香港環境輻射監測技術報告第 37 號
Technical Report No. 37 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

2016

江如秋 Y.C. Kong　　呂振文 C.M. Lui　　翁忠海 C.H. Yung

香港天文台
Hong Kong Observatory

二零一七年九月出版
Published in September 2017

香港天文台編製
香港九龍彌敦道134A號

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二零一六年踏入第三十年。年報收錄了監測計劃在二零一六年的主要工作內容、測量方法及結果。年報亦介紹了新的工作項目和轉變。

在二零一六年，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、氚、鍶-90 及鋂-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。

為了提高輻射監測網絡數據傳送的可靠性，所有監測站在二零一六年均陸續採用了一個政府專用通訊網絡作為其中一個主要的數據傳輸渠道。此外，數個新發展項目亦在推展中，包括更新低本底阿爾法–貝他粒子計數系統，建立在線伽馬譜法分析網絡，以及添置多一台輻射巡測車。預計這些項目將會在二零一七年完成，進一步加強天文台環境輻射監測及應急響應能力。

二零一六年的測量結果顯示，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 thirtieth year in 2016. This annual report incorporates salient features of the work of the programme during 2016, including a brief report on measurement methods and results, highlights of relevant new work and changes.

In 2016, the ambient radiation levels in Hong Kong as measured by the radiation monitoring network were all 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.

To enhance the reliability of data transmission of the Radiation Monitoring Network, a dedicated government communication network has been progressively adopted in all the monitoring stations as one of the main data transmission channels during 2016. Besides, several new development projects were also in progress, including replacement of the low level alpha-beta counting system, implementation of the online gamma spectroscopic analyser network and acquisition of an additional radiological survey vehicle. These projects are expected to be completed in 2017, thereby further strengthening the Observatory's capability in environmental radiation monitoring and emergency response.

Based on the measurement results in 2016, it is concluded that there was no measurable change in the ambient radiation levels in Hong Kong as well as the 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.

目錄

圖

頁數

表

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、測量及品質保證工作的詳情。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、食物和環境樣本活度的測量方法及儀器，以及品質保證。第 3 章則臚列二零一六年的測量結果及所得的結論。

2. 取樣、測量及品質保證

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 顯示二零一六年實時測量環境輻射的地點，圖 2 所示為二零一六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 列載二零一六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不同地點的十二個監測站(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。在二零一六年，所有監測站均陸續採用了一個政府專用通訊網絡作為其中一個主要的數據傳輸渠道，提高了數據傳送的可靠性。

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

此外，天文台在二零一六年亦進行在線伽馬譜法分析網絡建設的工作，陸續在個別輻射監測站安裝戶外伽馬譜法儀，實時監測環境中之伽馬放射性核素。測量得的譜法數據將有助提早判辨環境中有沒有異常的人工伽馬放射性核素，進一步提升應急響應及事故評估的能力。

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。在二零一六年，熱釋光劑量計網絡包括二十九個位於香港不同地點的固定監測站（圖 2）。這個網絡使用 Harshaw 8807 型號的氟化鋰(LiF:Mg,Ti)及氟化鈣(CaF_2:Dy)熱釋光劑量計。為確保數據的統計精確度，每個監測站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。

2.1.3 空中輻射監測系統

香港天文台在一九九八年開始進行空中輻射監測，並於二零一三年更換了一套新系統。目前運作之系統由Pico Envirotec Inc. 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。

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。該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。大氣飄塵中的阿爾法及貝他活度利用硫化鋅閃爍器測量，然後計算出來；大氣飄塵釋出的伽馬射線利用鍺探測器測量及伽馬譜法軟件作自動分析；碘−131 活度則利用碘化鈉探測器以量度碳濾盒。

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^3h^{-1}）	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^3h^{-1}）		
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。
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	置於車內，有需要時利用巡測車移至測量地點使用	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/高純度鍺探測器)		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。

爲了進一步加強輻射巡測的能力，天文台在二零一六年添置多一台輻射巡測車，並進行相關的組裝工作。預計新的巡測車於二零一七年投入運作。

2.1.6 高空輻射探測

天文台利用氣球攜帶 Vaisala RS92 或 Meisei RS-06G 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 或 Meisei MNS-13 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、BRL-3000M 及 HVP 4300 AFC 高容量空氣取樣器	一般設置為 17 m^3h^{-1}	透過高容量空氣取樣器內的濾紙每週收集常規大氣飄塵樣本。
	F&J Specialty Products UHV-600 更高容量空氣採樣器	一般設置為 800 m^3h^{-1}	透過更高容量空氣取樣器內的濾紙在有需要時收集大氣飄塵樣本。
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 m^3h^{-1}	濾盒每週收集和更換一次。
	附設於 F&J Specialty Products UHV-600 更高容量空氣採樣器的浸滲 TEDA (三乙烯二胺)碳濾盒	一般設置為 7.0 m^3h^{-1}	在有需要時以濾盒收集氣態碘樣本。
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 m^3h^{-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。在應急及演練時，亦可利用更高容量空氣採樣器增加大氣飄塵樣本的容量，有助提高測量效率。

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(原水)，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。

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)。

在環境保護署協助下，天文台每季均會交替在四個常規取樣地點之其中兩個抽取海水樣本。四個常規取樣地點(圖2)位於香港東部沿岸，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。二零一六年的取樣地點為大埔、粉嶺、沙頭角、大美督、城門水塘、荃灣、大欖涌水塘及青山發電廠（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 列載二零一六年樣本取樣及分析概要。

2.3 食物及環境樣本的實驗室測量

經處理後，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) 伽馬譜法分析

伽馬放射性核素的活度是採用伽馬譜法系統測量。該系統設有六個高純度鍺(HPGe)探測器，其中三個由 Ortec 公司製造，兩個由 Canberra 公司製造，餘下一個則由 Tennelec 公司製造。系統其中五個探測器使用液態氮冷卻，其餘一個(Ortec 公司)由電機冷卻，互相補足。

(b) 液體閃爍計數法

氚[†]的活度是採用 Perkin Elmer 公司製造的 TriCarb® 3170 TR/SL 型號之液體閃爍計數系統測量。

(c) 低本底總貝他計數法

鍶-90 的活度是採用 Berthold LB770-2 型號之低本底阿爾法-貝他粒子計數系統測量。更新該系統的工作於二零一六年在進行中，預計新系統於二零一七年投入業務運作。

(d) 阿爾法譜法分析

鈈-239 的活度是採用 EG&G Ortec OCTETE PC 型號之阿爾法譜法系統測量。

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

[†]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*）。

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 品質保證

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)。近年，天文台亦參加了中國原子能科學研究院(CIAE)及上海市輻射環境監督站(ShRESS)組織的比對。

在二零一六年五月，天文台參加了由 IAEA 安排就水樣本及植物(雲杉針)樣本進行之伽馬及鍶-90 活度測量的實驗室能力測試。同月，天文台亦參加了政府化驗所安排就檢定奶粉樣本中銫-134 及銫-137 活度之實驗室比對。此外，在同年十月，天文台亦參加了由上海市輻射環境監督站安排就碳濾盒及土壤樣本進行之伽馬及鍶-90 活度測量比對。詳情見 3.1.8 段。

除了參加測量比對及能力測試外，天文台亦透過內部品質保證程序，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 標準來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，天文台進一步加強環境伽馬輻射水平測量服務的管理，並於二零一五年底成功獲得 ISO 9001:2008 的認證，確保相關測量的品質管理水平符合國際標準。

認證機構會定期對輻射實驗室及環境伽馬輻射水平測量服務作跟進審查，核實其輻射測量服務可繼續獲得 ISO 9001:2008 認證。天文台輻射實驗室及環境伽馬輻射水平測量服務分別於二零一六年二月及四月順利通過年度審查，標誌著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

輻射監測網絡於二零一六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均載於表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至兩倍。

二零一六年環境伽馬劑量率的最大變幅是於十月二十一日錄得。當日香港受到與熱帶氣旋海馬相關的狂風及大雨影響，在平洲錄得的一分鐘平均劑量率較該年的平均值高出約1.2倍，但仍在本底輻射範圍之內。

3.1.2 熱釋光劑量計網絡

二零一六年各熱釋光劑量計站錄得的伽馬輻射劑量率的年平均值、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

在二零一六年一月和二月，空中輻射監測系統*以地面輻射污染測量模式分別於索罟群島和平洲進行本底輻射測量，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，測量結果與以往相若。圖 3 為測量當時這些地區的環境輻射計數率數據。

天文台亦於二零一六年十二月在大鵬灣地區及西貢以輻射煙羽追蹤模式量度垂直輻射水平。直升機由海拔約一百米升至約一千米，測量輻射水平隨高度變化，過程中並沒有探測到人工放射性核素。圖 4 顯示在大鵬灣及西貢所錄得的垂直輻射水平分佈數據。

一如以往觀測所得，在大鵬灣水面上所量度到的計數率在垂直方向並沒有明顯變化，基本上為本底輻射水平。

在西貢所錄得的垂直輻射水平分佈數據，亦一如以往觀測所得，在陸地上近地面所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。計數率數值自地面隨高度迅速遞減，直至達到相當於海面上所量度到的水平。

3.1.4 自動伽馬譜法系統

二零一六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。

* 搭載空中輻射監測系統的直升機在二零一六年中至後期因受海外飛行意外事件影響而暫停提供例行服務。

3.1.5 流動輻射監測站

二零一六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 0.034 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

天文台在二零一六年進行了共四次高空輻射探測。進行探測時的天氣情況如下：四月七日多雲，地面吹和緩東南風。五月五日多雲，地面吹輕微西南風。九月二十二日多雲，地面吹和緩東南風。十二月八日天晴，地面吹輕微東南風。

圖 5 顯示二零一六年高空輻射探測的平均大氣放射性垂直廓線，數據分析結果顯示，與以往結果大致相若(*李新偉等，2007*)。

3.1.7 食物及環境樣本

二零一六年天文台共收集了 429 個常規食物和環境樣本。表 7、8、9 和 10 分別列載樣本的伽馬譜法分析、氚、鍶-90 及釷-239 測量結果。

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二零一六年各主要樣本類別的測量結果。

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。

(a) 伽馬譜法分析

二零一六年在部分食物、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。

樣本包括海產、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) 氚

二零一六年在部份大氣、水及食物樣本中發現微量的氚，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。所偵測到的氚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) 鍶-90

二零一六年在部份大氣、食物及土壤樣本中發現微量的鍶-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、牛奶、蔬菜、水果、肉類、海產及海藻。在 BRMP 期間及過往 ERMP 的監測工作中，這些樣本中也曾發現鍶-90，相信主要也是來自以往大氣核武試驗(*UNSCEAR 2008)*。

(d) 鈈-239

二零一六年在部份潮間帶土及海床沉澱物樣本中發現微量的鈈-239，活度均在 BRMP 範圍之內。鈈-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

在二零一六年五月，天文台參加了由 IAEA 所舉辦的測量能力測試，量度由 IAEA 所提供的一個水樣本及一個植物(雲杉針)樣本內所含的伽馬及鍶-90 活度。IAEA 於同年十月公佈了有關測試的個別實驗室評估報告，該報告顯示天文台的測量結果均在 IAEA 所公佈的可接受範圍之內。表 12a – 12b 為天文台之測量結果。

同年五月，天文台亦參加了政府化驗所安排就檢定奶粉樣本中銫-134 及銫-137 活度之實驗室比對。政府化驗所隨後於六月公佈比對報告，顯示天文台的測量結果與其他參與單位的數值相當吻合。表 13 為天文台之測量結果。

在二零一六年十月，天文台亦參加了上海市輻射環境監督站安排就碳濾盒及土壤樣本進行之伽馬及鍶-90 活度測量比對。上海市輻射環境監督站在二零一七年五月的初步結果顯示天文台的測量結果與參考數值吻合。表 14 為天文台之測量結果。

3.1.9　三十年環境輻射監測結果分析

監測計劃至今已進行了三十年，天文台分析及發表當中的結果(*江如秋及李淑明，2017*)。除了在前蘇聯切爾諾貝爾核事故及日本福島核事故期間曾於部分收集的樣本檢出異常但微量的人工放射性核素外，其餘時間環境及食物樣本中的人工放射性核素活度均在本底範圍之內，而香港境內環境伽馬劑量率在 BRMP 及 ERMP 期間的長期平均值分布亦無顯著分別。

3.2 結論

二零一六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，包括銫−137、氚、鍶−90 及釙−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。

以此總結，二零一六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。

鳴謝

香港天文台感謝漁農自然護理署、土木工程拓展署、環境保護署、水務署及房屋署協助收集樣本，政府化驗所製備樣本，衛生署提供熱釋光劑量計和讀取有關數據，政府飛行服務隊配合天文台運作空中輻射監測系統，香港警務處讓天文台在其轄下警署裝設輻射監測站和自動伽馬譜法系統。我們亦衷心感謝多個政府合署和機構團體，容許香港天文台在其場地內安裝熱釋光劑量計和收集樣本。

參考文獻

1. Hong Kong Observatory (香港天文台) 1992 Environmental Radiation Monitoring in Hong Kong, Technical Report No. 8: Background Radiation Monitoring Programme 1987-1991.

