.

Only results pertaining to measurable activities of artificial radionuclides are included in all tables. For ease of reference, a summary of measurement results in 2013 for the major sample types according to different pathways is given in Table 11.

(a) Gamma Spectrometry Analyses

Traces of caesium-137, an artificial gamma-emitting radionuclide, were detected in some soil and sediment samples in 2013. The measured activities in these samples were all within the corresponding ranges of BRMP values. The samples included land soil, intertidal sediment and seabed sediment. Caesium-137 was detected in such sample types during BRMP and ERMP so far (*Wong et al. 2003*). The presence of the radionuclide in environmental and food samples could generally be attributed to the remnants of fallout from atmospheric nuclear weapon tests conducted from 1945 till 1980 (*UNSCEAR 2008*).

(b) Tritium

Very small amounts of tritium were detected in some atmospheric, water and food samples in 2013. The measured activities in these samples were all within the baseline radiation levels. The samples include water vapour in air, wet deposition, total deposition, underground water, sea water, drinking water, bottled water, fruits, rice, milk, vegetables, poultry, meat, seafood and seaweed. The source of tritium in the samples was attributable primarily to the natural cosmogenic processes with small contribution from the remnants from atmospheric nuclear weapon tests (*UNSCEAR 2008*).

(c) Strontium-90

Traces of strontium-90 were detected in some atmospheric, food and soil samples in 2013. The activities in these samples were within the baseline radiation levels. The samples included airborne particulates, wet deposition, total deposition, land soil, rice, milk, vegetables, fruits, poultry, seafood, seaweed and suspended particulate in sea water. Strontium-90 was detected in such sample types in both BRMP and ERMP. The radionuclide's presence was also primarily attributable to atmospheric nuclear tests in the past (*UNSCEAR 2008*).

(d) Plutonium-239

Minute amounts of plutonium-239 were detected in some seaweed, intertidal sediment and seabed sediment samples in 2013. The measured activities in these samples were all within the BRMP range. Fallout from past atmospheric nuclear weapon tests could again be the major source of plutonium-239 (*UNSCEAR 2008*).

### 3.1.8 Laboratory Proficiency Test Results

In September 2013, the Observatory participated in the laboratory proficiency test for the measurement of strontium-90 activity in water samples organized by CIRP. Observatory's measurement results are given in Table 12. CIRP released the test

results in March 2014. The measurement results of the Observatory were all within the acceptable ranges announced by CIRP.

In October, the Observatory took part in the laboratory proficiency test organized by NPL for the measurement of activities of four gamma-emitting radionuclides in a water sample provided by NPL. Observatory's measurement results are given in Table 13. NPL published the test results in July 2014. The measurement results of the Observatory were all within the acceptable ranges announced by NPL.

### 3.2 Conclusion

The ambient gamma dose rates recorded over various parts of the territory in 2013 were within the baseline radiation levels. As in the past years, traces of artificial radionuclides, namely caesium-137, tritium, strontium-90 and plutonium-239, were detected in various environmental and food samples. The levels of all these radionuclides were not significantly different from those recorded before the Guangdong Nuclear Power Station and Lingao Nuclear Power Station came into operation.

It can be inferred from the above results that the Fukushima nuclear accident in Japan did not bring any long-term effect to the ambient radiation levels in Hong Kong. According to World Health Organization (*World Health Organization 2013*), no discernible increase in health risks from the Fukushima nuclear accident is expected outside Japan, too.

It is concluded that in 2013 there was no measurable change in ambient radiation levels and in activities of artificial radionuclides in the Hong Kong environment and foodstuffs consumed by Hong Kong people.

### ACKNOWLEDGEMENT

The Hong Kong Observatory wishes to express its gratitude to the Agriculture, Fisheries and Conservation Department, Civil Engineering and Development Department, Environmental Protection Department, Water Supplies Department and Housing Department for their assistance in sample collection, the Government Laboratory for chemical treatment of samples, and the Department of Health for providing and reading thermoluminescent dosimeters. We would also like to express our appreciation to the Government Flying Service for the operation of the Aerial Radiation Monitoring System, and the Hong Kong Police Force for providing accommodation at police stations to a number of radiation monitoring stations and the Automatic Gamma Spectrometry System. Special thanks also go to government offices and various organisations for giving us permission to install thermoluminescent dosimeters and to collect samples within their premises.

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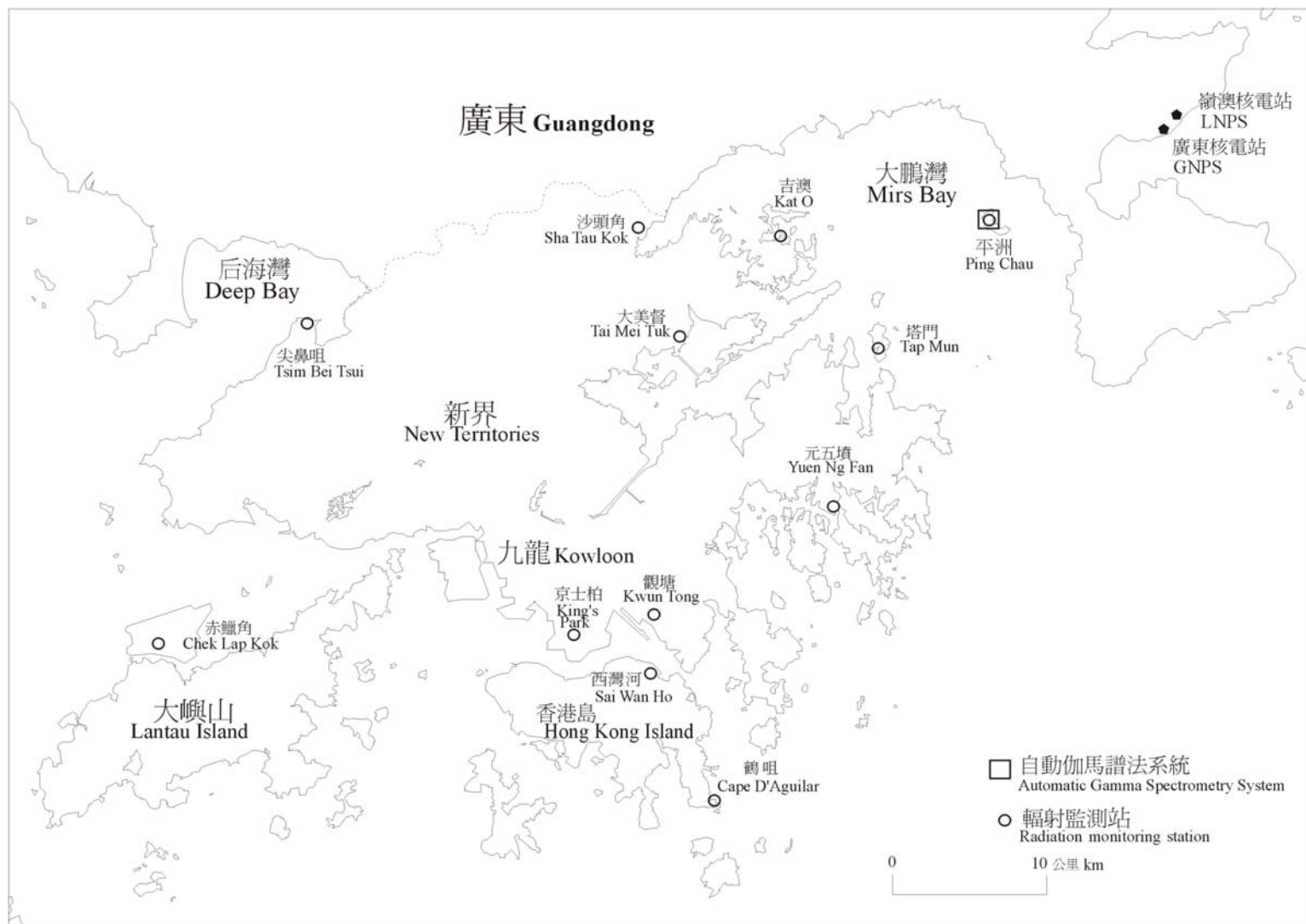


圖1. 二零一三年實時監測環境輻射的測量點。

Figure 1. Locations for real-time measurement of ambient radiation in 2013.

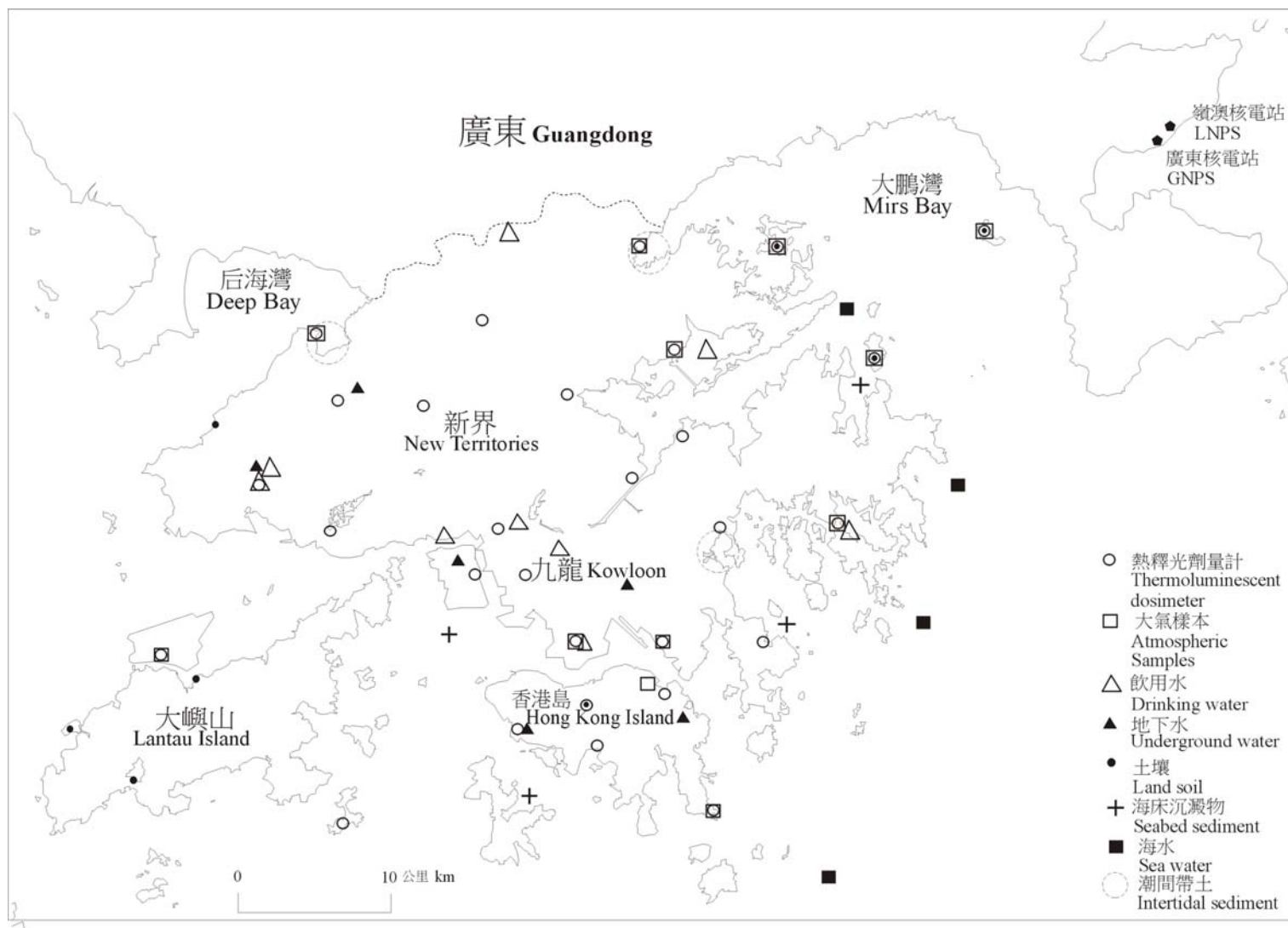


圖 2. 熱釋光劑量計網絡及二零一三年環境樣本收集點。

Figure 2. Thermoluminescent dosimeter network and locations for collection of environmental samples in 2013.



