FINAL REPORT

MEASUREMENT OF MERCURY LEVELS IN AMBIENT AIR WITH THEIR PROBABLE SOURCES

VOLUME 2

EM087C

L. Al-Awadi, M. Al-Rashidi, A. R. Khan, A. M. Al-Hemoud, A. Al-Rowayeh, M. Malak, A. Al-Senafi, M. Ejaz, W. Behbahani, A. Al-Saleh, M. Shalash, A. Al-Dabbous, S. Al-Shamali, M. Al-Burais, A. Al-Khayat, S. Al-Awadhi, B. Pereira, K. UR Beg, and F. Al-Shatti

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ABSTRACT (SUMMARY OF NOT MORE THAN 300 WORDS) المستخلص (ملخص لايزيد عن 300 كلمة)

طلبت الهيئة العامة للبيئة من معهد الكويت للأبحاث العلمية إجراء دراسة مستفيضة لتركيزات الزئبق في الجو المحيط بالكويت لوضع قاعدة بيانات أساسية لمستويات الزئبق من أجل التوافق مع أحدث الاتجاهات في العالم ذات الصلة للحد من انبعاثات الزئبق المستخدم في تطبيقات الحياة المختلفة. يتضمن هذا التقرير إنجازات مفصلة في أحد عشر قسمًا تم استكمالها خلال فترة تنفيذ هذا المشروع. وقد تم استخدام خمس تقنيات لقياس الزئبق ومركباته لإنشاء الخرائط الجغرافية لتغيرات تراكيز الزئبق المكانية والزمانية في دولة الكويت. تم قياس اجمالي الزئبق الغازي باستخدام العينات السلبية (passive samplers) التي تم تركيبها وتعريضها للهواء لمدة شهر في مراحل ومواسم مختلفة لمواقع مختلفة في جميع أنحاء البلاد (المناطق الساحلية ، الحضرية ، الصحراوية ، مواقع منبع البترول وتكريره ، الصناعات ، محطات الطاقة ، صناعة الإسمنت ، المحارق ، ورش الذهب ، وزارة الصحة (عيادات الأسنان) والمقابر). يتراوح إجمالي تركيزات الزئبق الغازية من العينات السلبية في الهواء المحيط ما بين 0.8 و 8.7 نانو جرام لكل متر مكعب .

تم قياس ترسبات الزئبق الجافة من حاوية الأتربة المتساقطة وكان أعلى ترسيب سنوي للزئبق في موقع الشقايا في الجزء الغربي من الكويت ، بينما كان أدنى تركيز سنوي للزئبق في موقع بحرة في الجزء الشمالي من الكويت. تم قياس جسيمات الزئبق الكلية (TPM) باستخدام اجهزة قياس الأتربة (PM10) في موقعين أساسيين في الكويت وهما منطقة علي صباح السالم السكنية (فترة سبع سنوات متتالية) ومنطقة العارضية السكنية (فترة 3 سنوات متتالية). وكان أعلى تركيز سنوي للـ TPM هو 106.3 بيكو جرام لكل متر مكعب في منطقة علي صباح السالم في العام 2013، اما في العارضية كان أعلى تركيز سنوي هو 31.3 بيكو جرام لكل متر مكعب في العام 2018. تم استخدام جهاز لقياس ومراقبة الزئبق الفلزي بشكل لحظي وفوري في كل من الهواء الجوي والبحر للكشف عن المناطق الساخنة لمصادر الزئبق.

تم قياس تركيز الزئبق الكلي في التربة في معظم المواقع في الكويت ومن ثم قُسِمَت المواقع إلى سبع مجموعات رئيسية ، وكان أعلى متوسط تركيز في مجموعة شركة نفط الكويت (محطات الدعم والتقوية ومنشآت معالجة الحمأة) تليها حقول النفط الغربية. تم إعداد ورسم الخرائط لانبعاث الزئبق باستخدام نظام المعلومات الجغرافية (GIS) في جميع أنحاء دولة الكويت لإظهار ومعرفة خط الأساس لتركيزات الزئبق. لقد تم الاستنتاج بأن مستويات الزئبق في الهواء المحيط في جميع أنحاء الكويت كانت أقل من إرشادات منظمة الصحة العالمية.