2. Wong, M.C., H.Y. Mok and H.K. Lam (黃明松，莫慶炎及林鴻鋆) 1996 Effects of Weather on the Ambient Gamma Radiation Levels in Hong Kong, Proceedings of the International Congress on Radiation Protection 1996, Volume 2, pp.181-183, IRPA, Vienna, 1996. (http://www.irpa.net/irpa9/cdrom/VOL.2/V2_50.PDF)

3. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 UNSCEAR, 2000: United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 Report, Volume I, Sources and Effects of Ionizing Radiation, Annex B: Exposures from Natural Radiation Sources.

4. Wong, M.C., H.T. Poon, H.Y. Mok and Y.S. Li (黃明松，潘海濤，莫慶炎及李月嬋) 2003 Environmental Radiation Monitoring in Hong Kong – 1987 to 2002, Technical Note No. 106, Hong Kong Observatory.

5.	Hui, K.C., S.W. Li and K.C. Tsui (許建忠，李新偉及徐傑志)	2007	Performance of Hong Kong Observatory in Inter-laboratory Comparison Exercises on Radioactivity Measurements 1989 to 2005, Technical Note (Local) No. 84, Hong Kong Observatory.
6.	Li, S.W., Y.S. Li and K.C. Tsui (李新偉，李月嬋及徐傑志)	2007	Radioactivity in the atmosphere over Hong Kong, Journal of Environmental Radioactivity, vol. 94, pp. 98-106.
7.	United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)	2008	Sources and Effects of Ionizing Radiation, Volume I: Sources.
8.	江如秋及李淑明	2017	香港三十年環境輻射監測，21 世紀初輻射防護論壇第十五次會議–中國的輻射水平及影響研討會論文集，pp. 32-38

CONTENTS

FIGURES

TABLES

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, activity in food and environmental samples as well as quality assurance. Measurement results of 2016 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 2016 are shown in Figure 1. The other locations for measurement of ambient gamma radiation and collection of environmental samples in 2016 are shown in Figure 2. A summary of the sampling and analysis programme in 2016 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 different locations of the territory (Figure 1). 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. To enhance the reliability of data transmission in the RMN, a dedicated government communication network has been progressively adopted in all the monitoring stations as one of the main data transmission channels in 2016.

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

Besides, the Observatory has been implementing an online gamma spectroscopic analyzer network in 2016 with outdoor gamma spectroscopic analyzers installed progressively in selected radiation monitoring stations for monitoring the ambient gamma-emitting radionuclides in real time. The measured spectral data will facilitate early identification of abnormal presence of artificial gamma-emitting radionuclides, if any, in the environment, thus further enhancing the capability of emergency response and consequence assessment.

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

2016, the network comprises 29 fixed monitoring stations over the territory (Figure 2). The TLDs are of the lithium fluoride (LiF:Mg,Ti) and calcium fluoride (CaF_2:Dy) type (Harshaw 8807). A batch of five TLDs is placed at each station to ensure statistical accuracy. The TLDs are replaced and read on a quarterly basis.

2.1.3 Aerial Radiation Monitoring System

The Observatory started carrying out aerial radiation monitoring in 1998. The existing Aerial Radiation Monitoring System (ARMS), manufactured by Pico Envirotec Inc., has been put into operation since 2013. 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 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 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 to monitor the change in radiation levels against altitude.

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 m^3/hour and 4 m^3/hour respectively. The carbon cartridge is replaced automatically at weekly intervals. Alpha and beta activities of the particulates are measured by the ZnS scintillator and then calculated. Gamma rays emitted by the particulates are measured by the HPGe detector and analysed automatically by a gamma spectrometry analyses software. The iodine-131 activity is measured by the NaI detector on 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^3h^{-1})	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^3h^{-1})		
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.

To further enhance the capability of radiological surveillance, the Observatory acquired an additional radiological survey vehicle and carried out associated modification works in 2016. The new survey vehicle is expected to be put into operation in 2017.

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 or Meisei RS-06G). The radioactivity sensor (Model Vaisala NSS921 or Meisei MNS-13) 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 carries 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, BRL-3000M and HVP 4300 AFC)	Typically set at 17 m^3h^{-1}	Routine weekly airborne particulate sample is collected from a filter paper installed inside the High Volume Air Sampler.
	Enhanced High Volume Air Sampler (F&J Specialty Products Model UHV-600)	Typically set at 800 m^3h^{-1}	Airborne particulate sample is collected from a filter paper installed inside the Enhanced High Volume Air Sampler, when needed.
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.

Atmospheric Samples	Sampling Equipment	Flow Rate	Sampling Method
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 m^3h^{-1}	The cartridge is collected and replaced weekly.
	TEDA (triethylene di-amine) impregnated carbon cartridge included in Enhanced High Volume Air Sampler (F&J Specialty Products Model UHV-600)	Typically set at 7.0 m^3h^{-1}	The cartridge is used to collect gaseous iodine samples, when needed.
Water Vapour	Collected using a gaseous effluent sampler (Pylon Electronics Inc. Model VFP-20) with a drierite cartridge.	Typically set at 0.12 m^3h^{-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. During emergency and drills, the enhanced high volume air sampler will also be used to collect larger volume of airborne particulate samples, thus increasing the measurement efficiency.

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 (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.

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.

Each quarter, with the assistance from the Environmental Protection Department, sea water is sampled alternately at two of four routine sampling locations. The four routine 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 2016, land soil samples were collected from Tai Po, Fanling, Sha Tau Kok, Tai Mei Tuk, Shing Mun Reservoir, Tsuen Wan, Tai Lam Chung Reservoir and Castle Peak Power Station (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 2016 is summarized in Table 1 and 2.

2.3 Measurement of food and environmental samples in laboratory

After treatment, all activity 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

The activities of gamma-emitting radionuclides are determined by using a gamma spectrometry system which consists of six high purity germanium (HPGe) detectors. Three detectors were manufactured by Ortec, two by Canberra and the remaining one by Tennelec. Among the HPGe detectors, five detectors are cooled by liquid nitrogen, complemented by one remaining detector manufactured by Ortec cooled by electric system.

(b) Liquid scintillation counting
The activity of tritium[†] is measured by a liquid scintillation counting system (TriCarb® 3170 TR/SL) manufactured by Perkin Elmer.

(c) Low-level gross beta counting
The activity of strontium-90 is measured by a low level alpha-beta counting system (Berthold LB770-2). Replacement of the system was in progress in 2016. The new system is expected to become operational in 2017.

(d) Alpha spectrometry analysis
The activity of plutonium-239 is measured by an alpha spectrometry system (EG&G Ortec OCTETE PC).

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.

[†]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*).

2.5 Quality assurance

Since 1989, the Observatory has been participating in inter-laboratory comparison exercises and proficiency tests organised by international and national organisations (*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 recent years, the Observatory also participated in the comparison exercises organised by the China Institute of Atomic Energy (CIAE) and the Shanghai Radiation Environmental Supervision Station (ShRESS).

In May 2016, the Observatory participated in a laboratory proficiency test organised by IAEA for the measurement of gamma and strontium-90 activities in water and plant (spruce needles) samples. In the same month, the Observatory also joined the inter-laboratory comparison organised by the Government Laboratory on the determination of activities of caesium-134 and caesium-137 in milk powder samples. In October of the same year, the Observatory participated in the comparison organised by the ShRESS on the measurement of gamma and strontium-90 activities in carbon cartridge and soil samples. 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 Observatory further enhanced the management of its Ambient Gamma Radiation Level Measurement Service and successfully received ISO 9001:2008 accreditation in late 2015 to ensure its level of quality management meeting international standard.

The certification body will conduct annual surveillance audits of the Radiation Laboratory and the Ambient Gamma Radiation Level Measurement Service to ascertain that their radiation measurement services meet the requirements for the continuation of ISO 9001:2008 certification. The quality radiation measurement services provided by the Radiation Laboratory and the Ambient Gamma Radiation Level Measurement Service were reaffirmed upon successfully passing the annual surveillance audits in February and April 2016 respectively.

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 2016 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 the radiation level may even be a couple of times higher than the level at other times.

The most significant change in the ambient gamma dose rate in 2016 was recorded on 21 October. Under the influence of squalls and heavy rain associated with tropical cyclone Haima, the 1-minute average dose rate at Ping Chau rose to about 1.2 times 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 2016 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 2016, background measurements in the ground contamination measurement mode were conducted in January and February using the Aerial Radiation Monitoring System (ARMS)* over Soko Islands and Ping Chau respectively. The measurement height followed terrain, maintaining at a height of about 100 metres above the ground. No artificial radionuclides were detected and measurement results obtained were similar to those in the past. Figure 3 shows the ambient radioactivity count rates over the areas on the days of measurements.

The Observatory used the plume tracking mode to carry out measurements of vertical radiation level profiles over Mirs Bay and Sai Kung in December 2016. The helicopter rose from about 100 metres up to about 1000 metres above sea level to measure the change of radiation levels against altitude. No artificial radionuclides were detected. Figures 4 depicts the vertical radiation level profiles over Mirs Bay and Sai Kung.

Similar to past observations, the count rates over waters of Mirs Bay showed no significant changes with height and reflected basically the background radiation levels.

* Due to the impact of an overseas flight accident, the helicopter carrying the ARMS was temporarily put on hold for routine services in mid to late 2016.

As to the vertical radiation level profiles over Sai Kung, similar to past observations, 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. 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 2016 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 2016. The average gamma dose rates ranged from 0.034 to 0.037 $\mu Gy\ h^{-1}$ (Table 6), close to those measured in previous years.

3.1.6 Upper-air Radioactivity Soundings

Four radioactivity soundings were made in 2016. The weather conditions during these soundings were: cloudy with moderate southeasterly winds at the surface on 7 April; cloudy with light southwesterly winds at the surface on 5 May; cloudy with moderate southeasterly winds at the surface on 22 September; and fine with light southeasterly winds at the surface on 8 December.

Figure 5 shows the average vertical profiles of atmospheric radioactivity from the four upper-air radioactivity soundings in 2016. The data analysis results obtained were similar to those of past years (*Li et al. 2007*).

3.1.7 Food and Environmental Samples

A total of 429 routine food and environmental samples were collected in 2016. 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.