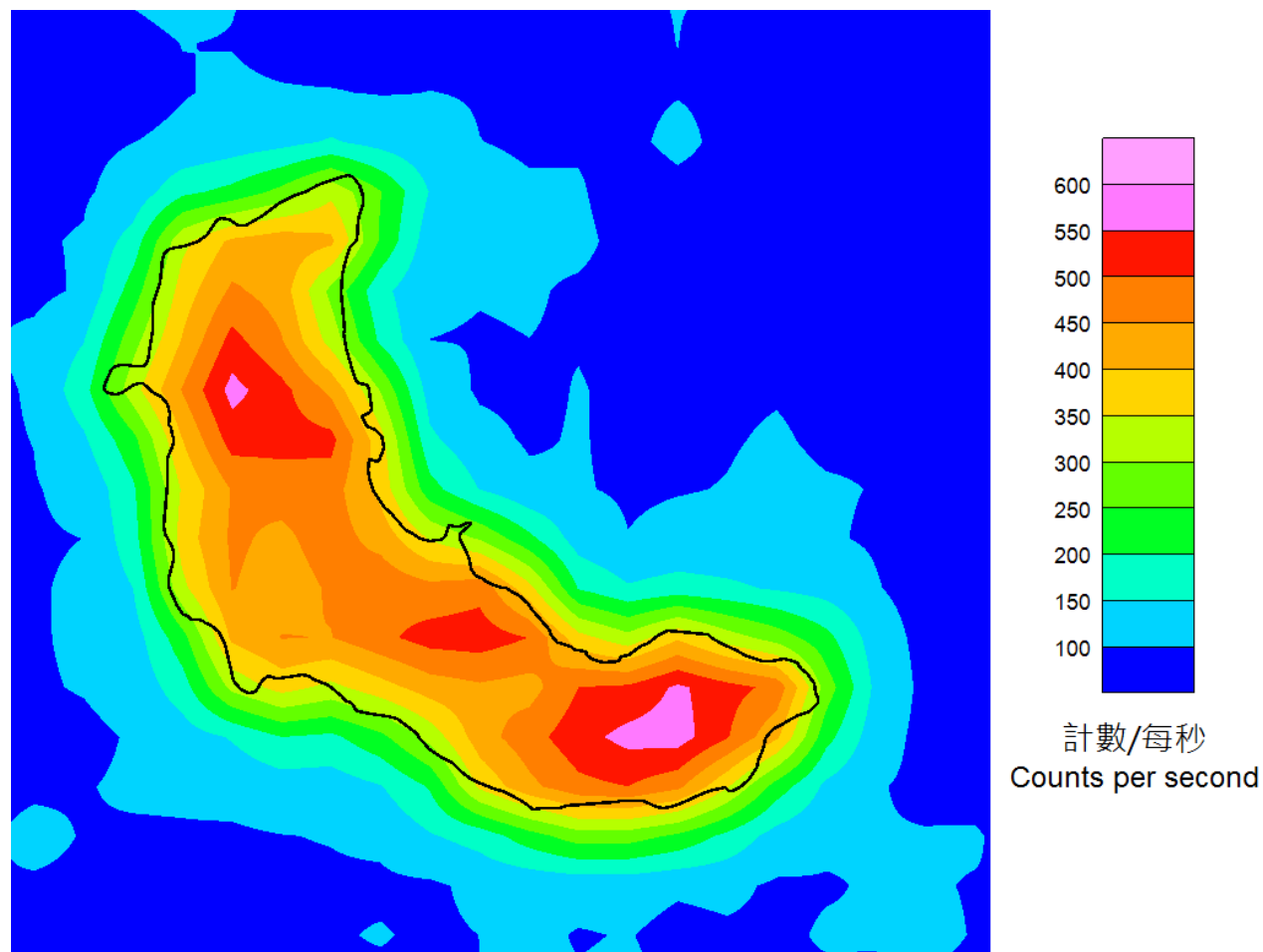


圖 3. 空中輻射監測系統在平洲測量到的計數率（測量高度距離地面約一百米）（二零一三年一月二十九日）。

Figure 3. Count rate over Ping Chau as measured by the Aerial Radiation Monitoring System at about 100 metres above the ground on 29 January 2013.

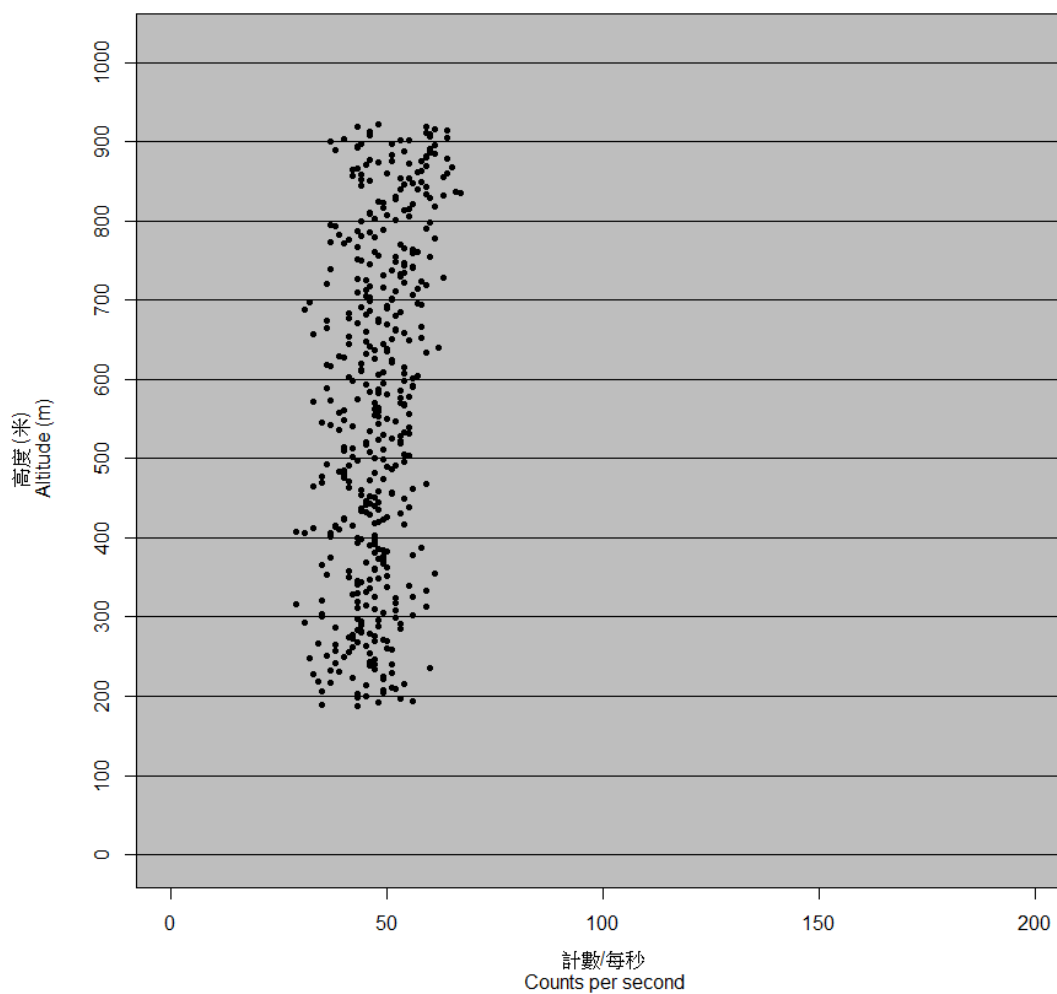


圖 4. 空中輻射監測系統在大鵬灣海面上空測量到的計數率隨高度的變化 (二零一三年七月三日)。

Figure 4. Variation of count rate with altitude at Mirs Bay, as measured by the Aerial Radiation Monitoring System on 3 July 2013.

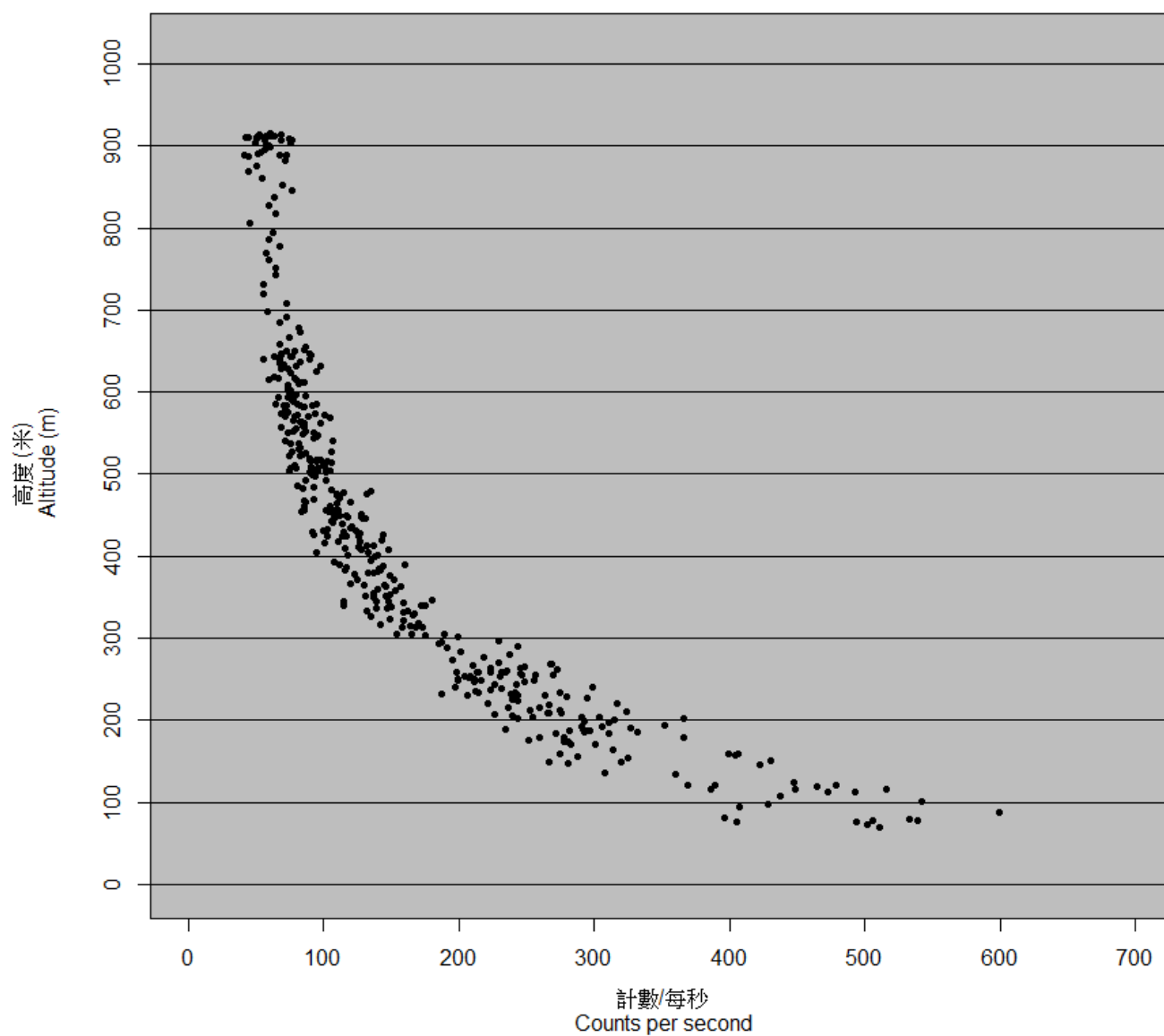


圖 5. 空中輻射監測系統在西貢地區上空測量到的計數率隨高度的變化 (二零一三年七月三日)。

Figure 5. Variation of count rate with altitude at Sai Kung area, as measured by the Aerial Radiation Monitoring System on 3 July 2013.