KEY WORDS: أهم المصطلحات:

انبعاثات الزئبق - حاوية الأتربة المتساقطة - قرارات منظمة الصحة العالمية - منشآت معالجة الحمأة

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ABSTRACT (SUMMARY OF NOT MORE THAN 300 WORDS) المستخلص (ملخص لايزيد عن 300 كلمة)

The Kuwait Environment Public Authority (KEPA) requested the Kuwait Institute for Scientific Research (KISR) to conduct an extensive study of mercury concentrations in the ambient air of Kuwait to establish a baseline (database) for mercury levels, in order to align with the latest trends in the world related to the reduction of emissions of mercury used in various life applications. This report presents the details of the achievements attained during the implementation of this project, in eleven sections. Five techniques were used for the measurement of mercury and its compounds and geographical maps were created for the variation of the spatial and temporal concentrations of mercury in the State of Kuwait. Total gaseous mercury was measured using passive samplers, which were installed and exposed to air for a month in different waves and seasons at different locations all over the country (i.e., coastal and urban areas, desert, landfill sites, petroleum downstream, upstream, industries, power stations, cement industry, incinerators, gold workshops, Ministry of Health [dental clinics], and cemeteries). The overall total gaseous mercury concentrations in the ambient air measured using the passive sampling techniques were found in the range of 0.8 to 8.7 ng m^{-3}. Dry mercury depositions were measured from dust collectors and the highest annual maximum mercury deposition was found at Shagaya location in the western part of Kuwait, while the lowest annual maximum concentration was found at Al-Bahra site in the northern part of Kuwait. Total particulate mercury (TPM) was measured using sequential PM_{10} samplers at two crucial locations in Kuwait, namely, Ali Sabah Al-Salem residential area (a period of seven consecutive years) and Al-Ardiya residential area (a period of three consecutive years). The highest annual TPM mean concentration was 106.3 pg m^{-3}, observed in 2013 at Ali Sabah Al-Salem, while the highest annual concentration was 31.3 pg m^{-3}, observed in 2018 at Al-Ardiya. Instantaneous real-time monitoring device Zeeman 915+, for elemental mercury, was used to detect any hotspot areas for mercury sources in ambient air and sea. Total mercury concentrations in soil at many locations in Kuwait were measured and then divided into seven major clusters, and the highest average concentration was observed at the Kuwait Oil Company cluster (booster stations and sludge treatment facilities) followed by western oil fields. The integrated concentration maps for the entire State of Kuwait were prepared using the Geographic Information System (GIS) to show the baseline concentrations of mercury. It has been concluded that mercury levels in ambient air all over Kuwait were below the World Health Organization (WHO) guidelines.

KEY WORDS: أهم المصطلحات:

Mercury emissions, dust collectors, WHO guidelines, sludge treatment facilities

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The project leader would like to acknowledge the support and encouragement of Dr. Samira A. S. Omar, Director General of the Kuwait Institute for Scientific Research; Dr. Mohammed Al-Rashid, Acting Executive Director; Dr. Sameer Al-Zenki, Scientific Technical Director; Dr. Afaf Al-Nasir, Operations Director of the Environment and Life Sciences Research Center; and Dr. Sultan Al-Salem, Program Manager of the Environmental Pollution and Climate Program. Gratitude is extended to the administrative support provided by Ms. Blossom Pereira, in preparing and finalizing this report on time, and the wholehearted support of the project team members.