Only results pertaining to measurable activities of artificial radionuclides are included in all tables. For ease of reference, a summary of measurement results in 2016 for the major sample types according to different pathways is given in Table 11.

All activity 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.

(a) Gamma Spectrometry Analyses

Traces of caesium-137, an artificial gamma-emitting radionuclide, were detected in some food, soil and sediment samples in 2016. The measured activities in these samples were all within the corresponding ranges of BRMP values. The samples included seafood, 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 2016. 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 2016. The activities in these samples were within the baseline radiation levels. The samples included airborne particulates, wet deposition, total deposition, land soil, milk, vegetables, fruits, meat, seafood, and seaweed. 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 intertidal sediment and seabed sediment samples in 2016. 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 Results of Laboratory Measurement Comparisons

In May 2016, the Observatory participated in a proficiency test organised by IAEA to measure the activities of gamma-emitting radionuclides and strontium-90 in one water sample and one plant (spruce needles) sample. IAEA released the evaluation report for individual laboratory in October 2016. The report revealed that the measurement results of the Observatory were all within the acceptable ranges announced by IAEA. The Observatory's measurement results are given in Tables 12a to 12b.

In May of the same year, the Observatory joined the inter-laboratory comparison organised by the Government Laboratory on the determination of activities of caesium-134 and caesium-137 in milk powder sample. The Government Laboratory subsequently released the comparison report in June 2016. The report revealed that the measurement results of the Observatory were in good agreement with those reported by other participants. The Observatory's measurement results are given in

Table 13.

In October 2016, the Observatory also participated in the comparison organised by the ShRESS to measure the activities of gamma-emitting radionuclides and strontium-90 in carbon cartridge and soil samples. ShRESS's preliminary results in May 2017 indicated that the measurement results of the Observatory agreed with the reference values. The Observatory's measurement results are given in Table 14.

3.1.9 Analysis of 30 Years of Environmental Radiation Monitoring Results

The ERMP has been in operation for thirty years hitherto. The Observatory carried out an analysis and published the results (*Kong Y.C. and Olivia S.M. Lee 2017*). Apart from the abnormal but trace amount of artificial radionuclides measured in some collected samples during the periods of the Chernobyl nuclear accident in the former Soviet Union and the Fukushima nuclear accident in Japan, the activity concentrations of artificial radionuclides measured in the environmental and food samples in the programme were within the baseline levels. The distributions of long term average of ambient gamma dose rates over the territory between BRMP and ERMP did not show any significant differences.

3.2 Conclusion

The ambient gamma dose rates recorded over various parts of the territory in 2016 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 is concluded that in 2016 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.

REFERENCES

1.	Hong Kong Observatory	1992	Environmental Radiation Monitoring in Hong Kong, Technical Report No. 8: Background Radiation Monitoring Programme 1987-1991.
2.	Wong, M.C., H.Y. Mok and H.K. Lam	1996	Effects of Weather on the Ambient Gamma Radiation Levels in Hong Kong, Proceedings of the International Congress on Radiation Protection 1996, Volume 2, pp.181-183, IRPA, Vienna, 1996. (http://www.irpa.net/ irpa9/cdrom/VOL.2/V2_50.PDF)
3.	United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)	2000	UNSCEAR, 2000: United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 Report, Volume I, Sources and Effects of Ionizing Radiation, Annex B: Exposures from Natural Radiation Sources.
4.	Wong, M.C., H.T. Poon, H.Y. Mok and Y.S. Li	2003	Environmental Radiation Monitoring in Hong Kong – 1987 to 2002, Technical Note No. 106, Hong Kong Observatory.
5.	Hui, K.C., S.W. Li and K.C. Tsui	2007	Performance of Hong Kong Observatory in Inter-laboratory Comparison Exercises on Radioactivity Measurements 1989 to 2005, Technical Note (Local) No. 84, Hong Kong Observatory.
6.	Li, S.W., Y.S. Li and K.C. Tsui	2007	Radioactivity in the atmosphere over Hong Kong, Journal of Environmental Radioactivity, vol. 94, pp. 98-106.
7.	United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)	2008	Sources and Effects of Ionizing Radiation, Volume I: Sources.
8.	Kong, Y.C. and Olivia S.M. Lee	2017	30 Years of Environmental Radiation Monitoring in Hong Kong, Conference Proceedings of the 15th meeting of Radiation Protection Forum in the early 21st Century – Radiation level and its impacts on China, pp. 32-38 (in Chinese with English abstract)

圖 1. 二零一六年實時監測環境輻射的測量點。

Figure 1. Locations for real-time measurement of ambient radiation in 2016.

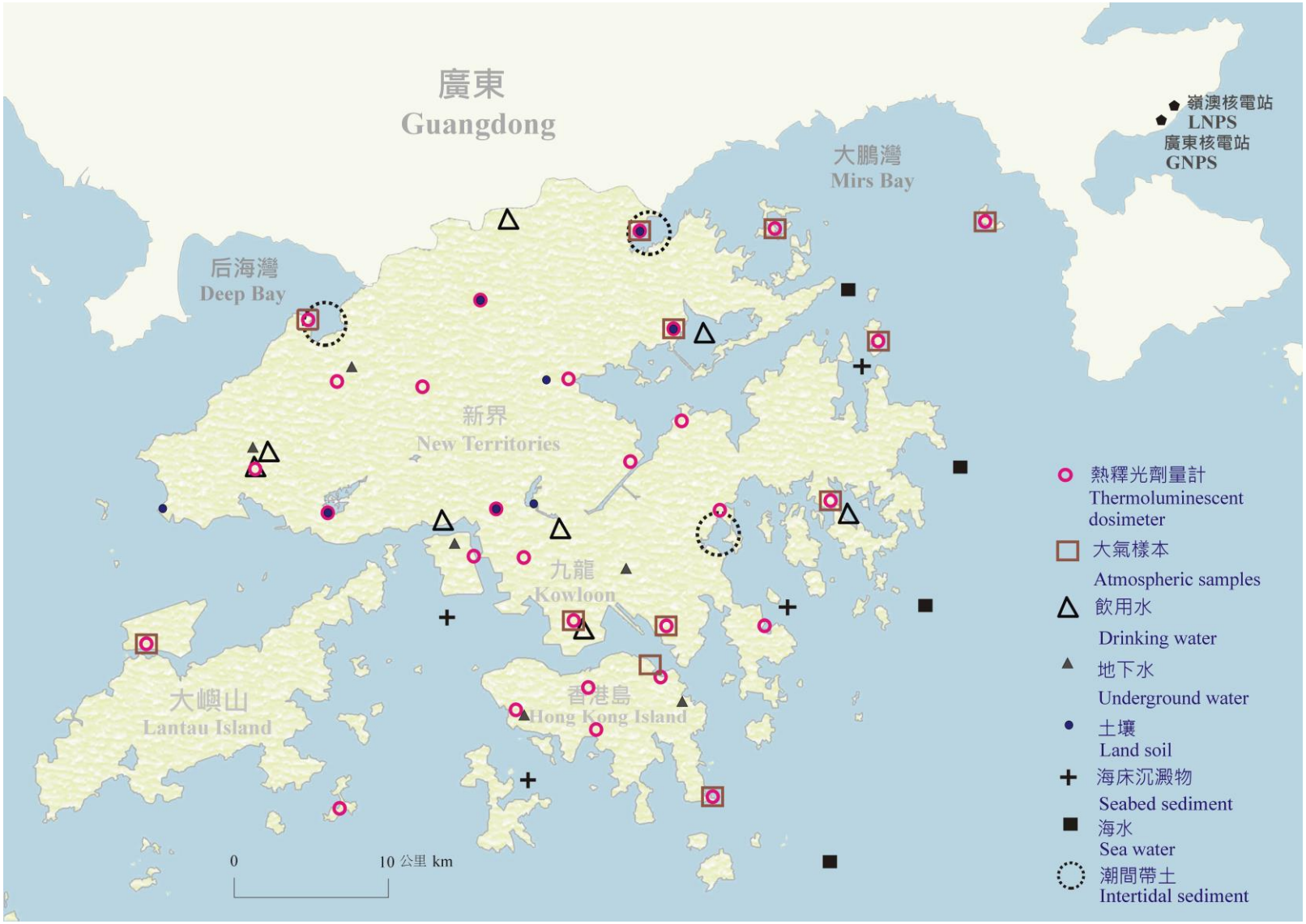

圖 2. 熱釋光劑量計網絡及二零一六年環境樣本收集點。

Figure 2. Thermoluminescent dosimeter network and locations for collection of environmental samples in 2016.

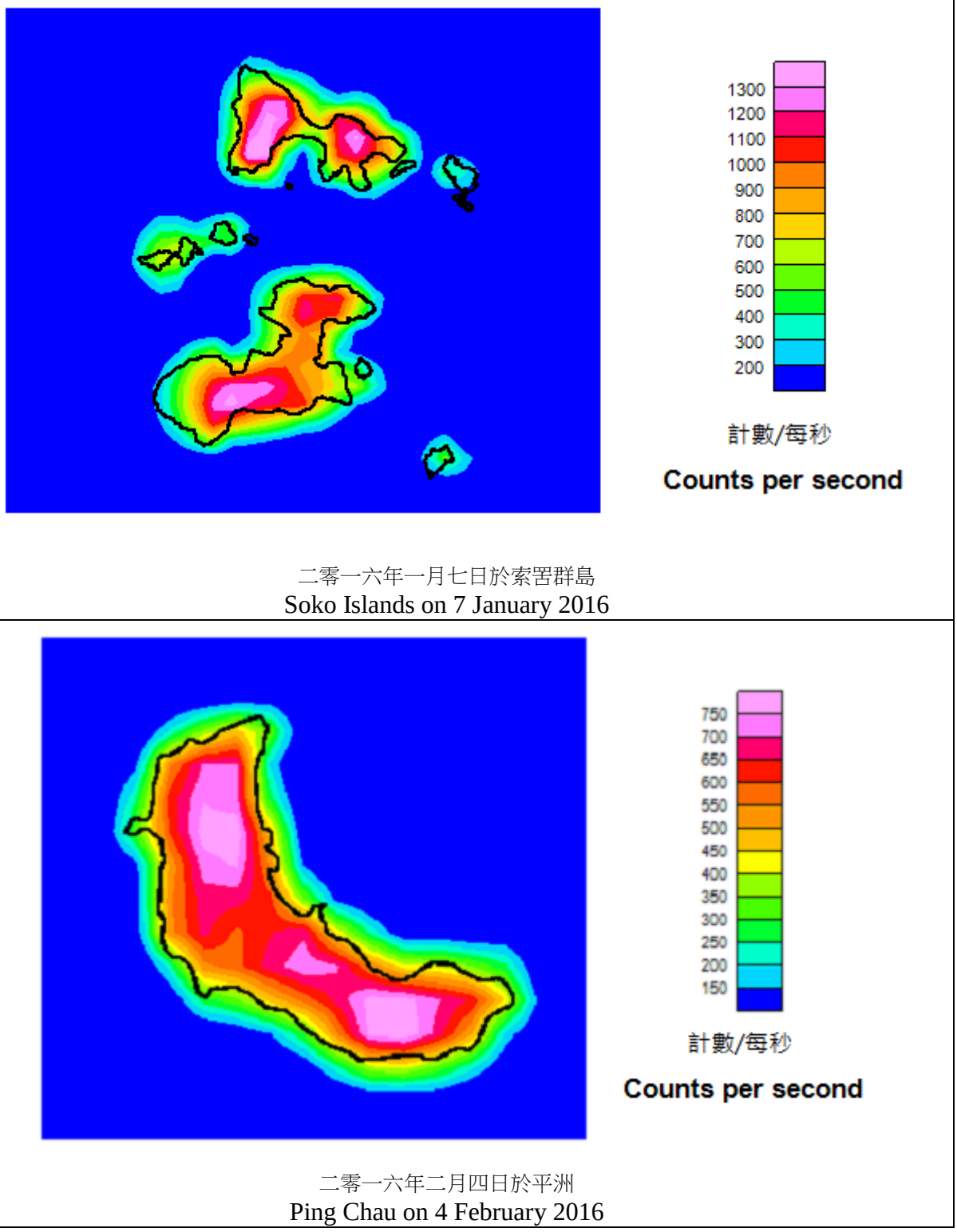

圖 3. 空中輻射監測系統在二零一六年分別於索罟群島和平洲測量到的計數率（測量高度距離地面約一百米）。

Figure 3. Count rate over Soko Islands and Ping Chau respectively as measured by the Aerial Radiation Monitoring System in 2016 (at about 100 metres above the ground)