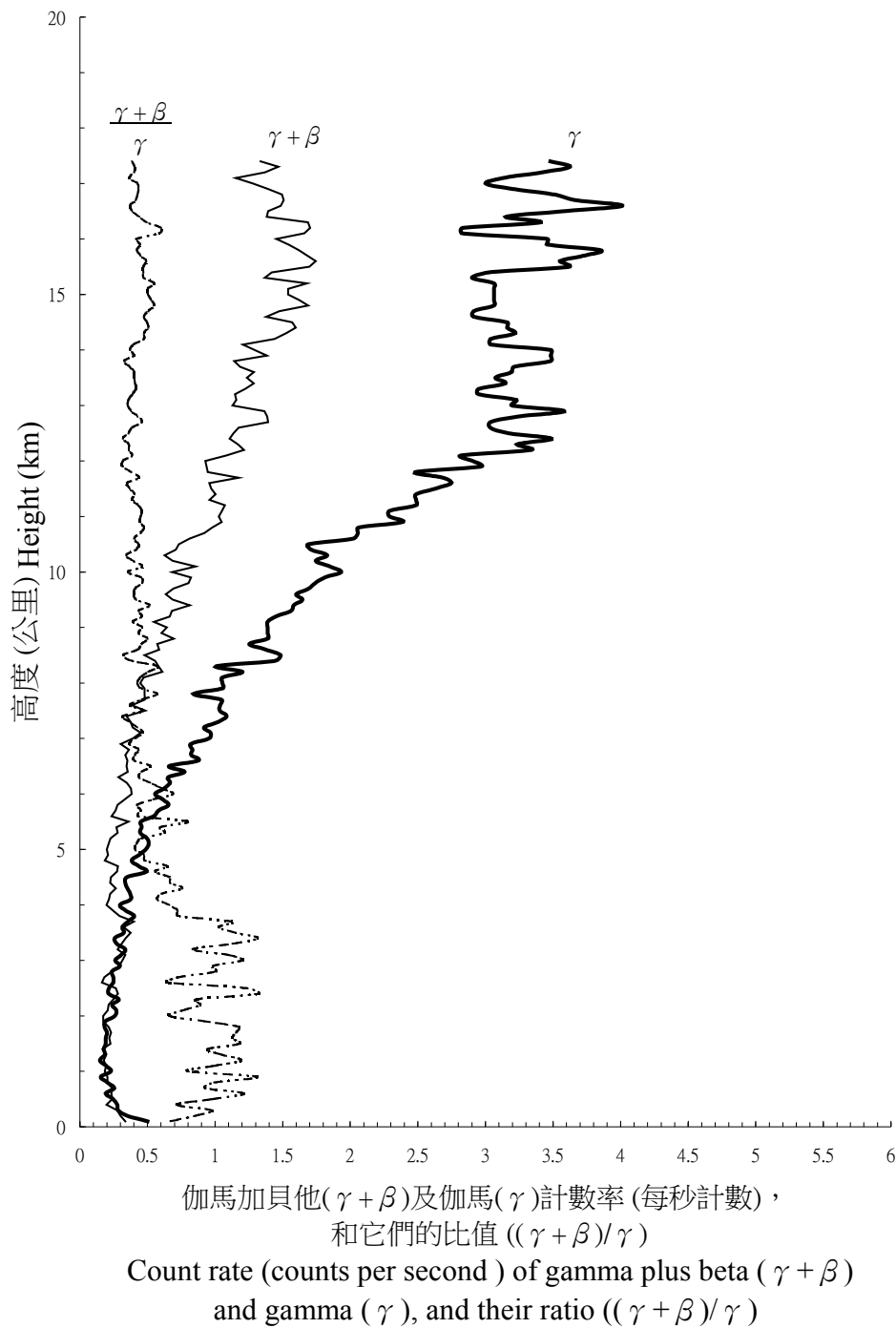


圖 6. 二零一三年內在京士柏進行的高空輻射探測之平均大氣放射性垂直廓線  
(探測日期為：三月七日、八月二十一日、九月二十六日、十月十日、  
十一月七日、十二月五日、十二月十九日)。

Figure 6. Average vertical profiles of atmospheric radioactivity from upper-air radioactivity soundings conducted at King's Park in 2013  
(dates of sounding: 7 March, 21 August, 26 September, 10 October, 7 November, 5 December and 19 December).

表 1. 二零一三年樣本取樣及分析概要

Table 1. Summary of the sampling and analysis programme in 2013

樣本類別 Sample type	取樣地點 Sampling location	地點數目 Number of location	分析類別 Type of analysis	取樣頻率 Sampling frequency
<b>環境伽馬輻射 Ambient Gamma Radiation</b>				
伽馬劑量率 Gamma dose rates	平洲 Ping Chau, 塔門 Tap Mun, 吉澳 Kat O, 沙頭角 Sha Tau Kok, 元五墳 Yuen Ng Fan, 大美督 Tai Mei Tuk, 尖鼻咀 Tsim Bei Tsui, 觀塘 Kwun Tong, 西灣河 Sai Wan Ho, 京士柏 King's Park 鶴咀 Cape D'Aguilar 赤鱗角 Chek Lap Kok	12	伽馬 $\gamma$	一分鐘 1-minute interval
累積伽馬劑量 Cumulative gamma doses	平洲 Ping Chau, 塔門 Tap Mun, 吉澳 Kat O, 元五墳 Yuen Ng Fan, 清水灣 Clear Water Bay, 西貢 Sai Kung, 大美督 Tai Mei Tuk, 烏溪沙 Wu Kai Sha, 鶴咀 Cape D'Aguilar, 沙頭角 Sha Tau Kok, 沙田 Shatin, 觀塘 Kwun Tong, 筲箕灣 Shau Kei Wan, 大埔 Tai Po, 京士柏 King's Park, 跑馬地 Happy Valley, 深水灣 Deep Water Bay, 石梨貝 Shek Lei Pui, 置富花園 Chi Fu Fa Yuen, 粉嶺 Fanling, 荃灣 Tsuen Wan, 石崗 Shek Kong, 長洲 Cheung Chau, 元朗 Yuen Long, 大欖涌 Tai Lam Chung, 尖鼻咀 Tsim Bei Tsui, 屯門 Tuen Mun 赤鱗角 Chek Lap Kok 青衣 Tsing Yi	29	伽馬 $\gamma$	每季 quarterly

表1. (續)  
Table 1. (cont'd)

樣本類別 Sample type	取樣地點 Sampling location	地點數目 Number of location	分析類別 Type of analysis	取樣頻率 Sampling frequency
<b>大氣樣本 Atmospheric Samples</b>				
大氣飄塵 Airborne particulate	京士柏 King's Park, 沙頭角 Sha Tau Kok, 元五墳 Yuen Ng Fan	3	伽馬 $\gamma$ , 銨-90 Sr-90, 釷-239 Pu-239	每週(累積一月) weekly (bulked monthly) (每週樣本只進行伽馬分析 Weekly sample for $\gamma$ analysis only)
濕沉積物(降雨) Wet deposition (precipitation)	京士柏 King's Park, 沙頭角 Sha Tau Kok, 元五墳 Yuen Ng Fan	3	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每週(累積一月作分 析) weekly (bulked monthly for analysis)
總沉積物 Total deposition	京士柏 King's Park	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每週(累積一月作分 析) weekly (bulked monthly for analysis)
氣態碘 Gaseous iodine	京士柏 King's Park	1	伽馬 $\gamma$	每週 weekly
大氣水蒸氣 Water vapour in air	京士柏 King's Park	1	氚 H-3	每月 monthly
<b>地面樣本 Terrestrial Samples</b>				
食米 Rice	內地 Mainland	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly
牛奶(經消毒) Pasteurized milk	深圳 Shenzhen, 沙頭角 Sha Tau Kok	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly
菜心 Choi sum	內地 Mainland, 本地 Local	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly
白菜 Pak choi	內地 Mainland, 本地 Local	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly
香蕉 Banana	內地 Mainland	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly
荔枝 Lychee	內地 Mainland	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	夏季 summer
柑橘 Mandarin	內地 Mainland	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	秋季及冬季 autumn and winter
甘蔗 Sugar cane	內地 Mainland	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	春季 spring
雞 Chicken	內地 Mainland, 本地 Local	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly
鴨 Duck	內地 Mainland	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly
牛肉 Beef	內地 Mainland	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly
豬肝 Pig's liver	內地 Mainland, 本地 Local	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly
豬肉 Pork	內地 Mainland, 本地 Local	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90	每季 quarterly

表 1. (續)  
Table 1. (cont'd)

樣本類別 Sample type	取樣地點 Sampling location	地點數目 Number of location	分析類別 Type of analysis	取樣頻率 Sampling frequency
土壤 (上層及下層) Land soil (upper and lower level)	京士柏 King's Park, 沙田 Shatin, 西貢 Sai Kung, 清水灣 Clear Water Bay, 萬宜水庫西 High Island West, 萬宜水庫東 High Island East, 北潭凹 Pak Tam Au, 白沙澳 Pak Sha O, 大埔 Tai Po, 粉嶺 Fanling, 沙頭角 Sha Tau Kok, 大美督 Tai Mei Tuk, 城門水塘 Shing Mun Reservoir, 荃灣 Tsuen Wan, 大欖涌水塘 Tai Lam Chung Reservoir, 青山發電廠 Castle Peak Power Station, 元朗 Yuen Long, 尖鼻咀 Tsim Bei Tsui, 石崗 Shek Kong, 嘉道理農場暨植物園 Kadoorie Farm and Botanic Garden, 長洲 Cheung Chau, 南丫島 Lamma Island, 坪洲 Peng Chau, 銀礦灣 Silvermine Bay 東涌 Tung Chung*, 石壁水塘 Shek Pik Reservoir*, 大澳 Tai O*, 白泥 Pak Nai*, 塔門 Tap Mun*, 吉澳 Kat O*, 平洲 Ping Chau*, 跑馬地 Happy Valley*, 薄扶林水塘 Pokfulam Reservoir, 香港仔下水塘 Lower Aberdeen Reservoir, 深水灣 Deep Water Bay, 大潭水塘 Tai Tam Reservoir, 鶴咀 Cape D'Aguilar, 牛頭角配水庫 Ngau Tau Kok Service Reservoir, 石梨貝水塘 Shek Lei Pui Reservoir	39	伽馬 $\gamma$ , 銈-90 Sr-90, 釷-239 Pu-239	每一地點每 5 年採樣一次 Each location is sampled once every 5 years.  * 2013 年採樣地點 * locations sampled in 2013

表 1. (續)  
Table 1. (cont'd)

樣本類別 Sample type	取樣地點 Sampling location	地點數目 Number of location	分析類別 Type of analysis	取樣頻率 Sampling frequency
<b>水體樣本 Aquatic Samples</b>				
飲用水(經處理) Drinking water (treated)	九龍配水管 Kowloon distribution tap, 屯門配水管 Tuen Mun distribution tap, 沙田濾水廠 Shatin Treatment Works, 屯門濾水廠 Tuen Mun Treatment Works, 油柑頭濾水廠/荃灣濾水廠 <sup>(1)</sup> Yau Kom Tau / Tsuen Wan Treatment Works <sup>(1)</sup>	5	伽馬 $\gamma$ , 氚 H-3	每季 quarterly
飲用水(未經處理) Drinking water (untreated)	萬宜水庫 High Island Reservoir, 船灣淡水湖 Plover Cove Reservoir, 木湖 B 抽水站 Muk Wu B Pumping Station, 沙田濾水廠 Shatin Treatment Works, 屯門濾水廠 Tuen Mun Treatment Works, 油柑頭濾水廠/荃灣濾水廠 <sup>(1)</sup> Yau Kom Tau / Tsuen Wan Treatment Works <sup>(1)</sup>	6	伽馬 $\gamma$ , 氚 H-3	每季 quarterly
樽裝水(蒸餾水) Bottled water (Distilled)	本地 Local	1	伽馬 $\gamma$ , 氚 H-3	每季 quarterly
樽裝水(礦泉水) Bottled water (Mineral)	本地 Local	1	伽馬 $\gamma$ , 氚 H-3	每季 quarterly
地下水 Underground water	長康邨 Cheung Hong Estate, 鈞樂新村 Kwan Lok San Tsuen, 環翠邨 Wan Tsui Estate, 華富邨 Wah Fu Estate, 富山邨 Fu Shan Estate, 清涼法苑 Ching Leung Nunnery	6	伽馬 $\gamma$ , 氚 H-3	每年 yearly
海水(上層、中層及低層) Sea water (upper, middle and lower level)	橫瀾島 Waglan Island, 火石洲 Basalt Island, 大浪灣 Tai Long Wan, 赤洲 Port Island	4	伽馬 $\gamma$ , 氚 H-3	每季 quarterly <sup>(2)</sup>
海水中懸浮粒子 (上層、中層及低層) Suspended particulate in sea water (upper, middle and lower level)	橫瀾島 Waglan Island, 火石洲 Basalt Island, 大浪灣 Tai Long Wan, 赤洲 Port Island	4	伽馬 $\gamma$ , 銥-90 Sr-90, 釷-239 Pu-239	每季 quarterly <sup>(2)</sup>