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List of Abbreviations

Abbreviations	Explanation
AGL	Above the Ground Level
AHU	Air Handling Units
AIGTCC	Al-Souhub International General Trading and Contracting Company
AMAP	Arctic Monitoring and Assessment Programme
APL	Air Pollution Laboratory
EIA	Environmental Impact Assessment
ELSRC	Environment and Life Sciences Research Center
EPA	Environment Public Authority
EPCP	Environmental Pollution and Climate Program
GC/FID	Gas Chromatography/Flame Ionization Detector
GC/MS	Gas Chromatography/Mass Spectrometry
GCC	Gulf Cooperation Council
GEM	Gaseous Elemental Mercury
GIS	Geographic Information System
GOM	Gaseous Oxidized Mercury
GPS	Global Positioning System
Hg^{++}	Reactive Mercury
Hg^{o}	Elemental Mercury
$Hg_{(p)}$	Particulate Mercury
HPLC	High Performance Liquid Chromatography
HVAC	Heating, Ventilating, and Air Conditioning
HVAS	High Volume Air Samplers
ICP/MS	Inductively Coupled Plasma Mass Spectrometry
JECFA	Joint (FAO/WHO) Expert Committee of Food Additives
KEPA	Kuwait Environment Public Authority
KFAS	Kuwait Foundation for the Advancement of Sciences
KIEIN	Kuwait Integrated Environmental Information Network
KISR	Kuwait Institute for Scientific Research
KNPC	Kuwait National Petroleum Company
KPC	Kuwait Petroleum Corporation

MAPL	Mobile Air Pollution Laboratory
MDF	Mercury Deposition Flux
MERCYMS	Mercury Cycling in the Mediterranean Basin
NAPESCO	National Petroleum Services Company (K.S.C.C.)
OSC	Oil Sector Complex
PI	Principal Investigator
PL	Project Leader
PM	Particulate Matter
ppb	part per billion
PPE	Personal Protective Equipment
QA	Quality Assurance
QC	Quality Control
RGM	Reactive Gaseous Mercury
RTD	Research, Technological Development, and Demonstration
ST	Scrap Tire
SPDP	Shuwaikh Power Desalination Plant
TM	Team Member
TOR	Terms of Reference
TPM	Total Particulate Mercury
TSP	Total Suspended Particulates
UK	United Kingdom
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
XRF	X-ray Fluorescence

Section 8 - Measurement of Monthly Total Mercury Deposition Flux Using Dust Collectors

Dust fallout containing ash from combustion processes may have high levels of mercury. Dust collectors were installed at various locations in Kuwait (Plate 46 and Table 35) to quantify mercury levels in suspended PM in air. These dust collectors consist of a trap that is composed of a container with 20 cm diameter and 35 cm length filled with marbles and fixed at 240 cm above the ground level (AGL). The fallen dust was collected on a monthly basis so that the sample size would be enough for the accurate measurement of mercury levels in suspended PM in the air (Plate 47).