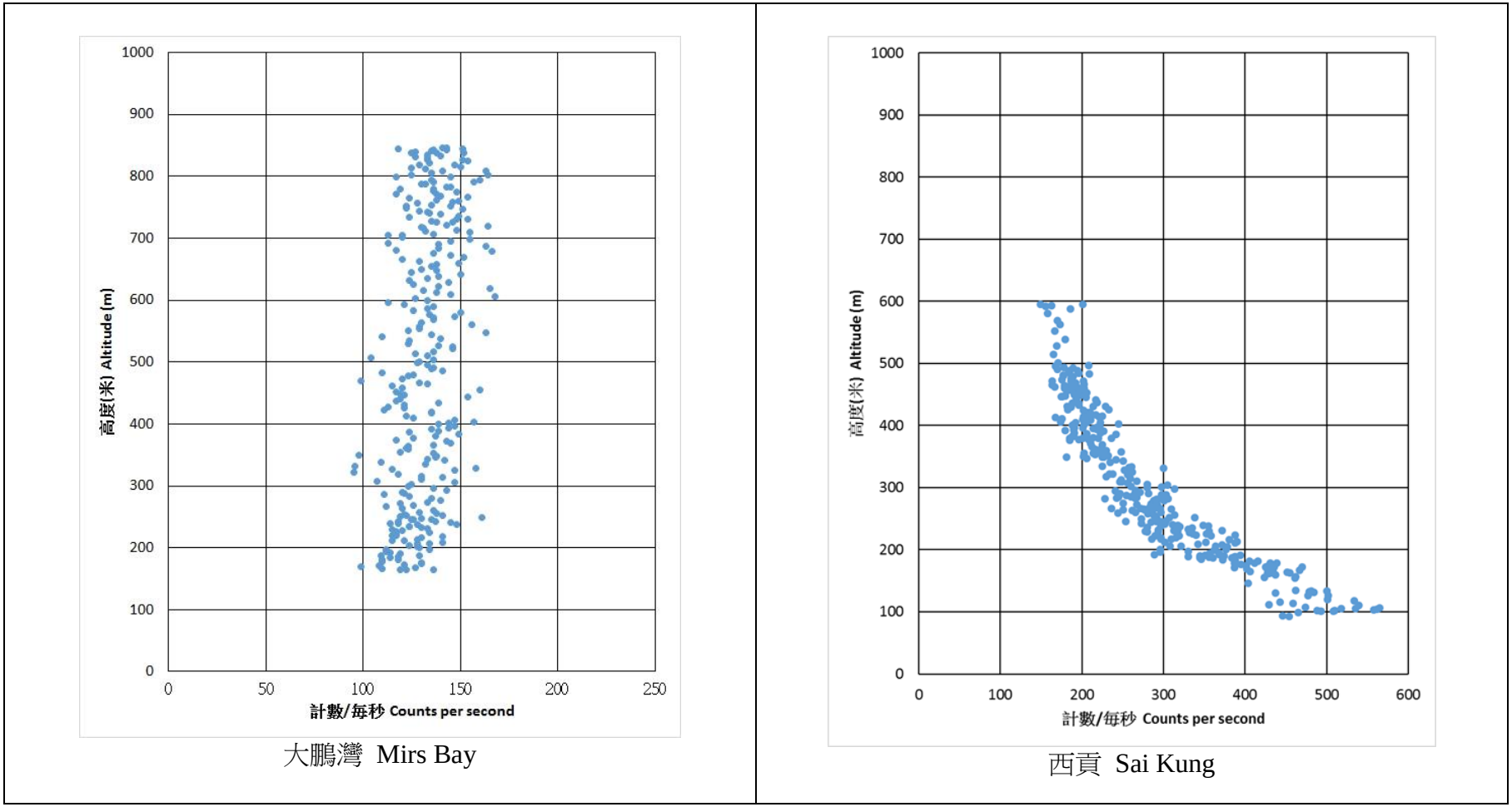

圖 4. 空中輻射監測系統在二零一六年十二月十五日於大鵬灣海面及西貢上空測量到的計數率隨高度的變化。

Figure 4. Variation of count rate with altitude at Mirs Bay and Sai Kung as measured by the Aerial Radiation Monitoring System on 15 December 2016.

[數據的分佈密度會根據直升機爬升速度而有所變化。]
[The density of data will vary with the climbing speed of the helicopter.]

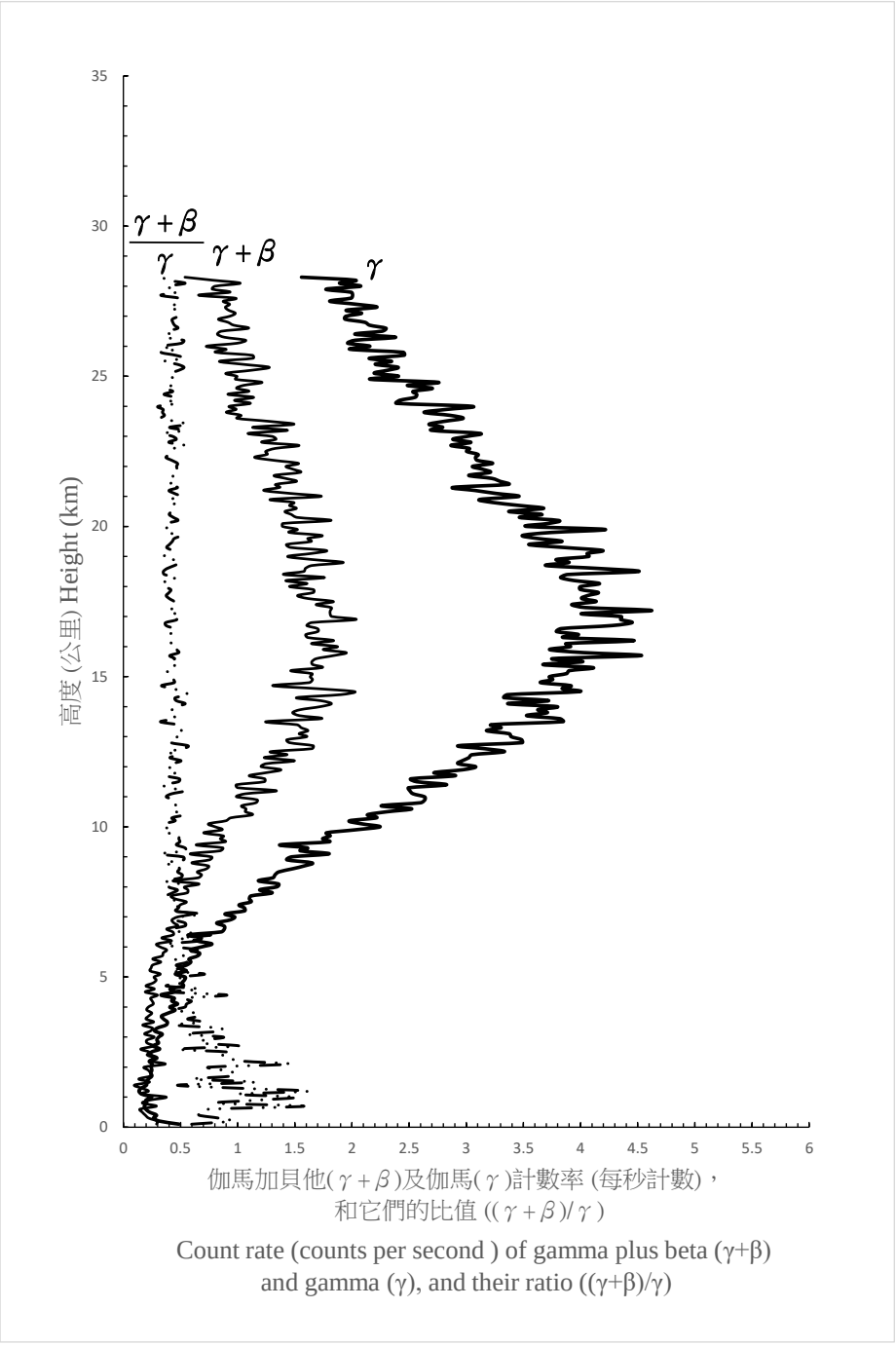

圖 5.　二零一六年內在京士柏進行的高空輻射探測之平均大氣放射性垂直廓線(探測日期為：四月七日、五月五日、九月二十二日、十二月八日)。

Figure 5. Average vertical profiles of atmospheric radioactivity from upper-air radioactivity soundings conducted at King's Park in 2016 (dates of sounding: 7 April, 5 May, 22 September and 8 December).

[平均值由 Vaisala NSS921 型號及 Meisei MNS-13 型號的輻射探測組件數據計算而成。]

[The average is computed based on the data from both the radioactivity sensors of model Vaisala NSS921 and model Meisei MNS-13.]

表 1.　二零一六年樣本取樣及分析概要

Table 1.　Summary of the sampling and analysis programme in 2016

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
環境伽馬輻射 Ambient Gamma Radiation				
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, 赤鱲角 Chek Lap Kok	12	伽馬 γ	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, 赤鱲角 Chek Lap Kok, 青衣 Tsing Yi	29	伽馬 γ	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
大氣樣本 Atmospheric Samples				
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 γ, 鍶-90 Sr-90, 鈈-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 γ 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γ, 氚 H-3, 鍶-90 Sr-90, 鈈-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γ, 氚 H-3, 鍶-90 Sr-90, 鈈-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 γ	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
地面樣本 Terrestrial Samples				
食米 Rice	內地 Mainland	1	伽馬γ, 氚 H-3, 鍶-90 Sr-90	每季 quarterly
牛奶(經消毒) Pasteurized milk	內地 Mainland	1	伽馬γ, 氚 H-3, 鍶-90 Sr-90	每季 quarterly
菜心 Choi sum	內地 Mainland, 本地 Local	2	伽馬γ, 氚 H-3, 鍶-90 Sr-90	每季 quarterly
白菜 Pak choi	內地 Mainland, 本地 Local	2	伽馬γ, 氚 H-3, 鍶-90 Sr-90	每季 quarterly
香蕉 Banana	內地 Mainland	1	伽馬γ, 氚 H-3, 鍶-90 Sr-90	每季 quarterly
荔枝 Lychee	內地 Mainland	1	伽馬γ, 氚 H-3, 鍶-90 Sr-90	夏季 summer
柑橘 Mandarin	內地 Mainland	1	伽馬γ, 氚 H-3, 鍶-90 Sr-90	秋季及冬季 autumn and winter
甘蔗 Sugar cane	內地 Mainland	1	伽馬γ, 氚 H-3, 鍶-90 Sr-90	春季 spring
雞 Chicken	內地 Mainland, 本地 Local	2	伽馬γ, 氚 H-3, 鍶-90 Sr-90	每季 quarterly
鴨 Duck	內地 Mainland	1	伽馬γ, 氚 H-3, 鍶-90 Sr-90	每季 quarterly
牛肉 Beef	內地 Mainland	1	伽馬γ, 氚 H-3, 鍶-90 Sr-90	每季 quarterly
豬肝 Pig's liver	內地 Mainland, 本地 Local	2	伽馬γ, 氚 H-3, 鍶-90 Sr-90	每季 quarterly
豬肉 Pork	內地 Mainland, 本地 Local	2	伽馬γ, 氚 H-3, 鍶-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 γ, 鍶-90 Sr-90, 鈈-239 Pu-239	每一地點每 5 年採樣一次 Each location is sampled once every 5 years. * 2016 年採樣地點 * locations sampled in 2016