表1. (續)  
Table 1. (cont'd)

樣本類別 Sample type	取樣地點 Sampling location	地點數目 Number of location	分析類別 Type of analysis	取樣頻率 Sampling frequency
<b>水體樣本 Aquatic Samples</b>				
大魚 <i>Aristichthys nobilis</i> (Big-head carp)	深圳 Shenzhen, 元朗 Yuen Long	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
瓜三 <i>Nemipterus japonicus</i> (Melon coat)	大亞灣 Daya Bay, 香港以西海域 Seas west of Hong Kong, 香港水域 Hong Kong Waters	3	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
牛鰱 <i>Platycephalus indicus</i> (Bartail flathead)	大亞灣 Daya Bay, 香港以西海域 Seas west of Hong Kong, 香港水域 Hong Kong Waters	3	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
牙帶 <i>Trichiurus haumela</i> (Hair tail)	大亞灣 Daya Bay, 香港以西海域 Seas west of Hong Kong, 香港水域 Hong Kong Waters	3	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
三點蟹 <i>Portunus sanguinolentus</i> (Three-spotted crab)	香港以西海域 Seas west of Hong Kong, 香港水域 Hong Kong Waters	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
赤米蝦 <i>Metapenaeopsis barbata</i> (Fire prawn)	香港以西海域 Seas west of Hong Kong, 香港水域 Hong Kong Waters	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
魷魚 <i>Loligo edulis</i> (Squid)	大亞灣 Daya Bay, 香港以西海域 Seas west of Hong Kong, 香港水域 Hong Kong Waters	3	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
墨魚 <i>Sepia spp.</i> (Cuttlefish)	香港水域 Hong Kong Waters	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
蜆 <i>Tapes philippinarum</i> (Clam)	長洲 Cheung Chau, 吐露港 Tolo Harbour	2	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
青口 <i>Perna viridis</i> (Green-lipped mussel)	長洲 Cheung Chau, 吐露港 Tolo Harbour, 大亞灣 Daya Bay	3	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
東風螺 <i>Babylonia formosae</i> (Gastropod)	香港水域 Hong Kong Waters	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	每季 quarterly
石莖 <i>Ulva lactuca</i> (Sea lettuce)	布袋澳 Po Toi O	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	冬季及春季 winter and spring

表1. (續)  
Table 1. (cont'd)

樣本類別 Sample type	取樣地點 Sampling location	地點數目 Number of location	分析類別 Type of analysis	取樣頻率 Sampling frequency
<b>水體樣本 Aquatic Samples</b>				
浒苔 <i>Enteromorpha prolifera</i> (Sea hair)	吐露港 Tolo Harbour	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	冬季 winter
長紫菜 <i>Porphyra dentata</i> (Red algae)	蒲台島 Po Toi Island	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	冬季 winter
半葉馬尾藻 <i>Sargassum hemiphyllum</i> (Brown algae)	布袋澳 Po Toi O	1	伽馬 $\gamma$ , 氚 H-3, 銨-90 Sr-90, 釷-239 Pu-239	冬季及春季 winter and spring
潮間帶土(上層及下層) Intertidal sediment (upper and lower level)	白沙灣 Pak Sha Wan, 尖鼻咀 Tsim Bei Tsui, 沙頭角 Sha Tau Kok	3	伽馬 $\gamma$ , 釷-239 Pu-239	每季 quarterly
海床沉澱物 Seabed sediment	大灘海 Tai Tan Hoi, 龍蝦灣 Lung Ha Wan, 索罟灣 Picnic Bay, 西區碇泊處 Western Anchorage	4	伽馬 $\gamma$ , 釷-239 Pu-239	每年 yearly

註:

- (1) 油柑頭濾水廠在二零一三年四月至七月進行維修，而荃灣濾水廠於上述期間代替油柑頭濾水廠供應飲用水給當區。因此，水務署的工作人員於二零一三年四月及七月這二個季度在荃灣濾水廠取樣，以代替來自油柑頭濾水廠所抽取之飲用水樣本。
- (2) 自二零一三年十一月起，天文台增加海水樣本取樣及測量頻率，由每年一次在四個地點(橫瀾島、火石洲、大浪灣及赤洲附近的海域)取樣，變為每季一次在以上其中兩個地點交替取樣，令每一地點取樣頻率由每年取樣一次增至每6個月取樣一次。

Note:

- (1) Yau Kom Tau Treatment Works was under maintenance during the period from April to July of 2013. Tsuen Wan Treatment Works, as a replacement, provided drinking water to the concerned area during the maintenance period. As such, staff of the Water Supplies Department collected drinking water samples from Tsuen Wan Treatment Works to replace those from Yau Kom Tau Treatment Works during the quarters April and July of 2013.
- (2) The Observatory has increased its sea water sampling and radiation measurement frequency since November 2013. Instead of yearly collection of sea water samples at the four locations (waters off Waglan Island, Basalt Island, Tai Long Wan and Port Island), samples are collected every quarter alternately at two of the aforesaid locations. As such, sampling frequency at each location has increased from once a year to once every 6 months.

表 2. 二零一三年食物樣本概要  
Table 2. Summary of food samples in 2013

類別 Type	地點 Location	收集樣本總數 Total no. of sample collected
食米 Rice	內地(珠江三角洲) Mainland (Pearl River Delta)	4
牛奶(經消毒) Pasteurized milk	深圳 Shenzhen	4
	沙頭角 Sha Tau Kok	4
菜心 Choi sum	內地(深圳) Mainland (Shenzhen)	4
	本地 Local	4
白菜 Pak choi	內地(深圳) Mainland (Shenzhen)	4
	本地 Local	4
香蕉 Banana	內地(廣東) Mainland (Guangdong)	4
荔枝 Lychee	內地 Mainland	1
柑橘 Mandarin orange	內地(廣東) Mainland (Guangdong)	2
甘蔗 Sugar cane	內地(廣東) Mainland (Guangdong)	1
雞 Chicken	內地(深圳) Mainland (Shenzhen)	4
	本地 Local	4
鴨 Duck	內地(深圳) Mainland (Shenzhen)	4
牛肉 Beef	內地 Mainland	4
豬肝 Pig's Liver	內地(廣東) Mainland (Guangdong)	4
	本地 Local	4
豬肉 Pork	內地(廣東) Mainland (Guangdong)	4
	本地 Local	4
大魚 <i>Aristichthys nobilis</i> (Big-head carp)	深圳 Shenzhen	3
	元朗 Yuen Long	3
瓜三 <i>Nemipterus japonicus</i> (Melon coat)	大亞灣 Daya Bay	1
	香港以西海域 Seas west of Hong Kong	1
	香港水域 Hong Kong Waters	3
牛鰱 <i>Platycephalus indicus</i> (Bartail flathead)	大亞灣 Daya Bay	1
	香港以西海域 Seas west of Hong Kong	1
	香港水域 Hong Kong Waters	3
牙帶 <i>Trichiurus haumela</i> (Hair tail)	大亞灣 Daya Bay	1
	香港以西海域 Seas west of Hong Kong	1
	香港水域 Hong Kong Waters	3
三點蟹 <i>Portunus sanguinolentus</i> (Three-spotted crab)	香港以西海域 Seas west of Hong Kong	1
	香港水域 Hong Kong Waters	3

表 2. (續)  
Table 2. (cont'd)

類別 Type	地點 Location	收集樣本總數 Total no. of sample collected
赤米蝦 <i>Metapenaeopsis barbata</i> (Fire prawn)	香港以南海域 Seas west of Hong Kong	1
	香港水域 Hong Kong Waters	3
魷魚 <i>Loligo edulis</i> (Squid)	大亞灣 Daya Bay	1
	香港以南海域 Seas west of Hong Kong	1
	香港水域 Hong Kong Waters	3
墨魚 <i>Sepia spp.</i> (Cuttlefish)	香港水域 Hong Kong Waters	3
蜆 <i>Tapes philippinarum</i> (Clam)	長洲 Cheung Chau	1
	吐露港 Tolo Harbour	3
青口 <i>Perna viridis</i> (Green-lipped mussel)	長洲 Cheung Chau	3
	吐露港 Tolo Harbour	3
	大亞灣 Daya Bay	3
東風螺 <i>Babylonia formosae</i> (Gastropod)	香港水域 Hong Kong Waters	3
石莖 <i>Ulva lactuca</i> (Sea lettuce)	布袋澳 Po Toi O	2
浒苔 <i>Enteromorpha prolifera</i> (Sea hair)	吐露港 Tolo Harbour	1
長紫菜 <i>Porphyra dentata</i> (Red algae)	蒲台島 Po Toi Island	0
半葉馬尾藻 <i>Sargassum hemiphyllum</i> (Brown algae)	布袋澳 Po Toi O	2

表 3. 二零一三年樣本之主要量度參數概要<sup>(1)</sup>  
 Table 3. Summary of key measurement parameters for samples in 2013<sup>(1)</sup>

測量類別 Measurement type		空氣流量 Air Flow Rate	樣本大小 Sample size	計數 時間(秒) Counting time (second)	探測下限 <sup>(2)</sup> Minimum Detectable Activity <sup>(2)</sup> (MDA)		
					碘-131 I-131	銫-137 Cs-137	銫-134 Cs-134
伽馬放射性 核素 Gamma emitting radionuclides	大氣飄塵 Airborne particulate	17 m <sup>3</sup> h <sup>-1</sup>	12000 m <sup>3</sup> (累積每月樣本 bulked monthly sample)	55000	10 μBq m <sup>-3</sup>	10 μBq m <sup>-3</sup>	10 μBq m <sup>-3</sup>
			3000 m <sup>3</sup> (每週樣本 weekly sample)	20000	50 μBq m <sup>-3</sup>	50 μBq m <sup>-3</sup>	100 μBq m <sup>-3</sup>
					碘-131 I-131		銫-137 Cs-137
	氣態碘 Gaseous Iodine	2.5 m <sup>3</sup> h <sup>-1</sup>	400 m <sup>3</sup>	55000	300 μBq m <sup>-3</sup>		-
	濕沉積物 Wet deposition	-	4 L	55000	0.2 Bq L <sup>-1</sup>		0.2 Bq L <sup>-1</sup>
	總沉積物 Total deposition	-	0.03 m <sup>2</sup>	55000	15 Bq m <sup>-2</sup>		15 Bq m <sup>-2</sup>
	食米 Rice	-	4 kg	20000	0.1 Bq kg <sup>-1</sup>		0.1 Bq kg <sup>-1</sup>
	牛奶 Milk	-	1 L	55000	0.2 Bq L <sup>-1</sup>		0.3 Bq L <sup>-1</sup>
	蔬菜 Vegetable	-	1 kg	20000	0.3 Bq kg <sup>-1</sup>		0.4 Bq kg <sup>-1</sup>
	水果 Fruit	-	2 kg	20000	0.3 Bq kg <sup>-1</sup>		0.3 Bq kg <sup>-1</sup>
	家禽 Poultry	-	2 kg	20000	0.2 Bq kg <sup>-1</sup>		0.2 Bq kg <sup>-1</sup>
	肉類 Meat	-	1 kg	20000	0.4 Bq kg <sup>-1</sup>		0.4 Bq kg <sup>-1</sup>
	土壤 Land soil	-	1 kg	20000	1.0 Bq kg <sup>-1</sup>		1.5 Bq kg <sup>-1</sup>
	水樣本 Water samples	-	4 L	55000	0.1 Bq L <sup>-1</sup>		0.1 Bq L <sup>-1</sup>
	海水中懸浮 粒子 Suspended particulate	-	5 L	55000	0.02 Bq L <sup>-1</sup>		0.02 Bq L <sup>-1</sup>
	海產 Seafood	-	2 kg	72000	0.1 Bq kg <sup>-1</sup>		0.1 Bq kg <sup>-1</sup>
	海藻 Seaweed	-	0.5 kg	20000	1 Bq kg <sup>-1</sup>		2 Bq kg <sup>-1</sup>
	潮間帶土/ 海床沉澱物 Sediment	-	2 kg	20000	0.5 Bq kg <sup>-1</sup>		0.5 Bq kg <sup>-1</sup>

表 3. (續)  
Table 3. (cont'd)

測量類別 Measurement type		樣本大小 Sample size	計數 時間(秒) Counting time (second)	本底 Background (CPM)	計數 效率 Counting efficiency (%)	化學 復得率 Chemical recovery (%)	探測下限 <sup>(2)</sup> Minimum Detectable Activity <sup>(2)</sup> (MDA)
氚 Tritium	濕沉積物 Wet deposition	0.007 L	18000	2	25	-	4 Bq L <sup>-1</sup>
	總沉積物 Total deposition	0.0001 m <sup>2</sup>	18000	2	25	-	300 Bq m <sup>-2</sup>
	水蒸氣 Water vapour	2 m <sup>3</sup>	18000	2	25	-	0.01 Bq m <sup>-3</sup>
	食米 Rice	0.08 kg	18000	2	25	-	0.3 Bq kg <sup>-1</sup>
	牛奶 Milk	0.007 L	18000	2	25	-	4 Bq L <sup>-1</sup>
	蔬菜 Vegetable	0.008 kg	18000	2	25	-	3 Bq kg <sup>-1</sup>
	水果 Fruit	0.01 kg	18000	2	25	-	3 Bq kg <sup>-1</sup>
	家禽 Poultry	0.02 kg	18000	2	25	-	2 Bq kg <sup>-1</sup>
	肉類 Meat	0.01 kg	18000	2	25	-	3 Bq kg <sup>-1</sup>
	水樣本 Water samples	0.007 L	18000	2	25	-	4 Bq L <sup>-1</sup>
	地下水 Underground water	0.1 L	18000	2	25	-	0.3 Bq L <sup>-1</sup>
	海產 Seafood	0.02 kg	18000	2	25	-	1 Bq kg <sup>-1</sup>
	海藻 Seaweed	0.05 kg	18000	2	25	-	1 Bq kg <sup>-1</sup>
銩-90 Strontium-90	大氣飄塵 Airborne particulate	5000 m <sup>3</sup>	30000	1	75	90	1 μ Bq m <sup>-3</sup>
	濕沉積物 Wet deposition	2 L	30000	1	75	100	0.002 Bq L <sup>-1</sup>
	總沉積物 Total deposition	0.01 m <sup>2</sup>	30000	1	75	100	0.5 Bq m <sup>-2</sup>
	米 Rice	3 kg	30000	1	75	90	0.002 Bq kg <sup>-1</sup>
	牛奶 Milk	1 L	30000	1	75	90	0.005 Bq L <sup>-1</sup>
	蔬菜 Vegetable	1 kg	30000	1	75	90	0.005 Bq kg <sup>-1</sup>
	水果 Fruit	2 kg	30000	1	75	90	0.003 Bq kg <sup>-1</sup>
	家禽 Poultry	2 kg	30000	1	75	90	0.003 Bq kg <sup>-1</sup>
	肉類 Meat	1 kg	30000	1	75	90	0.005 Bq kg <sup>-1</sup>
	土壤 Land soil	0.005 kg	30000	1	75	90	1 Bq kg <sup>-1</sup>
	海水中懸浮粒子 Suspended particulate	3 L	30000	1	75	90	0.002 Bq L <sup>-1</sup>
	海產 Seafood	1.5 kg	30000	1	75	90	0.004 Bq kg <sup>-1</sup>
	海藻 Seaweed	0.05 kg	30000	1	75	90	0.1 Bq kg <sup>-1</sup>

表 3 (續)  
Table 3. (cont'd)

測量類別 Measurement type		樣本大小 Sample size	計數 時間(秒) Counting time (second)	本底 Background (CPM)	計數 效率 Counting efficiency (%)	化學 復得率 Chemical recovery (%)	探測下限 <sup>(2)</sup> Minimum Detectable Activity <sup>(2)</sup> (MDA)
鈾-239 Plutonium-239	大氣飄塵 Airborne particulate	6000 m <sup>3</sup>	220000	0.003	20	40	0.2 μ Bq m <sup>-3</sup>
	濕沉積物 Wet deposition	2 L	220000	0.003	20	60	0.0004 Bq L <sup>-1</sup>
	總沉積物 Total deposition	0.01 m <sup>2</sup>	220000	0.003	20	60	0.07 Bq m <sup>-2</sup>
	土壤 Land soil	0.003 kg	220000	0.003	20	50	0.3 Bq kg <sup>-1</sup>
	海水中懸浮 粒子 Suspended particulate	3 L	220000	0.003	20	50	0.0003 Bq L <sup>-1</sup>
	海產 Seafood	0.5 kg	220000	0.003	20	40	0.002 Bq kg <sup>-1</sup>
	海藻 Seaweed	0.05 kg	220000	0.003	20	60	0.01 Bq kg <sup>-1</sup>
	潮間帶土 / 海床沉澱物 Sediment	0.003 kg	220000	0.003	20	50	0.3 Bq kg <sup>-1</sup>

註:

- (1) 表內所列是 ERMP 在二零一三年主要量度參數的典型數值，僅供參考之用。視乎實際操作情況，量度參數可能有變化。在特別情況下，部份樣本會使用與上表頗為不同的參數進行量度。
- (2) 測量的探測下限是指一個測量系統在該次測量時實際能測量到的最低活度水平。探測下限的數值取決於多個因數，包括個別測量系統的特質、測量方法、樣本的特質及測量的情況，所以探測下限會隨著個別樣本和測量而改變。表內所示的探測下限為在一般測量情況下的典型數值，僅供在理解此報告的結果時作簡易參考之用。有時在個別樣本的測量情況下，可能測量出遠低於探測下限的活度水平。

Note:

- (1) The values given in the table are typical values of key measurement parameters in the ERMP in 2013. The values may vary in practice, and should thus be used as reference only. Under special circumstances, some samples may be measured under substantially different conditions.
- (2) The minimum detectable activity (MDA) of a measurement is the lowest activity level that is practically achievable by the counting system for that measurement. MDA values depend on the characteristics of the measurement system, method of measurement, sample characteristics and measurement conditions, and thus vary with individual samples and measurements. The listed MDAs are typical values under “typical” measurement conditions and serve as a quick reference in interpreting results in this report. Under individual measurement conditions, activity much lower than the typical MDA would sometimes be measured.

表 4a. 輻射監測網絡在二零一三年錄得的環境伽馬劑量率。(單位為每小時微戈)  
 Table 4a. Ambient gamma dose rates recorded by the radiation monitoring network in 2013 (dose rate in  $\mu\text{Gy h}^{-1}$ )

輻射監測站 Radiation Monitoring Station	年平均值 Annual Average	標準差 Standard Deviation	一分鐘平均值變幅 Variation of 1-min Average
吉澳 Kat O	0.108	0.004	0.094 – 0.141
京士柏 King's Park	0.137	0.004	0.123 – 0.202
觀塘 Kwun Tong	0.121	0.002	0.106 – 0.171
平洲 Ping Chau	0.089	0.004	0.076 – 0.156
西灣河 Sai Wan Ho	0.097	0.007	0.081 – 0.148
沙頭角 Sha Tau Kok	0.101	0.003	0.091 – 0.174
大美督 Tai Mei Tuk	0.116	0.003	0.105 – 0.197
塔門 Tap Mun	0.084	0.003	0.073 – 0.141
尖鼻咀 Tsim Bei Tsui	0.130	0.003	0.103 – 0.194
元五墳 Yuen Ng Fan	0.116	0.004	0.103 – 0.178
赤蠟角 Chek Lap Kok	0.149	0.003	0.136 – 0.204
鶴咀 Cape D'Aguilar	0.136	0.004	0.122 – 0.200
參考範圍 <sup>(1)</sup> Reference Range <sup>(1)</sup>			0.062 – 0.271

註： (1) 參考範圍為一九九二至一九九六年輻射監測網絡錄得的環境伽馬劑量率範圍。

Note: (1) Reference range is the ambient gamma dose rates recorded by the radiation monitoring network from 1992 to 1996.



表 4b. 熱釋光劑量計網絡在二零一三年錄得的環境伽馬劑量率。(單位為每小時微戈)

Table 4b. Ambient gamma dose rates recorded by the thermoluminescent network in 2013 (dose rate in  $\mu\text{Gy h}^{-1}$ )

熱釋光劑量計監測點 TLD Location		年平均值 Annual Average	標準差 Standard Deviation	變幅 Variation
鶴咀 Cape D'Aguilar <sup>(1)</sup>		0.15	0.01	0.13 – 0.16
赤鱗角 Chek Lap Kok		0.14	0.01	0.13 – 0.16
長洲 Cheung Chau		0.12	0.01	0.11 – 0.12
置富花園 Chi Fu Fa Yuen		0.15	<0.01	0.14 – 0.15
清水灣 Clear Water Bay		0.10	0.01	0.09 – 0.12
深水灣 Deep Water Bay		0.13	0.01	0.12 – 0.14
粉嶺 Fanling		0.11	0.01	0.10 – 0.12
跑馬地 Happy Valley		0.09	<0.01	0.08 – 0.09
吉澳 <sup>(2)</sup> Kat O <sup>(2)</sup>	漁業研究站 Fisheries Research Station	0.11	0.01	0.11 – 0.12
	輻射監測站 Radiation Monitoring Station	0.11	0.01	0.10 – 0.11
京士柏 King's Park		0.15	0.02	0.14 – 0.17
觀塘 Kwun Tong		0.12	0.01	0.11 – 0.13
平洲 Ping Chau		0.12	0.01	0.12 – 0.13
西貢 Sai Kung		0.13	0.01	0.11 – 0.15
沙頭角 Sha Tau Kok		0.09	0.01	0.08 – 0.10
BRMP 參考數值 <sup>(3)</sup> BRMP Reference Values <sup>(3)</sup>				0.03 – 0.29

表 4b. (續)

Table 4b. (cont'd)

熱釋光劑量計監測點 TLD Location	年平均值 Annual Average	標準差 Standard Deviation	變幅 Variation
沙田 Shatin	0.13	0.01	0.12 – 0.14
筲箕灣 Shau Kei Wan	0.13	0.01	0.13 – 0.14
石崗 Shek Kong	0.12	0.01	0.11 – 0.13
石梨貝 Shek Lei Pui	0.20	0.01	0.18 – 0.21
大欖涌 Tai Lam Chung	0.18	0.01	0.17 – 0.20
大美督 Tai Mei Tuk	0.14	0.01	0.13 – 0.15
大埔 Tai Po	0.10	0.01	0.09 – 0.11
塔門 Tap Mun	0.10	0.01	0.09 – 0.11
尖鼻咀 Tsim Bei Tsui	0.13	0.01	0.12 – 0.14
青衣 Tsing Yi	0.13	0.01	0.12 – 0.14
荃灣 Tsuen Wan	0.14	0.01	0.13 – 0.16
屯門 Tuen Mun	0.15	0.01	0.13 – 0.16
烏溪沙 Wu Kai Sha	0.13	0.01	0.12 – 0.14
元朗 Yuen Long	0.11	0.01	0.11 – 0.12
元五墳 Yuen Ng Fan	0.13	0.02	0.11 – 0.14
BRMP 參考數值 <sup>(3)</sup> BRMP Reference Values <sup>(3)</sup>			0.03 – 0.29

- 註: (1) 天文台在二零一二年於新建之鶴咀輻射監測站增設熱釋光劑量計監測點，準備以此取代原本位於鶴咀無線電發射站的監測點。經過一整年時間兩站並行，設置於鶴咀輻射監測站之熱釋光劑量計監測點於二零一三年正式取代鶴咀無線電發射站的監測點。
- (2) 由於設置於吉澳漁業研究站的監測點之設施有所改動，因此吉澳之熱釋光劑量計監測點在二零一三年七月遷移至同位於漁業研究站內的吉澳輻射監測站。原吉澳漁業研究站監測點所錄得的為二零一三年第一及第二季的數據，而吉澳輻射監測站所錄得的為二零一三年第二至第四季的数据。
- (3) BRMP參考數值為熱釋光劑量計網絡於BRMP期間所錄得的伽馬劑量率的範圍。

Note: (1) In 2012, an additional TLD monitoring point was established at the new Cape D'Aguilar Radiation Monitoring Station with a view to replacing the TLD monitoring point originally located at the nearby Cape D'Aguilar Radio Transmitting Station. After a whole year's parallel run, the TLD monitoring point located at Cape D'Aguilar Radiation Monitoring Station officially replaced that located at Cape D'Aguilar Radio Transmitting Station in 2013.