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
水體樣本 Aquatic Samples				
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[)] Yau Kom Tau Treatment Works	5	伽馬 γ, 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 Yau Kom Tau Treatment Works	6	伽馬 γ, 氚 H-3	每季 quarterly
樽裝水(蒸餾水) Bottled water (Distilled)	本地 Local	1	伽馬 γ, 氚 H-3	每季 quarterly
樽裝水(礦泉水) Bottled water (Mineral)	本地 Local	1	伽馬 γ, 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 γ, 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 γ, 氚 H-3	每季 quarterly
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 γ, 鍶-90 Sr-90, 鈈-239 Pu-239	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
水體樣本 Aquatic Samples				
大魚 *Aristichthys nobilis* (Big-head carp)	深圳 Shenzhen, 元朗 Yuen Long	2	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
瓜三 *Nemipterus japonicus* (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 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
牛鰍 *Platycephalus indicus* (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 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
牙帶 *Trichiurus haumela* (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 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
三點蟹 *Portunus sanguinolentus* (Three-spotted crab)	香港以西海域 Seas west of Hong Kong, 香港水域 Hong Kong Waters	2	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
赤米蝦 *Metapenaeopsis barbata* (Fire prawn)	香港以西海域 Seas west of Hong Kong, 香港水域 Hong Kong Waters	2	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
魷魚 *Loligo edulis* (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 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
墨魚 *Sepia spp.* (Cuttlefish)	香港水域 Hong Kong Waters	1	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
蜆 *Tapes philippinarum* (Clam)	長洲 Cheung Chau, 吐露港 Tolo Harbour	2	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
青口 *Perna viridis* (Green-lipped mussel)	長洲 Cheung Chau, 吐露港 Tolo Harbour, 大亞灣 Daya Bay	3	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
東風螺 *Babylonia formosae* (Gastropod)	香港水域 Hong Kong Waters	1	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	每季 quarterly
石蒓 *Ulva lactuca* (Sea lettuce)	布袋澳 Po Toi O	1	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-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
水體樣本 Aquatic Samples				
滸苔 *Enteromorpha prolifera* (Sea hair)	吐露港 Tolo Harbour	1	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	冬季 winter
長紫菜 *Porphyra dentata* (Red algae)	蒲台島 Po Toi Island	1	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-239 Pu-239	冬季 winter
半葉馬尾藻 *Sargassum hemiphyllum* (Brown algae)	布袋澳 Po Toi O	1	伽馬 γ, 氚 H-3, 鍶-90 Sr-90, 鈈-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 γ, 鈈-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 γ, 鈈-239 Pu-239	每年 yearly

表 2. 二零一六年食物樣本概要
Table 2. Summary of food samples in 2016

類別 Type	**地點 Location**	**收集樣本數目 No. of samples collected**
食米 Rice	內地(珠江三角洲) Mainland (Pearl River Delta)	4
牛奶(經消毒) Pasteurized milk	內地(深圳/惠州) Mainland (Shenzhen/Huizhou)	8
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 *Aristichthys nobilis* (Big-head carp)	深圳 Shenzhen	3
	元朗 Yuen Long	3
瓜三 *Nemipterus japonicus* (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
牛鰍 *Platycephalus indicus* (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 *Trichiurus haumela* (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 *Portunus sanguinolentus* (Three-spotted crab)	香港以西海域 Seas west of Hong Kong	1
	香港水域 Hong Kong Waters	4

表 2. (續)
Table 2. (cont'd)

類別 Type	**地點 Location**	**收集樣本數目 No. of samples collected**
赤米蝦 *Metapenaeopsis barbata* (Fire prawn)	香港以西海域 Seas west of Hong Kong	1
	香港水域 Hong Kong Waters	4
魷魚 *Loligo edulis* (Squid)	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
墨魚 *Sepia spp.* (Cuttlefish)	香港水域 Hong Kong Waters	4
蜆 *Tapes philippinarum* (Clam)	長洲 Cheung Chau	2
	吐露港 Tolo Harbour	2
青口 *Perna viridis* (Green-lipped mussel)	長洲 Cheung Chau	3
	吐露港 Tolo Harbour	3
	大亞灣 Daya Bay	3
東風螺 *Babylonia formosae* (Gastropod)	香港水域 Hong Kong Waters	4
石蓯 *Ulva lactuca* (Sea lettuce)	布袋澳 Po Toi O	2
滸苔 *Enteromorpha prolifera* (Sea hair)	吐露港 Tolo Harbour	1
長紫菜 *Porphyra dentata* (Red algae)	蒲台島 Po Toi Island	0
半葉馬尾藻 *Sargassum hemiphyllum* (Brown algae)	布袋澳 Po Toi O	2

表 3. 二零一六年樣本之主要量度參數概要[1]

Table 3. Summary of key measurement parameters for samples in 2016[1]

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[2] Minimum Detectable Activity[2] (MDA)	
					碘-131 I-131	銫-137 Cs-137
伽馬放射性核素 Gamma emitting radionuclides	大氣飄塵 Airborne Particulate	17 m^3h^{-1} (由高容量取樣器收集) (collected by High Volume Air Sampler)	12000 m^3 (累積每月樣本 bulked monthly sample)	55000	10 μBq m^{-3}	10 μBq m^{-3}
			3000 m^3 (每週樣本 weekly sample)	20000	50 μBq m^{-3}	50 μBq m^{-3}
		800 m^3h^{-1} (由更高容量採樣器收集)[3] (collected by Enhanced High Volume Air Sampler)[3]	800 m^3 (每小時樣本 hourly sample) | 19200 m^3 (每日樣本 daily sample)	900 | 10800	60 | 8000 μBq m^{-3}	60 | 10000 μBq m^{-3}
	氣態碘 Gaseous Iodine	2.5 m^3h^{-1} (由放射性碘取樣器收集) (collected by Radioiodine Sampler)	400 m^3 (每週樣本 weekly sample)	55000	300 μBq m^{-3}	-
		7 m^3h^{-1} (由更高容量採樣器收集)[3] (collected by Enhanced High Volume Air Sampler)[3]	7 m^3 (每小時樣本 hourly sample) | 168 m^3 (每日樣本 daily sample)	900 | 10800	2 | 150 mBq m^{-3}	-
	濕沉積物 Wet deposition	-	4 L	55000	0.2 Bq L^{-1}	0.2 Bq L^{-1}
	總沉積物 Total deposition	-	0.03 m^2	55000	15 Bq m^{-2}	15 Bq m^{-2}
	食米 Rice	-	4 kg	20000	0.1 Bq kg^{-1}	0.1 Bq kg^{-1}
	牛奶 Milk	-	1 L	55000	0.2 Bq L^{-1}	0.3 Bq L^{-1}
	蔬菜 Vegetable	-	1 kg	20000	0.3 Bq kg^{-1}	0.4 Bq kg^{-1}
	水果 Fruit	-	2 kg	20000	0.3 Bq kg^{-1}	0.3 Bq kg^{-1}
	家禽 Poultry	-	2 kg	20000	0.2 Bq kg^{-1}	0.2 Bq kg^{-1}
	肉類 Meat	-	1 kg	20000	0.4 Bq kg^{-1}	0.4 Bq kg^{-1}
	土壤 Land soil	-	1 kg	20000	1.0 Bq kg^{-1}	1.5 Bq kg^{-1}
	水樣本 Water samples	-	4 L	55000	0.1 Bq L^{-1}	0.1 Bq L^{-1}
	海水中懸浮粒子 Suspended particulate	-	5 L	55000	0.02 Bq L^{-1}	0.02 Bq L^{-1}
	海產 Seafood	-	2 kg	72000	0.1 Bq kg^{-1}	0.1 Bq kg^{-1}
	海藻 Seaweed	-	0.5 kg	20000	1 Bq kg^{-1}	2 Bq kg^{-1}
	潮間帶土/海床沉澱物 Sediment	-	2 kg	20000	0.5 Bq kg^{-1}	0.5 Bq kg^{-1}

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(2) Minimum Detectable Activity(2) (MDA)
氚 Tritium	濕沉積物 Wet deposition	0.007 L	18000	2	25	-	4 Bq L^{-1}
	總沉積物 Total deposition	0.0001 m^2	18000	2	25	-	300 Bq m^{-2}
	水蒸氣 Water vapour	2 m^3	18000	2	25	-	0.01 Bq m^{-3}
	食米 Rice	0.08 kg	18000	2	25	-	0.3 Bq kg^{-1}
	牛奶 Milk	0.007 L	18000	2	25	-	4 Bq L^{-1}
	蔬菜 Vegetable	0.008 kg	18000	2	25	-	3 Bq kg^{-1}
	水果 Fruit	0.01 kg	18000	2	25	-	3 Bq kg^{-1}
	家禽 Poultry	0.02 kg	18000	2	25	-	2 Bq kg^{-1}
	肉類 Meat	0.01 kg	18000	2	25	-	3 Bq kg^{-1}
	水樣本 Water samples	0.007 L	18000	2	25	-	4 Bq L^{-1}
	地下水 Underground water	0.1 L	18000	2	25	-	0.3 Bq L^{-1}
	海產 Seafood	0.02 kg	18000	2	25	-	1 Bq kg^{-1}
	海藻 Seaweed	0.05 kg	18000	2	25	-	1 Bq kg^{-1}
鍶-90 Strontium-90	大氣飄塵 Airborne particulate	5000 m^3	30000	1	75	90	1 μ Bq m^{-3}
	濕沉積物 Wet deposition	2 L	30000	1	75	100	0.002 Bq L^{-1}
	總沉積物 Total deposition	0.01 m^2	30000	1	75	100	0.5 Bq m^{-2}
	米 Rice	3 kg	30000	1	75	90	0.002 Bq kg^{-1}
	牛奶 Milk	1 L	30000	1	75	90	0.005 Bq L^{-1}
	蔬菜 Vegetable	1 kg	30000	1	75	90	0.005 Bq kg^{-1}
	水果 Fruit	2 kg	30000	1	75	90	0.003 Bq kg^{-1}
	家禽 Poultry	2 kg	30000	1	75	90	0.003 Bq kg^{-1}
	肉類 Meat	1 kg	30000	1	75	90	0.005 Bq kg^{-1}
	土壤 Land soil	0.005 kg	30000	1	75	90	1 Bq kg^{-1}
	海水中懸浮粒子 Suspended particulate	3 L	30000	1	75	90	0.002 Bq L^{-1}
	海產 Seafood	1.5 kg	30000	1	75	90	0.004 Bq kg^{-1}
	海藻 Seaweed	0.05 kg	30000	1	75	90	0.1 Bq kg^{-1}

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(2) Minimum Detectable Activity(2) (MDA)
鈈-239 Plutonium-239	大氣飄塵 Airborne particulate	6000 m^3	220000	0.003	20	40	0.2 μ Bq m^{-3}
	濕沉積物 Wet deposition	2 L	220000	0.003	20	60	0.0004 Bq L^{-1}
	總沉積物 Total deposition	0.01 m^2	220000	0.003	20	60	0.07 Bq m^{-2}
	土壤 Land soil	0.003 kg	220000	0.003	20	50	0.3 Bq kg^{-1}
	海水中懸浮粒子 Suspended particulate	3 L	220000	0.003	20	50	0.0003 Bq L^{-1}
	海產 Seafood	0.5 kg	220000	0.003	20	40	0.002 Bq kg^{-1}
	海藻 Seaweed	0.05 kg	220000	0.003	20	60	0.01 Bq kg^{-1}
	潮間帶土 / 海床沉澱物 Sediment	0.003 kg	220000	0.003	20	50	0.3 Bq kg^{-1}

註:

(1) 表內所列是 ERMP 在二零一六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。

(3) 列出的數值為更高容量採樣器使用的參數和探測下限的一般範圍。採樣及計數時間或會按不同情況而改變。

Note:

(1) The values given in the table are typical values of key measurement parameters in the ERMP in 2016. 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.