(2) Since the facilities of Kat O Fisheries Research Station were altered, the original TLD monitoring point at the Fisheries Research Station was moved to Kat O Radiation Monitoring Station, which is also situated inside the Fisheries Research Station, in July 2013. The data recorded at the original Kat O Fisheries Research Station TLD monitoring point represented the first and second quarters of 2013, whereas that recorded at Kat O Radiation Monitoring Station represented the second to fourth quarter of 2013.

(3) BRMP reference values represent the range of the ambient gamma dose rates recorded by the thermoluminescent dosimeter network during BRMP.

表 5. 平洲自動伽馬譜法系統在二零一三年的輻射測量結果

Table 5. Results of measurement by the Automatic Gamma Spectrometry System at Ping Chau in 2013

	空氣流量 Air Flow Rate	年平均值 Annual Average	標準差 Standard Deviation	日平均值範圍 Range of Daily Average	首五年(一九九七至 二零零一年) 參考範圍 <sup>(1)</sup> Reference range from first 5 years of operation (1997 - 2001) <sup>(1)</sup>
阿爾法粒子 Alpha (每立方米貝可 Bq m <sup>-3</sup> )	30 m <sup>3</sup> h <sup>-1</sup>	< 1	N/A <sup>(2)</sup>	N/A	1.0 – 5.8
貝他粒子 Beta (每立方米貝可 Bq m <sup>-3</sup> )	30 m <sup>3</sup> h <sup>-1</sup>	1.4	0.3	1.0 – 2.2	1.0 – 10.1
碘-131 I-131 (每立方米毫貝可 mBq m <sup>-3</sup> )	30 m <sup>3</sup> h <sup>-1</sup>	< 4	N/A	N/A	< 4 <sup>(3)</sup>
銫-137 Cs-137 (每立方米毫貝可 mBq m <sup>-3</sup> )	30 m <sup>3</sup> h <sup>-1</sup>	< 4	N/A	N/A	< 4
氣態碘-131 Gaseous I-131 (每立方米貝可 Bq m <sup>-3</sup> )	4 m <sup>3</sup> h <sup>-1</sup>	< 1	N/A	N/A	< 1

註: (1) 自動伽馬譜法系統的主要目的是測量人工放射性核素。一般情況下，其阿爾法粒子和貝他粒子數值顯示該系統在環境中所錄得的變化，而並非環境中阿爾法及貝他粒子的含量。

(2) N/A 表示不適用。

(3) 測量結果低於探測下限以 “< xx” 表示，xx是該類測量的典型探測下限值。

Note: (1) Automatic Gamma Spectrometry System aims at detecting artificial radionuclides. In general, the alpha and beta values obtained by the system indicate the variations as depicted by the system in the environment, rather than the concentration of alpha and beta activities in the environment.

(2) N/A means 'Not applicable'.

(3) Results below the minimum detectable activity (MDA) are reported as “< xx” where xx is the typical MDA value for that type of measurement.

表 6. 二零一三年宇宙輻射引致的伽馬劑量率測量結果 (測量地點: 船灣淡水湖)

Table 6. Measurement results of gamma dose rates due to cosmic radiation in 2013 (measurement site: Plover Cove)

測量日期 Date of measurement	平均伽馬劑量率(每小時微戈) Average gamma dose rate (μGy h <sup>-1</sup> )
二零一三年三月二十二日 22 Mar 2013	0.029
二零一三年六月二十一日 21 Jun 2013	0.036
二零一三年九月二十六日 26 Sep 2013	0.037
二零一三年十二月二十日 20 Dec 2013	0.037

表 7. 二零一三年食物及環境樣本中之人工伽馬放射性核素的可測量伽馬活度測量結果  
 Table 7. Measurement results of measurable gamma activities of artificial gamma-emitting radionuclides in food and environmental samples in 2013

**放射性核素: 銫-137 Radionuclide: Cs-137**

類別 Type	地點 Location	含有可測量活度的 樣本總數 Total no. of samples with measurable activity	範圍 Range	活度 <sup>(1)</sup> Activity <sup>(1)</sup>	BRMP 範圍 <sup>(2)</sup> BRMP range <sup>(2)</sup>	單位 Unit
土壤(上層) Land soil (upper)	見表 1 See Table 1	2	0.8 – 0.9	0.9	≤ 10.0	Bq kg <sup>-1</sup>
土壤(下層) Land soil (lower)	見表 1 See Table 1	3	0.7 – 2.5	1.3	≤ 4.0	Bq kg <sup>-1</sup>
潮間帶土(上層) Intertidal sediment (upper)	白沙灣 Pak Sha Wan	4	0.3 – 0.5	0.4	≤ 2.4	Bq kg <sup>-1</sup>
	尖鼻咀 Tsim Bei Tsui	4	0.6 – 0.8	0.7		
	沙頭角 Sha Tau Kok	4	0.4 – 0.8	0.6		
潮間帶土(下層) Intertidal sediment (lower)	白沙灣 Pak Sha Wan	3	0.3 – 0.4	0.4	≤ 3.1	Bq kg <sup>-1</sup>
	尖鼻咀 Tsim Bei Tsui	3	0.6 – 0.7	0.7		
	沙頭角 Sha Tau Kok	4	0.3 – 0.6	0.4		
海床沉澱物 Seabed sediment	大灘海 Tai Tan Hoi	1	-	0.5	≤ 1.9	Bq kg <sup>-1</sup>
	龍蝦灣 Lung Ha Wan	1	-	0.8		
	索罟灣 Picnic Bay	1	-	0.6		
	西區碇泊處 Western Anchorage	1	-	0.3		

註: (1) 如有多過一個樣本發現可測量活度，此欄則報告平均值。

(2) BRMP 測量結果低於探測下限以“< xx”表示，xx 是該類測量的典型探測下限值。如只在部份樣本中探測到該放射性核素，結果將報告為“≤ xx”，xx 則為測量到的活度最大值。

Note: (1) The mean activity is reported if there are more than one sample with measurable activities.

(2) BRMP results that are below the minimum detectable activity (MDA) are reported as “< xx” where xx is the typical MDA value for that type of measurement. When a particular radionuclide was detected only in some of the samples in a certain sample type, the results will be reported as “≤ xx” where xx is the maximum measured activity value.

表 8. 二零一三年食物及環境樣本的可測量氚活度測量結果

Table 8. Measurement results of measurable activities of tritium in food and environmental samples in 2013

(每公斤貝可 Bq kg<sup>-1</sup>; 每公升貝可 Bq L<sup>-1</sup>; 每平方米貝可 Bq m<sup>-2</sup>; 每立方米貝可 Bq m<sup>-3</sup>)

類別 Type	地點 Location	含有可測量活度的樣本總數 Total no. of samples with measurable activity	範圍 Range	活度 <sup>(1)</sup> Activity <sup>(1)</sup>	BRMP 範圍 <sup>(2)</sup> BRMP range <sup>(2)</sup>	單位 Unit
食米 Rice	內地 Mainland	2	0.06 – 0.09	0.08	< 1	Bq kg <sup>-1</sup>
牛奶(經消毒) Pasteurized milk	深圳 Shenzhen	2	1.7 – 4.1	2.9	< 6	Bq L <sup>-1</sup>
	沙頭角 Sha Tau Kok	2	1.3 – 1.9	1.6		
菜心 Choi sum	深圳 Shenzhen	3	0.4 – 2.3	1.1	≤ 7.4	Bq kg <sup>-1</sup>
	本地 Local	3	1.0 – 2.1	1.5		
白菜 Pak Choi	深圳 Shenzhen	3	0.8 – 2.4	1.3	< 6	Bq kg <sup>-1</sup>
	本地 Local	2	0.1 – 2.0	1.1		
香蕉 Banana	內地 Mainland	4	0.2 – 0.5	0.4	< 3	Bq kg <sup>-1</sup>
甘蔗 Sugar cane	內地 Mainland	1	-	0.1	< 2	Bq kg <sup>-1</sup>
荔枝 Lychee	內地 Mainland	1	-	0.6	< 4	Bq kg <sup>-1</sup>
柑橘 Mandarin	內地 Mainland	1	-	0.2	< 4	Bq kg <sup>-1</sup>
雞 Chicken	內地 Mainland	3	0.2 – 0.5	0.3	≤ 2.2	Bq kg <sup>-1</sup>
	本地 Local	1	-	0.6		
鴨 Duck	內地 Mainland	3	0.1 – 0.2	0.1	≤ 3.5	Bq kg <sup>-1</sup>
牛肉 Beef	內地 Mainland	1	-	0.2	≤ 5.3	Bq kg <sup>-1</sup>
豬肝 Pig's liver	內地 Mainland	3	0.1 – 0.4	0.2	< 4	Bq kg <sup>-1</sup>
	本地 Local	3	0.5 – 1.0	0.7		
豬肉 Pork	內地 Mainland	1	-	0.8	< 4	Bq kg <sup>-1</sup>
	本地 Local	2	0.3 – 0.6	0.5		
大魚 <i>Aristichthys nobilis</i> (Big-head carp)	深圳 Shenzhen	1	-	0.3	< 2	Bq kg <sup>-1</sup>
	元朗 Yuen Long	1	-	0.3		Bq kg <sup>-1</sup>
瓜三 <i>Nemipterus japonicus</i> (Melon coat)	大亞灣 Daya Bay	1	-	0.4	< 2	Bq kg <sup>-1</sup>
	香港水域 Hong Kong Waters	2	0.07 – 0.14	0.1		
	香港以南海域 Seas west of Hong Kong	1	-	0.4		
牛鯪 <i>Platycephalus indicus</i> (Bartail flathead)	香港水域 Hong Kong Waters	2	0.04 – 0.05	0.05	< 2	Bq kg <sup>-1</sup>
牙帶 <i>Trichiurus haumela</i> (Hair tail)	大亞灣 Daya Bay	1	-	0.7	< 2	Bq kg <sup>-1</sup>
	香港水域 Hong Kong Waters	1	-	0.1		
	香港以南海域 Seas west of Hong Kong	1	-	0.2		

表 8. (續)

Table 8. (cont'd)

類別 Type	地點 Location	含有可測量活度的 樣本總數 Total no. of samples with measurable activity	範圍 Range	活度 <sup>(1)</sup> Activity <sup>(1)</sup>	BRMP 範圍 <sup>(2)</sup> BRMP range <sup>(2)</sup>	單位 Unit
三點蟹 <i>Portunus sanguinolentus</i> (Three-spotted crab)	香港水域 Hong Kong Waters	2	0.1 – 0.2	0.2	< 2	Bq kg <sup>-1</sup>
	香港以西海域 Seas west of Hong Kong	1	-	0.6		
赤米蝦 <i>Metapenaeopsis barbata</i> (Fire prawn)	香港水域 Hong Kong Waters	1	-	0.1	≤ 4.9	Bq kg <sup>-1</sup>
	香港以西海域 Seas west of Hong Kong	1	-	0.3		
墨魚 <i>Sepia spp.</i> (Cuttlefish)	香港水域 Hong Kong Waters	1	-	0.4	≤ 2.7 <sup>(3)</sup>	Bq kg <sup>-1</sup>
魷魚 <i>Loligo edulis</i> (Squid)	大亞灣 Daya Bay	1	-	1.0	< 3	Bq kg <sup>-1</sup>
	香港水域 Hong Kong Waters	1	-	0.4		
	香港以西海域 Seas west of Hong Kong	1	-	1.2		
東風螺 <i>Babylonia formosae</i> (Gastropod)	香港水域 Hong Kong Waters	1	-	0.3	< 1	Bq kg <sup>-1</sup>
青口 <i>Perna viridis</i> (Green-lipped mussel)	長洲 Cheung Chau	2	0.1 – 0.3	0.2	< 2	Bq kg <sup>-1</sup>
	吐露港 Tolo Harbour	1	-	0.1		
	大亞灣 Daya Bay	2	0.06 – 0.09	0.08		
蜆 <i>Tapes philippinarum</i> (Clam)	長洲 Cheung Chau	1	-	0.9	< 2	Bq kg <sup>-1</sup>
	吐露港 Tolo Harbour	1	-	0.02		
半葉馬尾藻 <i>Sargassum hemiphyllum</i> (Brown algae)	布袋澳 Po Toi O	1	-	0.1	< 2	Bq kg <sup>-1</sup>
浒苔 <i>Enteromorpha prolifera</i> (Sea hair)	吐露港 Tolo Harbour	1	-	0.8	< 5	Bq kg <sup>-1</sup>
濕沉積物 (降雨) Wet deposition (precipitation)	京士柏 King's Park	4	0.4 – 2.0	1.3	≤ 12	Bq L <sup>-1</sup>
	沙頭角 Sha Tau Kok	5	0.2 – 2.7	1.5		
	元五墳 Yuen Ng Fan	4	0.6 – 2.0	1.1		
總沉積物 Total deposition	京士柏 King's Park	9	20 – 592	197	≤ 2210 <sup>(4)</sup>	Bq m <sup>-2</sup>

表 8. (續)

Table 8. (cont'd)

類別 Type	地點 Location	含有可測量活度的 樣本總數 Total no. of samples with measurable activity	範圍 Range	活度 <sup>(1)</sup> Activity <sup>(1)</sup>	BRMP 範圍 <sup>(2)</sup> BRMP range <sup>(2)</sup>	單位 Unit
大氣水蒸氣 Water vapour in air	京士柏 King's Park	5	0.01	0.01	$\leq 242^{(5)}$	Bq m <sup>-3</sup>
飲用水(經處理) Drinking water (treated)	九龍配水管 Kowloon distribution tap	2	0.5 – 0.8	0.6	< 6	Bq L <sup>-1</sup>
	屯門配水管 Tuen Mun distribution tap	2	0.1 – 0.7	0.4		
	油柑頭濾水廠 Yau Kom Tau Treatment Works	1	-	0.9		
	沙田濾水廠 Shatin Treatment Works	2	0.1 – 0.8	0.5		
	荃灣濾水廠 Tsuen Wan Treatment Works	1	-	0.7		
飲用水 (未經處理) Drinking water (untreated)	木湖 B 抽水站 Muk Wu B Pumping Station	2	0.3 – 1.3	0.8	< 6	Bq L <sup>-1</sup>
	油柑頭濾水廠 Yau Kom Tau Treatment Works	1	-	0.4		
	屯門濾水廠 Tuen Mun Treatment Works	2	0.1– 1.8	1.0		
	沙田濾水廠 Shatin Treatment Works	3	0.5 – 0.7	0.6		
	萬宜水庫 High Island Reservoir	3	0.1 – 2.0	1.0		
	船灣淡水湖 Plover Cove Reservoir	3	0.7 – 1.7	1.2		
	荃灣濾水廠 Tsuen Wan Treatment Works	1	-	0.5		

表 8. (續)

Table 8. (cont'd)

類別 Type	地點 Location	含有可測量活度的樣本總數 Total no. of samples with measurable activity	範圍 Range	活度 <sup>(1)</sup> Activity <sup>(1)</sup>	BRMP 範圍 <sup>(2)</sup> BRMP range <sup>(2)</sup>	單位 Unit
地下水 Underground water	長康邨 Cheung Hong Estate	1	-	0.2	≤ 2.8	Bq L <sup>-1</sup>
	鈞樂新村 Kwan Lok San Tsuen	1	-	0.2		
	環翠邨 Wan Tsui Estate	1	-	0.3		
	華富邨 Wah Fu Estate	1	-	0.2		
	富山邨 Fu Shan Estate	1	-	0.3		
	清涼法苑 Ching Leung Nunnery	1	-	0.4		
海水(上層) Sea water (upper level)	火石洲 Basalt Island	1	-	0.9	< 6	Bq L <sup>-1</sup>
	大浪灣 Tai Long Wan	1	-	3.1		
	赤洲 Port Island	1	-	2.2		
海水(中層) Sea water (middle level)	大浪灣 Tai Long Wan	1	-	2.9	< 6	Bq L <sup>-1</sup>
	赤洲 Port Island	1	-	1.5		
	橫瀾島 Waglan Island	2	0.5 – 0.6	0.5		
海水(低層) Sea water (lower level)	大浪灣 Tai Long Wan	1	-	1.9	< 6	Bq L <sup>-1</sup>
	赤洲 Port Island	1	-	1.3		
樽裝水(蒸餾水) Bottled water (Distilled)	本地 Local	3	0.6 – 1.6	1.0	≤ 4.9 <sup>(6)</sup>	Bq L <sup>-1</sup>
樽裝水(礦泉水) Bottled water (Mineral)	本地 Local	2	1.3 – 1.4	1.3	≤ 5.8 <sup>(6)</sup>	Bq L <sup>-1</sup>

註: (1) 如有多過一個樣本發現可測量活度, 此欄則報告平均值。

(2) BRMP 測量結果低於探測下限以 “< xx” 表示, xx 是該類測量的典型探測下限值。如只在部份樣本中探測到該放射性核素, 結果將報告為 “≤ xx”, xx 則為測量到的活度最大值。

(3) 該樣本測量始於一九九七年十月, 並沒有在 BRMP 測量。這裡顯示的測量範圍為該樣本首五年的測量數值。

(4) 該樣本測量始於一九九六年一月, 並沒有在 BRMP 測量。這裡顯示的測量範圍為該樣本首五年的測量數值。

(5) 現時測量的準確度相比 BRMP 時大幅提高, 同時探測下限亦大幅下降, 原因是在 2011 年採用了新的樣本前處理方法及在 2008 年應用了新的液體閃爍計數系統作測量。

(6) 該樣本測量始於二零零七年五月, 並沒有在 BRMP 測量。這裡顯示的測量範圍為該樣本首五年的測量數值。

Note: (1) The mean activity is reported if there is more than one sample with measurable activities.

(2) BRMP results that are below the minimum detectable activity (MDA) are reported as “< xx” where xx is the typical MDA value for that type of measurement. When a particular radionuclide was detected only in some of the samples in a certain sample type, the results will be reported as “≤ xx” where xx is the maximum measured activity value.

(3) Measurement of this sample started in October 1997. The sample was not measured in BRMP. The indicated range refers to results from first 5 years' sample measurement.

(4) Measurement of this sample started in January 1996. The sample was not measured in BRMP. The indicated range refers to results from first 5 years' sample measurement.

(5) Substantially higher accuracy and lower detection limit are achieved for current measurement when compared to those of the BRMP owing to the adoption of a new sample pre-treatment method in 2011 and the implementation of a new Liquid Scintillation Counting System for measurement in 2008.

(6) Measurement of this sample started in May 2007. The sample was not measured in BRMP. The indicated range refers to results from first 5 years' sample measurement.



表 9. 二零一三年食物及環境樣本的可測量銥-90 活度測量結果

Table 9. Measurement results of measurable activities of strontium-90 in food and environmental samples in 2013

(每公斤貝可 Bq kg<sup>-1</sup>; 每公升貝可 Bq L<sup>-1</sup>; 每立方米貝可 Bq m<sup>-3</sup>; 每平方米貝可 Bq m<sup>-2</sup>; 每公斤毫貝可 mBq kg<sup>-1</sup>; 每公升毫貝可 mBq L<sup>-1</sup>; 每立方米微貝可 μBq m<sup>-3</sup>)

類別 Type	地點 Location	含有可測量活度的 樣本總數 Total no. of samples with measurable activity	範圍 Range	活度 <sup>(1)</sup> Activity <sup>(1)</sup>	BRMP 範圍 <sup>(2)</sup> BRMP range <sup>(2)</sup>	單位 Unit
食米 Rice	內地 Mainland	4	4 – 7	6	≤ 56	mBq kg <sup>-1</sup>
牛奶(經消毒) Pasteurized milk	深圳 Shenzhen	4	4 – 11	7	≤ 81	mBq L <sup>-1</sup>
	沙頭角 Sha Tau Kok	4	5 – 10	8		
菜心 Choi sum	深圳 Shenzhen	4	46 – 66	51	≤ 266	mBq kg <sup>-1</sup>
	本地 Local	4	22 – 149	75		
白菜 Pak Choi	深圳 Shenzhen	4	19 – 73	47	≤ 570	mBq kg <sup>-1</sup>
	本地 Local	4	33 – 170	76		
香蕉 Banana	內地 Mainland	1	-	4	≤ 27	mBq kg <sup>-1</sup>
甘蔗 Sugar cane	內地 Mainland	1	-	4	≤ 14	mBq kg <sup>-1</sup>
荔枝 Lychee	內地 Mainland	1	-	9	≤ 14	mBq kg <sup>-1</sup>
柑橘 Mandarin	內地 Mainland	2	23 – 66	45	≤ 84	mBq kg <sup>-1</sup>
雞 Chicken	內地 Mainland	1	-	3	≤ 37	mBq kg <sup>-1</sup>
鴨 Duck	內地 Mainland	1	-	2	≤ 53	mBq kg <sup>-1</sup>
大魚 <i>Aristichthys nobilis</i> (Big-head carp)	深圳 Shenzhen	2	3 – 15	9	≤ 94	mBq kg <sup>-1</sup>
	元朗 Yuen Long	3	5 – 8	7		
牛鰵 <i>Platycephalus indicus</i> (Bartail flathead)	大亞灣 Daya Bay	1	-	8	≤ 25	mBq kg <sup>-1</sup>
牙帶 <i>Trichiurus haumela</i> (Hair tail)	大亞灣 Daya Bay	1	-	12	≤ 49	mBq kg <sup>-1</sup>
赤米蝦 <i>Metapenaeopsis barbata</i> (Fire prawn)	香港水域 Hong Kong Waters	2	7 – 12	10	≤ 66	mBq kg <sup>-1</sup>
	香港以西海域 Seas west of Hong Kong	1	-	8		
魷魚 <i>Loligo edulis</i> (Squid)	大亞灣 Daya Bay	1	-	10	≤ 43	mBq kg <sup>-1</sup>
	香港水域 Hong Kong Waters	1	-	17		
	香港以西海域 Seas west of Hong Kong	1	-	15		
青口 <i>Perna viridis</i> (Green-lipped mussel)	長洲 Cheung Chau	1	-	47	≤ 47	mBq kg <sup>-1</sup>
	吐露港 Tolo Harbour	2	40 – 44	42		
	大亞灣 Daya Bay	1	-	6		

表 9. (續)  
Table 9. (cont'd)

類別 Type	地點 Location	含有可測量活度的 樣本總數 Total no. of samples with measurable activity	範圍 Range	活度 <sup>(1)</sup> Activity <sup>(1)</sup>	BRMP 範圍 <sup>(2)</sup> BRMP range <sup>(2)</sup>	單位 Unit
蜆 <i>Tapes philippinarum</i> (Clam)	長洲 Cheung Chau	1	-	4	≤ 32	mBq kg <sup>-1</sup>
	吐露港 Tolo Harbour	3	6 – 31	22		
半葉馬尾藻 <i>Sargassum hemiphyllum</i> (Brown algae)	布袋澳 Po Toi O	1	-	218	≤ 1440	mBq kg <sup>-1</sup>
大氣飄塵 Airborne particulate	京士柏 King's Park	2	3.1 – 4.8	3.9	≤ 5	μBq m <sup>-3</sup>
	沙頭角 Sha Tau Kok	6	1.0 – 3.7	2.3		
	元五墳 Yuen Ng Fan	6	0.9 – 4.6	2.5		
濕沉積物(降雨) Wet deposition (precipitation)	京士柏 King's Park	3	3.1 – 6.6	4.3	≤ 39	mBq L <sup>-1</sup>
	元五墳 Yuen Ng Fan	3	3.5 – 9.5	6.7		
總沉積物 Total deposition	京士柏 King's Park	3	0.7 – 2.1	1.3	≤ 3.9 <sup>(3)</sup>	Bq m <sup>-2</sup>
土壤(上層) Land soil (upper)	見表 1. Please see Table 1.	5	1.4 – 26.8	12.8	≤ 27.3	Bq kg <sup>-1</sup>
土壤(下層) Land soil (lower)	見表 1. Please see Table 1.	5	7.3 – 16.5	12.3	≤ 19.9	Bq kg <sup>-1</sup>
海水中懸浮粒子 (上層) Suspended particulate in sea water (upper level)	橫瀾島 Waglan Island	1	-	6.5	< 7	mBq L <sup>-1</sup>

- 註: (1) 如有多過一個樣本發現可測量活度，此欄則報告平均值。  
 (2) BRMP 測量結果低於探測下限以 “< xx” 表示，xx 是該類測量的典型探測下限值。如只在部份樣本中探測到該放射性核素，結果將報告為 “≤ xx”，xx 則為測量到的活度最大值。  
 (3) 該樣本測量始於一九九六年一月，並沒有在 BRMP 測量。這裡顯示的測量範圍為該樣本首五年的測量數值。

- Note: (1) The mean activity is reported if there is more than one sample with measurable activities.  
 (2) BRMP results that are below the minimum detectable activity (MDA) are reported as “< xx” where xx is the typical MDA value for that type of measurement. When a particular radionuclide was detected only in some of the samples in a certain sample type, the results will be reported as “≤ xx” where xx is the maximum measured activity value.  
 (3) Measurement of this sample started in January 1996. The sample was not measured in BRMP. The indicated range refers to results from first 5 years' sample measurement.