(3) The values listed are the typical ranges of parameters and MDA of the Enhanced High Volume Air Sampler (EHVAS). The sampling and counting times will be adjusted depending on different situations.

表 4a. 輻射監測網絡在二零一六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 2016 (dose rate in μGy 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[2]	0.095	0.006	0.074 – 0.132
京士柏 King's Park	0.142	0.003	0.127 – 0.214
觀塘 Kwun Tong	0.119	0.002	0.101 – 0.177
平洲 Ping Chau	0.079	0.003	0.068 – 0.176
西灣河 Sai Wan Ho	0.092	0.004	0.077 – 0.176
沙頭角 Sha Tau Kok	0.102	0.002	0.089 – 0.188
大美督 Tai Mei Tuk[3]	0.127	0.004	0.111 – 0.208
塔門 Tap Mun	0.087	0.003	0.074 – 0.168
尖鼻咀 Tsim Bei Tsui	0.128	0.003	0.115 – 0.220
元五墳 Yuen Ng Fan	0.117	0.003	0.105 – 0.201
赤鱲角 Chek Lap Kok	0.145	0.003	0.123 – 0.190
鶴咀 Cape D'Aguilar	0.131	0.003	0.118 – 0.239
參考範圍[1] Reference Range[1]			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。
(2) 吉澳監測站於二零一六年六月一日更換高壓電離室，更新儀器後錄得的數據跟之前大致相若。
(3) 大美督輻射監測站於二零一六年十一月二十二日從大美督活動訓練中心附近地面的臨時站址搬回該中心天台原址。

Note: (1) Reference range is the ambient gamma dose rates recorded by the radiation monitoring network from 1992 to 1996.
(2) The high pressure ionization chamber in the radiation monitoring station at Kat O was replaced on 1 June 2016. The gamma dose rates measured before and after equipment replacement were generally comparable.
(3) The radiation monitoring station at Tai Mei Tuk, temporarily located on the ground next to the Tai Mei Tuk Activity Training Centre, was relocated back to its original site at the rooftop of the Centre on 22 November 2016.

表 4b. 熱釋光劑量計網絡在二零一六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 2016 (dose rate in μGy 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	0.15	0.01	0.13 – 0.16
赤鱲角 Chek Lap Kok	0.14	0.01	0.13 – 0.15
長洲 Cheung Chau	0.12	0.01	0.11 – 0.12
置富花園 Chi Fu Fa Yuen	0.16	0.01	0.14 – 0.17
清水灣 Clear Water Bay	0.10	0.01	0.10 – 0.11
深水灣 Deep Water Bay	0.11	0.01	0.10 – 0.12
粉嶺 Fanling	0.11	0.01	0.10 – 0.12
跑馬地 Happy Valley	0.09	0.01	0.08 – 0.10
吉澳 Kat O	0.11	0.01	0.10 – 0.12
京士柏 King's Park	0.14	0.01	0.13 – 0.16
觀塘 Kwun Tong	0.11	0.01	0.11 – 0.12
平洲 Ping Chau	0.12	0.01	0.11 – 0.13
西貢 Sai Kung	0.12	0.01	0.11 – 0.13
沙頭角 Sha Tau Kok	0.09	0.01	0.08 – 0.10
BRMP 參考數值[(1)] **BRMP Reference Values**[(1)]			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	0.14	0.01	0.13 – 0.15
石崗 Shek Kong	0.12	0.01	0.12 – 0.13
石梨貝 Shek Lei Pui	0.19	0.01	0.18 – 0.21
大欖涌 Tai Lam Chung	0.18	0.01	0.17 – 0.19
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	0.09	0.01	0.08 – 0.10
尖鼻咀 Tsim Bei Tsui	0.13	0.01	0.12 – 0.14
青衣 Tsing Yi	0.14	0.01	0.14 – 0.15
荃灣 Tsuen Wan	0.14	0.01	0.12 – 0.15
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	0.10 – 0.12
元五墳 Yuen Ng Fan	0.13	0.01	0.12 – 0.14
BRMP 參考數值(1) **BRMP Reference Values**(1)			0.03 – 0.29

註: (1) BRMP 參考數值為熱釋光劑量計網絡於 BRMP 期間所錄得的環境伽馬劑量率範圍。

Note: (1) 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二零一六年的輻射測量結果

Table 5. Results of measurement by the Automatic Gamma Spectrometry System at Ping Chau in 2016

	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[(1)] Reference range from first 5 years of operation (1997 - 2001) [(1)]**
阿爾法粒子 Alpha (每立方米貝可 Bq m^{-3})	30 m^3h^{-1}	1.5	0.4	1.0 – 2.5	1.0 – 5.8
貝他粒子 Beta (每立方米貝可 Bq m^{-3})	30 m^3h^{-1}	1.6	0.6	1.0 – 4.2	1.0 – 10.1
碘-131 I-131 (每立方米毫貝可 mBq m^{-3})	30 m^3h^{-1}	< 4	N/A[(2)]	N/A	< 4[(3)]
銫-137 Cs-137 (每立方米毫貝可 mBq m^{-3})	30 m^3h^{-1}	< 4	N/A	N/A	< 4
氣態碘-131 Gaseous I-131 (每立方米貝可 Bq m^{-3})	4 m^3h^{-1}	< 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. 二零一六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 2016 (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^{-1})**
二零一六年三月十八日	18 March 2016	0.036
二零一六年六月十七日	17 June 2016	0.034
二零一六年九月十四日	14 September 2016	0.037
二零一六年十二月十二日	12 December 2016	0.035

表 7. 二零一六年食物及環境樣本中之人工伽馬放射性核素的可測量(1)伽馬活度測量結果

Table 7. Measurement results of measurable(1) gamma activities of artificial gamma-emitting radionuclides in food and environmental samples in 2016

(每公斤貝可 Bq kg^{-1})

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(2) Activity(2)	BRMP 範圍(3) BRMP range(3)	單位 Unit
牙帶 *Trichiurus haumela* (Hair tail)	大亞灣 Daya Bay	1	-	0.1	≤ 0.2	Bq kg^{-1}
	香港以西海域 Seas west of Hong Kong	1	-	0.1		
土壤(上層) Land soil (upper)	見表 1 See Table 1	4	0.4 – 2.1	1.4	≤ 10.0	Bq kg^{-1}
土壤(下層) Land soil (lower)	見表 1 See Table 1	1	-	1.8	≤ 4.0	Bq kg^{-1}
潮間帶土(上層) Intertidal sediment (upper)	白沙灣 Pak Sha Wan	4	0.2 – 0.5	0.4	≤ 2.4	Bq kg^{-1}
	尖鼻咀 Tsim Bei Tsui	4	0.3 – 0.5	0.4		
	沙頭角 Sha Tau Kok	4	0.5	0.5		
潮間帶土(下層) Intertidal sediment (lower)	白沙灣 Pak Sha Wan	4	0.2 – 0.4	0.3	≤ 3.1	Bq kg^{-1}
	尖鼻咀 Tsim Bei Tsui	4	0.4 – 0.5	0.4		
	沙頭角 Sha Tau Kok	4	0.3 – 0.5	0.4		
海床沉澱物 Seabed sediment	大灘海 Tai Tan Hoi	1	-	0.3	≤ 1.9	Bq kg^{-1}
	龍蝦灣 Lung Ha Wan	1	-	0.2		
	索罟灣 Picnic Bay	1	-	0.6		
	西區碇泊處 Western Anchorage	1	-	0.4		

註: (1) 當在樣本中可分辨出相關核素的伽馬射線能峰，而測量信號亦高於該能譜本底時，該樣本的測量結果視為"可測量"。

(2) 如有多過一個樣本發現可測量活度，此欄則報告平均值。

(3) 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) When the gamma energy peak(s) of the concerned nuclide is/are discernible in a sample and the detected signal is above the respective spectral background, the measurement result of that sample is considered as "measurable".

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

(3) 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. 二零一六年食物及環境樣本的可測量[(1)]氚活度測量結果

Table 8. Measurement results of measurable[(1)] activities of tritium in food and environmental samples in 2016

(每公斤貝可 Bq kg^{-1}；每公升貝可 Bq L^{-1}；每平方米貝可 Bq m^{-2}；每立方米貝可 Bq m^{-3})

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[(2)] Activity[(2)]**	**BRMP 範圍[(3)] BRMP range[(3)]**	**單位 Unit**
食米 Rice	內地 Mainland	1	-	0.1	< 1	Bq kg^{-1}
牛奶(經消毒) Pasteurized milk	內地(深圳) Mainland (Shenzhen)	1	-	2.0	< 6	Bq L^{-1}
	內地(惠州) Mainland (Huizhou)	2	0.7 – 1.1	0.9		
菜心 Choi sum	深圳 Shenzhen	4	0.7 – 2.8	1.5	≤ 7.4	Bq kg^{-1}
	本地 Local	4	0.4 – 1.7	1.0		
白菜 Pak choi	深圳 Shenzhen	1	-	0.3	< 6	Bq kg^{-1}
	本地 Local	1	-	0.6		
香蕉 Banana	內地 Mainland	2	0.1 – 0.5	0.3	< 3	Bq kg^{-1}
柑橘 Mandarin	內地 Mainland	2	0.5 – 1.6	1.1	< 4	Bq kg^{-1}
雞 Chicken	內地 Mainland	1	-	0.3	≤ 2.2	Bq kg^{-1}
	本地 Local	2	0.1	0.1		
鴨 Duck	內地 Mainland	2	0.1	0.1	≤ 3.5	Bq kg^{-1}
牛肉 Beef	內地 Mainland	2	0.4 – 0.6	0.5	≤ 5.3	Bq kg^{-1}
豬肝 Pig's liver	內地 Mainland	1	-	1.0	< 4	Bq kg^{-1}
	本地 Local	2	0.6 – 1.0	0.8		
豬肉 Pork	內地 Mainland	1	-	0.3	< 4	Bq kg^{-1}
	本地 Local	1	-	0.2		
大魚 *Aristichthys nobilis* (Big-head carp)	深圳 Shenzhen	1	-	0.1	< 2	Bq kg^{-1}
	元朗 Yuen Long	1	-	0.3		
瓜三 *Nemipterus japonicus* (Melon coat)	大亞灣 Daya Bay	1	-	0.3	< 2	Bq kg^{-1}
	香港水域 Hong Kong Waters	2	0.1– 0.3	0.2		
	香港以西海域 Seas west of Hong Kong	1	-	0.3		
牛鰍 *Platycephalus indicus* (Bartail flathead)	大亞灣 Daya Bay	1	-	0.6	< 2	Bq kg^{-1}
	香港水域 Hong Kong Waters	2	0.3 – 0.9	0.6		
	香港以西海域 Seas west of Hong Kong	1	-	0.6		
牙帶 *Trichiurus haumela* (Hair tail)	大亞灣 Daya Bay	1	-	0.1	< 2	Bq kg^{-1}
	香港水域 Hong Kong Waters	1	-	1.0		

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[2] Activity[2]	BRMP 範圍[3] BRMP range[3]	單位 Unit
三點蟹 *Portunus sanguinolentus* (Three-spotted crab)	香港水域 Hong Kong Waters	3	0.1 – 0.2	0.1	< 2	Bq kg^{-1}
	香港以西海域 Seas west of Hong Kong	1	-	0.3		
赤米蝦 *Metapenaeopsis barbata* (Fire prawn)	香港水域 Hong Kong Waters	3	0.1 – 0.2	0.2	≤ 4.9	Bq kg^{-1}
	香港以西海域 Seas west of Hong Kong	1	-	0.4		
墨魚 *Sepia spp.* (Cuttlefish)	香港水域 Hong Kong Waters	2	0.1 – 0.2	0.2	≤ 2.7 [4]	Bq kg^{-1}
魷魚 *Loligo edulis* (Squid)	香港水域 Hong Kong Waters	2	0.1 – 0.3	0.2	< 3	Bq kg^{-1}
東風螺 *Babylonia formosae* (Gastropod)	香港水域 Hong Kong Waters	4	0.1– 0.4	0.2	< 1	Bq kg^{-1}
青口 *Perna viridis* (Green-lipped mussel)	長洲 Cheung Chau	3	0.2 – 0.4	0.3	< 2	Bq kg^{-1}
	吐露港 Tolo Harbour	2	0.1	0.1		
	大亞灣 Daya Bay	2	0.1 – 0.2	0.1		
蜆 *Tapes philippinarum* (Clam)	長洲 Cheung Chau	2	0.1	0.1	< 2	Bq kg^{-1}
	吐露港 Tolo Harbour	1	-	0.1		
石蒓 *Ulva lactuca* (Sea lettuce)	布袋澳 Po Toi O	1	-	0.3	< 2	Bq kg^{-1}
濕沉積物 (降雨) Wet deposition (precipitation)	京士柏 King's Park	5	0.2 – 2.0	0.9	≤ 12	Bq L^{-1}
	沙頭角 Sha Tau Kok	5	0.1 – 1.6	0.7		
	元五墳 Yuen Ng Fan	5	0.1 – 2.4	1.3		
總沉積物 Total deposition	京士柏 King's Park	5	122 – 404	247	≤ 2210 [5]	Bq m^{-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[2] Activity[2]**	**BRMP 範圍[3] BRMP range[3]**	**單位 Unit**
大氣水蒸氣 Water vapour in air	京士柏 King's Park	6	0.01	0.01	≤ 242 [6]	Bq m^{-3}
飲用水(經處理) Drinking water (treated)	九龍配水管 Kowloon distribution tap	4	0.1 – 0.6	0.4	< 6	Bq L^{-1}
	屯門配水管 Tuen Mun distribution tap	2	0.8 – 1.5	1.1		
	油柑頭濾水廠 Yau Kom Tau Treatment Works	1	-	0.7		
	屯門濾水廠 Tuen Mun Treatment Works	2	1.2 – 1.9	1.6		
	沙田濾水廠 Shatin Treatment Works	3	0.2 – 1.0	0.6		
飲用水 (未經處理) Drinking water (untreated)	木湖 B 抽水站 Muk Wu B Pumping Station	2	0.2 – 0.5	0.3	< 6	Bq L^{-1}
	油柑頭濾水廠 Yau Kom Tau Treatment Works	2	0.6 – 1.6	1.1		
	屯門濾水廠 Tuen Mun Treatment Works	2	0.2 – 1.8	1.0		
	沙田濾水廠 Shatin Treatment Works	3	0.3 – 1.2	0.6		
	萬宜水庫 High Island Reservoir	3	0.4 – 1.0	0.6		
	船灣淡水湖 Plover Cove Reservoir	3	0.4 – 0.7	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(2) Activity(2)	BRMP 範圍(2) BRMP range(2)	單位 Unit
地下水 Underground water	長康邨 Cheung Hong Estate	1	-	0.3	≤ 2.8	Bq L^{-1}
	鈞樂新村 Kwan Lok San Tsuen	1	-	0.3		
	環翠邨 Wan Tsui Estate	1	-	0.2		
	華富邨 Wah Fu Estate	1	-	0.2		
	富山邨 Fu Shan Estate	1	-	0.2		
	清涼法苑 Ching Leung Nunnery	1	-	0.3		
海水(上層) Sea water (upper level)	火石洲 Basalt Island	1	-	0.9	< 6	Bq L^{-1}
	赤洲 Port Island	1	-	1.2		
海水(中層) Sea water (middle level)	火石洲 Basalt Island	1	-	0.6	< 6	Bq L^{-1}
	赤洲 Port Island	2	0.1 – 0.3	0.2		
海水(低層) Sea water (lower level)	火石洲 Basalt Island	1	-	1.4	< 6	Bq L^{-1}
	赤洲 Port Island	1	-	0.6		
樽裝水(蒸餾水) Bottled water (Distilled)	本地 Local	3	0.1 – 1.4	0.6	≤ 4.9(7)	Bq L^{-1}
樽裝水(礦泉水) Bottled water (Mineral)	本地 Local	3	0.1 – 0.6	0.3	≤ 5.8(7)	Bq L^{-1}

註: (1) 當樣本的探測信號高於空白樣本的探測信號時，該樣本的測量結果視為"可測量"。

(2) 如有多過一個樣本發現可測量活度，此欄則報告平均值。

(3) 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。

(4) 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。

(5) 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。

(6) 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。

(7) 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) When the detected signal of a sample is stronger than that of a blank sample, the measurement result of that sample is considered as "measurable".

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

(3) 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.

(4) 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.

(5) 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.

(6) 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.

(7) 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. 二零一六年食物及環境樣本的可測量[(1)]鍶-90 活度測量結果

Table 9. Measurement results of measurable[(1)] activities of strontium-90 in food and environmental samples in 2016

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

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[(2)] Activity[(2)]	BRMP 範圍[(3)] BRMP range[(3)]	單位 Unit
牛奶(經消毒) Pasteurized milk	內地(深圳) Mainland (Shenzhen)	4	9 – 11	10	≤ 81	mBq L^{-1}
	內地(惠州) Mainland (Huizhou)	4	4 – 14	9		
菜心 Choi sum	深圳 Shenzhen	4	17 – 112	60	≤ 266	mBq kg^{-1}
	本地 Local	4	20 – 59	39		
白菜 Pak choi	深圳 Shenzhen	4	22 – 95	43	≤ 570	mBq kg^{-1}
	本地 Local	4	18 – 101	46		
香蕉 Banana	內地 Mainland	1	-	8	≤ 27	mBq kg^{-1}
荔枝 Lychee	內地 Mainland	1	-	8	≤ 14	mBq kg^{-1}
柑橘 Mandarin	內地 Mainland	2	10 – 18	14	≤ 84	mBq kg^{-1}
牛肉 Beef	內地 Mainland	2	7 – 13	10	≤ 35	mBq kg^{-1}
大魚 *Aristichthys nobilis* (Big-head carp)	深圳 Shenzhen	1	-	4	≤ 94	mBq kg^{-1}
	元朗 Yuen Long	3	3 – 8	5		
瓜三 *Nemipterus japonicus* (Melon coat)	大亞灣 Daya Bay	1	-	9	≤ 21	mBq kg^{-1}
	香港水域 Hong Kong Waters	2	4 – 8	6		
	香港以西海域 Seas west of Hong Kong	1	-	8		
牛鰍 *Platycephalus indicus* (Bartail flathead)	大亞灣 Daya Bay	1	-	3	≤ 25	mBq kg^{-1}
牙帶 *Trichiurus haumela* (Hair tail)	香港水域 Hong Kong Waters	1	-	11	≤ 49	mBq kg^{-1}
三點蟹 *Portunus sanguinolentus* (Three-spotted crab)	香港水域 Hong Kong Waters	1	-	3	≤ 105	mBq kg^{-1}
赤米蝦 *Metapenaeopsis barbata* (Fire prawn)	香港水域 Hong Kong Waters	2	17 – 32	25	≤ 66	mBq kg^{-1}
魷魚 *Loligo edulis* (Squid)	大亞灣 Daya Bay	1	-	15	≤ 43	mBq kg^{-1}
	香港水域 Hong Kong Waters	3	9 – 20	14		

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[2] Activity[2]	BRMP 範圍[3] BRMP range[3]	單位 Unit
東風螺 *Babylonia formosae* (Gastropod)	香港水域 Hong Kong Waters	1	-	14	≤ 31	mBq kg^{-1}
青口 *Perna viridis* (Green-lipped mussel)	長洲 Cheung Chau	2	40 – 44	42	≤ 47	mBq kg^{-1}
	吐露港 Tolo Harbour	2	26 – 36	31		
	大亞灣 Daya Bay	3	29 – 44	37		
蜆 *Tapes philippinarum* (Clam)	長洲 Cheung Chau	1	-	28	≤ 32	mBq kg^{-1}
	吐露港 Tolo Harbour	2	20 – 25	22		
半葉馬尾藻 *Sargassum hemiphyllum* (Brown algae)	布袋澳 Po Toi O	1	-	796	≤ 1440	mBq kg^{-1}
大氣飄塵 Airborne particulate	京士柏 King's Park	4	1.3 – 3.1	1.9	≤ 5	μBq m^{-3}
	沙頭角 Sha Tau Kok	3	1.3 – 3.0	2.4		
	元五墳 Yuen Ng Fan	1	-	2.4		
濕沉積物(降雨) Wet deposition (precipitation)	京士柏 King's Park	6	2.5 – 9.7	5.6	≤ 39	mBq L^{-1}
	沙頭角 Sha Tau Kok	4	4.1 – 14.4	9.8		
	元五墳 Yuen Ng Fan	2	2.8 –5.4	4.1		
總沉積物 Total deposition	京士柏 King's Park	1	-	3.9	≤ 3.9 [4]	Bq m^{-2}
土壤(上層) Land soil (upper)	見表 1. Please see Table 1.	3	1.4 – 18.9	9.2	≤ 27.3	Bq kg^{-1}
土壤(下層) Land soil (lower)	見表 1. Please see Table 1.	6	1.2 – 4.9	2.9	≤ 19.9	Bq kg^{-1}

註:
(1) 當樣本的探測信號高於本底信號時，該樣本的測量結果視為"可測量"。
(2) 如有多過一個樣本發現可測量活度，此欄則報告平均值。
(3) 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。
(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。

Note:
(1) When the detected signal of a sample is stronger than background signal, the meausurement result of that sample is considered as "measurable".
(2) The mean activity is reported if there is more than one sample with measurable activities.
(3) 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.
(4) Measurement of this sample started in January 1996. The sample was not measured in BRMP. The indicated range refers to the measurement results of the first 5 years.

表 10. 二零一六年食物及環境樣本的可測量(1)鈈-239活度測量結果

Table 10. Measurement results of measurable(1) activities of plutonium-239 in food and environmental samples in 2016

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(2) Activity(2)**	**BRMP 範圍(3) BRMP range(3)**	**單位 Unit**
潮間帶土(上層) Intertidal sediment (upper)	沙頭角 Sha Tau Kok	3	0.13 – 0.16	0.14	≤ 0.19	Bq kg^{-1}
潮間帶土(下層) Intertidal sediment (lower)	沙頭角 Sha Tau Kok	1	-	0.12	≤ 0.14	Bq kg^{-1}
	尖鼻咀 Tsim Bei Tsui	2	0.09 – 0.10	0.10		
海床沉澱物 Seabed sediment	索罟灣 Picnic Bay	1	-	0.28	≤ 0.57	Bq kg^{-1}
	大灘海 Tai Tan Hoi	1	-	0.45		
	龍蝦灣 Lung Ha Wan	1	-	0.34		

註: (1) 當在樣本中可分辨出鈈-239 的阿爾法粒子能峰，而測量信號亦高於該能譜本底時，該樣本的測量結果視為"可測量"。

(2) 如有多過一個樣本發現可測量活度，此欄則報告平均值。

(3) 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) When the alpha energy peaks of plutonium-239 are discernible in a sample and the detected signal is above the respective spectral background, the measurement result of that sample is considered as "measurable".