表 10. 二零一三年食物及環境樣本的可測量鈾-239活度測量結果

Table 10. Measurement results of measurable activities of plutonium-239 in food and environmental samples in 2013

類別 Type	地點 Location	含有可測量活度的 樣本總數 Total no. of samples with measurable activity	範圍 Range	活度 <sup>(1)</sup> Activity <sup>(1)</sup>	BRMP 範圍 <sup>(2)</sup> BRMP range <sup>(2)</sup>	單位 Unit 每公斤貝可 Bq kg <sup>-1</sup>
半葉馬尾藻 <i>Sargassum hemiphyllum</i> (Brown algae)	布袋澳 Po Toi O	1	-	0.04	≤ 0.07	Bq kg <sup>-1</sup>
潮間帶土(上層) Intertidal sediment (upper)	沙頭角 Sha Tau Kok	1	-	0.15	≤ 0.19	Bq kg <sup>-1</sup>
	尖鼻咀 Tsim Bei Tsui	2	0.13 – 0.17	0.15		
	白沙灣 Pak Sha Wan	1	-	0.09		
潮間帶土(下層) Intertidal sediment (lower)	白沙灣 Pak Sha Wan	1	-	0.13	≤ 0.14	Bq kg <sup>-1</sup>
海床沉澱物 Seabed sediment	索罟灣 Picnic Bay	1	-	0.34	≤ 0.57	Bq kg <sup>-1</sup>
	大灘海 Tai Tan Hoi	1	-	0.39		
	龍蝦灣 Lung Ha Wan	1	-	0.26		

註:

- (1) 如有多過一個樣本發現可測量活度，此欄則報告平均值。
- (2) BRMP 測量結果低於探測下限以“< xx”表示，xx 是該類測量的典型探測下限值。如只在部份樣本中探測到該放射性核素，結果將報告為“≤ xx”，xx 則為測量到的活度最大值。

Note:

- (1) The mean activity is reported if there is more than one sample with measurable activities.
- (2) BRMP results that are below the minimum detectable activity (MDA) are reported as “< xx” where xx is the typical MDA value for that type of measurement. When a particular radionuclide was detected only in some of the samples in a certain sample type, the results will be reported as “≤ xx” where xx is the maximum measured activity value.

表 11. 二零一三年樣本整體測量結果概要

Table 11. Overall summary of measurement results of samples in 2013

(每公斤貝可 Bq kg<sup>-1</sup>; 每公升貝可 Bq L<sup>-1</sup>; 每立方米微貝可 μBq m<sup>-3</sup>)

途徑 Pathway	樣本類別 Sample Type	測量結果 <sup>(1)</sup> Measurement results <sup>(1)</sup>	碘-131 I-131	銫-137 Cs-137	銫-134 Cs-134	氚 H-3	銩-90 Sr-90	鈾-239 Pu-239	單位 Unit
		參考數值 <sup>(1)</sup> Reference values <sup>(1)</sup>							
大氣 Atmospheric	大氣飄塵 (每月累積樣本) Airborne Particulate (bulk monthly sample)	範圍 Range	< 10	< 10	< 10	--- <sup>(2)</sup>	0.9   4.8	< 0.2	μBq m <sup>-3</sup>
		BRMP	< 10 <sup>(3)</sup>	< 10	< 10		≤ 5	< 0.2	
地面 Terrestrial	食米 Rice	範圍 Range	< 0.1	< 0.1	< 0.1	0.06   0.09	0.004   0.007	---	Bq kg <sup>-1</sup>
		BRMP	< 0.1	≤ 0.9	< 0.1	< 1	≤ 0.056		
	牛奶 Milk	範圍 Range	< 0.2	< 0.3	< 0.3	1.3   4.1	0.004   0.011	---	Bq L <sup>-1</sup>
		BRMP	< 0.2	≤ 0.3	< 0.3	< 6	≤ 0.081		
	蔬菜 Vegetable	範圍 Range	< 0.3	< 0.4	< 0.3	0.1   2.4	0.019   0.170	---	Bq kg <sup>-1</sup>
		BRMP	< 0.3	< 0.4	< 0.3	≤ 7.4	≤ 0.570		
水 Aquatic	魚 Fish	範圍 Range	< 0.1	< 0.1	< 0.1	0.04   0.7	0.003   0.015	< 0.002	Bq kg <sup>-1</sup>
		BRMP	< 0.1	≤ 0.2	< 0.1	< 2	≤ 0.094	< 0.002	
	經處理的 飲用水 Treated Drinking Water	範圍 Range	< 0.1	< 0.1	< 0.1	0.1   0.9	---	---	Bq L <sup>-1</sup>
		BRMP	< 0.1	< 0.1	< 0.1	< 6			

註:

- (1) 測量結果低於探測下限以 “< xx” 表示, xx 是該類測量的典型探測下限值。如只在部份樣本中探測到該放射性核素, BRMP 結果將報告為 “≤ xx”, xx 則為測量到的活度最大值。
- (2) --- 表示沒有在 BRMP 及 ERMP 進行此項測量。
- (3) 在 BRMP 期間分析的大氣飄塵樣本中, 只有京士柏兩個樣本測量出碘-131, 活度分別是 328 μBq m<sup>-3</sup> 及 38 μBq m<sup>-3</sup>, 但經調查後相信碘-131 是來自附近伊利沙伯醫院的小量低放射性醫療廢物排放, 因此並不應將這些樣本在 BRMP 期間測量出的碘-131 活度視為大氣飄塵的本底活度範圍。大氣飄塵的 BRMP 碘-131 本底範圍應為低於探測下限。

Notes:

- (1) Results that are below the minimum detectable activity (MDA) are reported as “< xx” where xx is the typical MDA value for that type of measurement. When a particular radionuclide was detected only in some of the samples in a certain sample type, the BRMP results will be reported as “≤ xx” where xx is the maximum measured activity value.
- (2) --- means “Measurements not included under BRMP and ERMP”.
- (3) During the BRMP period, among the airborne particulate samples analysed, I-131 was detected only in two weekly samples at King’s Park (activity 328 μBq m<sup>-3</sup> and 38 μBq m<sup>-3</sup>), subsequent investigation suggested that a possible source of I-131 could be the release of small amount of low-level radioactive medical waste from Queen Elizabeth Hospital nearby. Hence the I-131 activities detected in these samples during BRMP should not be interpreted as baseline activity for airborne particulate. The baseline BRMP range of I-131 in airborne particulate should be below MDA.

表 12. 二零一三年中國輻射防護研究院安排的水樣本銈-90 活度測量實驗室能力測試結果

Table 12. Results of the 2013 laboratory proficiency test on strontium-90 measurement of water samples, organised by the China Institute for Radiation Protection (CIRP)

天文台測量值 Measurement Result of the Hong Kong Observatory (Bq/L)				參考值 Reference Value (Bq/L)	偏差 <sup>(1)</sup> Deviation <sup>(1)</sup> (%)
水樣本 1 Water Sample 1	水樣本 2 Water Sample 2	水樣本 3 Water Sample 3	平均 Average		
16.1	16.4	16.2	16.2	17.5	-7.4

註:

- (1) 偏差 = (測量值 — 參考值) / 參考值 x 100%。CIRP 報告指出，根據美國能源部 RESL 實驗室組織的國際比對結果的評判標準，數據偏離參考值小於 20% 為可接受之分析結果。

Note:

- (1) Deviation = (Measured value – Reference value)/Reference value x 100%. CIRP's report indicated that according to the criteria adopted by the Radiological and Environmental Sciences Laboratory (RESL) of US Department of Energy in evaluation of international inter-laboratory comparison results, measured value with deviation less than 20% from the reference value is considered acceptable.

表 13. 二零一三年英國國家物理實驗室(NPL)籌劃的水體樣本伽馬放射性核素測量能力測試結果

Table 13. Results of the 2013 proficiency test on gamma radioactivity measurement of water samples, organised by the National Physical Laboratory of the United Kingdom (NPL).

放射性核素 Radionuclide	天文台測量值 Measurement Result of the Hong Kong Observatory (Bq/kg)	NPL 指定值 Assigned Value (Bq/kg)	Zeta ( $\zeta$ ) 評分 Score <sup>(1)</sup>	Z 評分 Score <sup>(2)</sup>	R <sub>L</sub> 測試 Test <sup>(3)</sup>
鈷-60 <sup>60</sup> Co	13.2 ± 0.6	13.23 ± 0.11	-0.05	-0.04	及格 Pass
銫-134 <sup>134</sup> Cs	3.40 ± 0.20	3.42 ± 0.03	-0.10	-0.10	及格 Pass
銫-137 <sup>137</sup> Cs	1.86 ± 0.10	1.766 ± 0.016	0.93	0.92	及格 Pass
銻-152 <sup>152</sup> Eu	20.5 ± 1.5	21.9 ± 0.4	-0.88	-1.07	及格 Pass

註 Note:

(1) Zeta 評分( $\zeta$ ) 計算方法 Calculation of Zeta Score ( $\zeta$ ):

$$\zeta = \frac{L - N}{\sqrt{u_L^2 + u_N^2}}$$

*L*: 參加測試實驗室測量值 Participant's Value;

*N*: NPL 指定值 Assigned Value

*u<sub>L</sub>*: 參加測試實驗室測量值之標準不確定度 Standard uncertainty of the Participant's Value;

*u<sub>N</sub>*: NPL 指定值之標準不確定度 Standard uncertainty of the NPL Assigned Value

Zeta 評分絕對值在 2.576 以下為可接受之測量值。Absolute value of Zeta Score below 2.576 is acceptable.

(2) Z 評分(*z*)計算方法 Calculation of Z Score (*z*):

$$z = \frac{L - N}{\sigma_p} = \frac{L - N}{0.05823 N}$$

*L*: 參加測試實驗室測量值 Participant's Value;

*N*: NPL 指定值 Assigned Value

*σ<sub>p</sub>*: 能力測試之標準不確定度 Standard uncertainty for proficiency assessment

Z 評分絕對值在 2.576 以下為可接受之測量值。Absolute value of Z Score below 2.576 is acceptable.

(3) NPL 利用四分位距離群測試決定參加測試實驗室之 R<sub>L</sub> 測試是否合格，如 R<sub>L</sub> 值比其他實驗室之 R<sub>L</sub> 值顯著較大為不合格

NPL used the Interquartile Range Outlier Test to determine whether a participant's measurement passes the R<sub>L</sub> test or not. If a participant's R<sub>L</sub> value is significantly larger than other participants' R<sub>L</sub> values, it fails the R<sub>L</sub> test.