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

(3) 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. 二零一六年樣本整體測量結果概要

Table 11. Overall summary of measurement results of samples in 2016

(每公斤貝可 Bq kg^{-1}；每公升貝可 Bq L^{-1}；每立方米微貝可μBq m^{-3})

途徑 Pathway	樣本類別 Sample Type	測量結果(1) Measurement results(1) / 參考數值(1) Reference values(1)	碘-131 I-131	銫-137 Cs-137	銫-134 Cs-134	氚 H-3	鍶-90 Sr-90	鈈-239 Pu-239	單位 Unit
大氣 Atmospheric	大氣飄塵 (每月累積樣本) Airborne Particulate (bulked monthly sample)	範圍 Range	< 10	< 10	< 10	---(2)	1.3 | 3.1	< 0.2	μBq m^{-3}
		BRMP	< 10(3)	< 10	< 10		≤ 5	< 0.2	
地面 Terrestrial	食米 Rice	範圍 Range	< 0.1	< 0.1	< 0.1	0.1	< 0.002	---	Bq kg^{-1}
		BRMP	< 0.1	≤ 0.9	< 0.1	< 1	≤ 0.056		
	牛奶 Milk	範圍 Range	< 0.2	< 0.3	< 0.3	0.7 | 2.0	0.004 | 0.014	---	Bq L^{-1}
		BRMP	< 0.2	≤ 0.3	< 0.3	< 6	≤ 0.081		
	蔬菜 Vegetable	範圍 Range	< 0.3	< 0.4	< 0.3	0.3 | 2.8	0.017 | 0.112	---	Bq kg^{-1}
		BRMP	< 0.3	< 0.4	< 0.3	≤ 7.4	≤ 0.570		
水 Aquatic	魚 Fish	範圍 Range	< 0.1	0.1	< 0.1	0.1 | 1.0	0.003 | 0.011	< 0.002	Bq kg^{-1}
		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 | 1.9	---	---	Bq L^{-1}
		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^{-3} 及 38 μBq m^{-3}，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 μBqm^{-3} and 38 μBq m^{-3}), 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.　二零一六年國際原子能機構安排的水和植物樣本中伽馬及鍶-90 放射性核素測量能力測試結果

Table 12.　Results of the 2016 proficiency test organised by the International Atomic Energy Agency for the measurement of activities of gamma-emitting radionuclides and strontium-90 in water and plant samples.

表 Table 12a.　水樣本 Water Sample

放射性核素 Radionuclide	**天文台測量結果 Measurement Result of HKO (Value_HKO) (每公斤貝可 Bq/kg)**	**天文台測量結果不確定度 Measurement Uncertainty of HKO (U_HKO) (每公斤貝可 Bq/kg)**	**國際原子能機構所提供之目標值 IAEA Target Value (Value_IAEA) (每公斤貝可 Bq/kg)**	**國際原子能機構所提供之目標值不確定度 Uncertainty of IAEA Target Value (U_IAEA) (每公斤貝可 Bq/kg)**	**相對偏差(1) Relative Bias(1) ($Bias_{relative}$) (%)**	**P(2) (%)**	**國際原子能機構所提供之最大相對偏差 Maximum Acceptable Relative Bias (MARB) provided by IAEA (%)**	**準確度(3) Accuracy(3)**	**精確度(4) Precision(4)**
銫-134 Cs-134	20.1	1.1	19.9	0.6	+1.01	6.25	15	可接受 Acceptable	可接受 Acceptable
銫-137 Cs-137	40.8	2.1	39.6	1.0	+3.03	5.73	15	可接受 Acceptable	可接受 Acceptable
鈉-22 Na-22	49.9	2.6	53.2	1.5	-6.20	5.92	15	可接受 Acceptable	可接受 Acceptable
鍶-90 Sr-90	14.6	1.1	14.7	0.5	-0.68	8.27	15	可接受 Acceptable	可接受 Acceptable

表 12.　(續)

Table 12. (cont'd)

表 Table 12b. 植物(雲杉針)樣本 Plant (spruce needles) Sample

放射性核素 Radionuclide	**天文台測量結果 Measurement Result of HKO (Value_HKO) (每公斤貝可 Bq/kg)**	**天文台測量結果不確定度 Measurement Uncertainty of HKO (U_HKO) (每公斤貝可 Bq/kg)**	**國際原子能機構所提供之目標值 IAEA Target Value (Value_IAEA) (每公斤貝可 Bq/kg)**	**國際原子能機構所提供之目標值不確定度 Uncertainty of IAEA Target Value (U_IAEA) (每公斤貝可 Bq/kg)**	**相對偏差(1) Relative Bias(1) ($Bias_{relative}$) (%)**	**P(2) (%)**	**國際原子能機構所提供之最大相對偏差 Maximum Acceptable Relative Bias (MARB) provided by IAEA (%)**	**準確度(3) Accuracy(3)**	**精確度(4) Precision(4)**
鍶-90 Sr-90	17.5	1.3	17	2	+2.94	13.91	30	可接受 Acceptable	可接受 Acceptable

註:

(1) 相對偏差 $Bias_{relative} = (Value\_HKO - Value\_IAEA)/Value\_IAEA \times 100\%$

(2) $P=\sqrt{((U\_IAEA/Value\_IAEA)^2 + (U\_HKO/Value\_HKO)^2)} \times 100\%$

(3) 若 $Bias_{relative} <= MARB$，測量結果之準確度為「可接受」。

(4) 若 $P<=MARB$ 及 $Bias_{relative} <= k*P$，測量結果之精確度為「可接受」。k 為覆蓋因子，95%置信水平時 k 為 2.56。

Note:

(1) Relative Bias, $Bias_{relative} = (Value\_HKO - Value\_IAEA)/Value\_IAEA \times 100\%$

(2) $P=\sqrt{((U\_IAEA/Value\_IAEA)^2 + (U\_HKO/Value\_HKO)^2)} \times 100\%$

(3) If $Bias_{relative} <= MARB$, accuracy of the measurement is considered "Acceptable".

(4) If $P<=MARB$ and $Bias_{relative} <= k*P$, precision of the measurement is considered "Acceptable". k is the coverage factor. For the 95% confidence level, k is 2.56.

表 13. 二零一六年政府化驗所安排就檢定奶粉樣本中銫-134 及銫-137 活度之實驗室比對結果

Table 13. Results of the 2016 inter-laboratory comparison organised by the Government Laboratory on the determination of activities of caesium-134 and caesium-137 in milk power sample.

放射性核素 Radionuclide	**天文台 測量結果 Measurement Result of the HKO (每公斤貝可 Bq/kg)**	**比對單位 1 測量結果 Measurement Result of Participating Unit 1 (PU1) (每公斤貝可 Bq/kg)**	**比對單位 2 測量結果 Measurement Result of Participating Unit 2 (PU2) (每公斤貝可 Bq/kg)**	**HKO 與 PU1 結果絕對差 Absolute Difference between HKO and PU1 (Δ_m)[1] (每公斤貝可 Bq/kg)**	**HKO 與 PU2 結果絕對差 Absolute Difference between HKO and PU2 (Δ_m)[1] (每公斤貝可 Bq/kg)**	**HKO 與 PU1 結果的 組合不確定度 Combined Uncertainty of HKO and PU1 U_Δ(HKO-PU1)[2] (每公斤貝可 Bq/kg)**	**HKO 與 PU2 結果的 組合不確定度 Combined Uncertainty of HKO and PU2 U_Δ(HKO-PU2)[2] (每公斤貝可 Bq/kg)**	**比對結果 Comparison Result**
銫-134 Cs-134	低於探測下限 Below detection limit	低於探測下限 Below detection limit	低於探測下限 Below detection limit	不適用 Not Applicable	不適用 Not Applicable	不適用 Not Applicable	不適用 Not Applicable	一致 Same
銫-137 Cs-137	數值 Value: C_{HKO} = 1010 不確定度 Uncertainty: U_{HKO} = 41	數值 Value: C_{PU1} = 1030 不確定度 Uncertainty: U_{PU1} = 41	數值 Value: C_{PU2} = 1029 不確定度 Uncertainty: U_{PU2} = 31	20 (2.0%)	19 (1.9%)	58.1 (5.7%)	51.4 (5.0%)	無顯著分別[3] No significant difference[3]

註:

(1) $\Delta_m = C_{單位\,1} - C_{單位\,2}$ (2) $U_\Delta = \sqrt{((U_{單位\,1})^2 + U_{單位\,2})^2)}$ (3) 如 $\Delta_m \leq 2U_\Delta$，比對兩個測量結果為「無顯著分別」。

Note:

(1) $\Delta_m = C_{Participant\,1} - C_{Participant\,2}$ (2) $U_\Delta = \sqrt{((U_{Participant\,1})^2 + U_{Participant\,2})^2)}$

(3) If $\Delta_m \leq 2U_\Delta$, the comparison of two measurement results is considered as "No significant difference".

表 14. 二零一六年上海市輻射環境監督站安排就碳濾盒和土壤樣本進行之伽馬及鍶-90 活度測量比對初步結果

Table 14. Preliminary results of the comparison organised by the Shanghai Radiation Environmental Supervision Station in 2016 for the measurement of activities of gamma-emitting radionuclides and strontium-90 in carbon cartridge and soil samples

表 Table 14a. 碳濾盒 Carbon Cartridge

放射性核素 Radionuclide	**天文台測量結果[(1)] Measurement Result[(1)] of HKO (每樣本貝可) (Bq/sample)**	**上海市輻射環境監督站提供之參考值[(2)] Reference Value[(2)] provided by ShRESS (每樣本貝可) (Bq/sample)**	**相對誤差[(3)] Relative Error[(2)] (%)**	**比對結果 Comparison Result**
鈷-60 Co-60	194 ± 16	205 ± 6	-5.4	可接受 Acceptable
鋇-133 Ba-133	182 ± 26	201 ± 7	-9.5	可接受 Acceptable
銫-137 Cs-137	117 ± 10	125 ± 4	-6.4	可接受 Acceptable
銪-152 Eu-152	384 ± 40	403 ± 16	-4.7	可接受 Acceptable

表 Table 14b. 土壤樣本 Soil Sample

放射性核素 Radionuclide	**天文台測量結果 Measurement Result of HKO (每樣本貝可) (Bq/sample)**	**上海市輻射環境監督站提供之參考值[(2)] Reference Value[(2)] provided by ShRESS (每樣本貝可) (Bq/sample)**	**相對誤差[(3)] Relative Error[(2)] (%)**	**比對結果 Comparison Result**
鍶-90 Sr-90	4.15	4.35	-4.6	可接受 Acceptable

註:

(1) 測量不確定度為 95%置信水平。

(2) 參考值及不確定度均來自標準源証書。

(3) 相對誤差 = (測量結果 - 參考值)/參考值 x 100%。如相對誤差在 10%以內，比對結果為「可接受」。

Note:

(1) Measurement uncertainty at 95% confidence level.

(2) Both the reference value and the uncertainty are quoted from the certificate of the reference source.

(3) Relative Error = (Measurement Result – Reference Value)/(Reference value) x 100%. If Relative Error is within 10%, the comparison result is considered “Acceptable”.