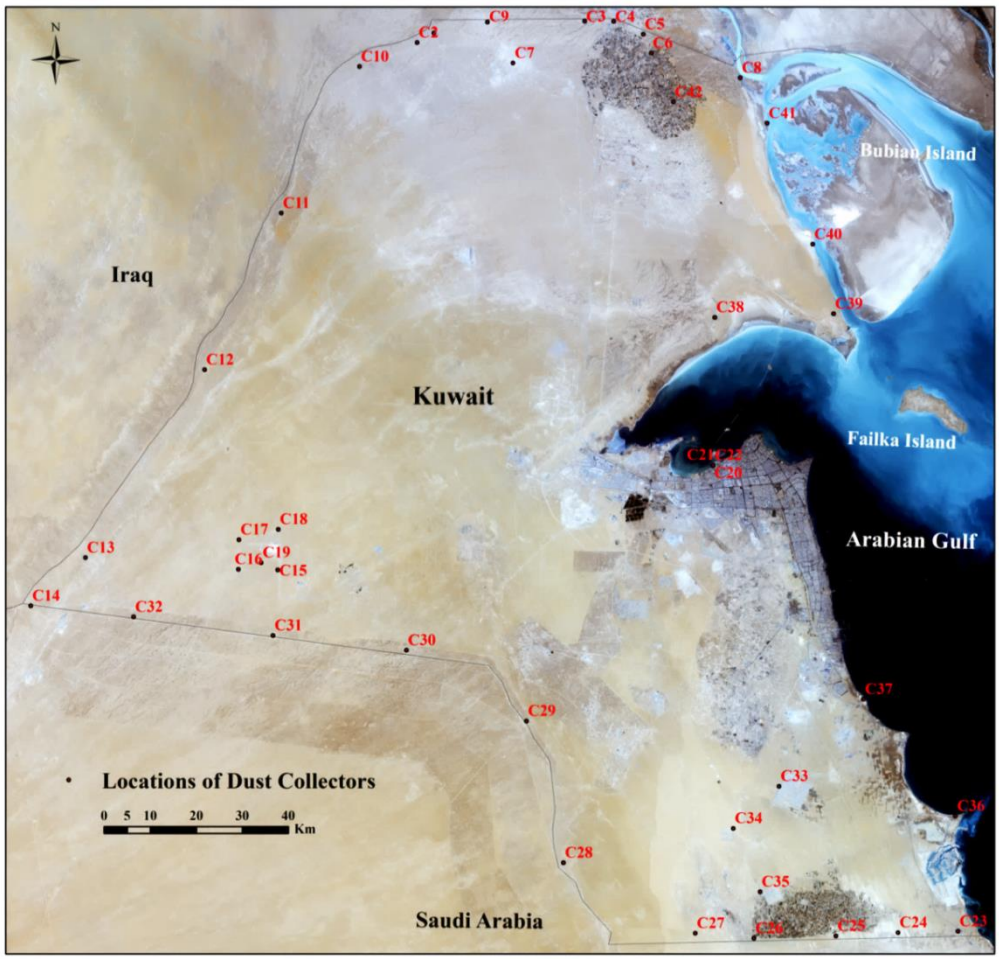


Plate 46. Sampling locations (C1 – C42) for dust collectors placed in various parts of Kuwait (except Liyah, Bubiyan, and Al-Bahra locations).

Table 35. Locations for Each Dust Collector Placed in Various Parts of Kuwait

*Dust Collector No.	GPS Coordinates		Area	Area Description
	Latitude (N)	Longitude (E)		
C1	30.0715096°	47.3613074°	Al-Tahreer Center	
C2	30.05534°	47.32869°	Al Sukhaibri Center	
C3	30.0917393°	47.655737°	Um Sudairah Center	
C4	30.0912605°	47.7122124°	Al Abdali Center	
C5	30.0694149°	47.7700665°	Al Mazarea' Center	
C6	30.0376106°	47.7857968°	Al Azmiya Center	
C7	30.02071°	47.51591°	Um Niqa Center	
C8	29.9957776°	47.9594236°	Al Buhaith Center	
C9	30.0898839°	47.4661286°	Al Ritqa Center	
C10	30.0149398°	47.2162539°	Bahrat Hoshan Center	
C11	29.7668371°	47.0631178°	Al-Somoud Center	
C12	29.5012389°	46.9138662°	Al-Abraq Center	
C13	29.1813058°	46.6808855°	Al-Shagaya Center	
C14	29.0991676°	46.5743071°	Al-Shaheed Jerman Center (Tri-border area)	
C15	29.160281°	47.056431°	Shagaya	
C16	29.161405°	46.979464°	Shagaya	
C17	29.212119°	46.980339°	Shagaya	
C18	29.229152°	47.05784°	Shagaya	
C19	29.112582°	47.045027°	Shagaya	
C20	29.337883°	47.9059°	KISR	14th floor of KISR's new building
C21	29.339033°	47.905533°	KISR	Coastal - by the mangrove in KISR
C22	29.33895°	47.906567°	KISR	Regional Centre for Development of Educational Software
C23	28.542567°	48.38475°	Kuwait-Saudi Border	Nuwaiseeb Centre (south)
C24	28.5403°	48.267717°	Kuwait-Saudi Border	Jlaida Centre
C25	28.5345°	48.1464°	Kuwait-Saudi Border	Raghwa Centre

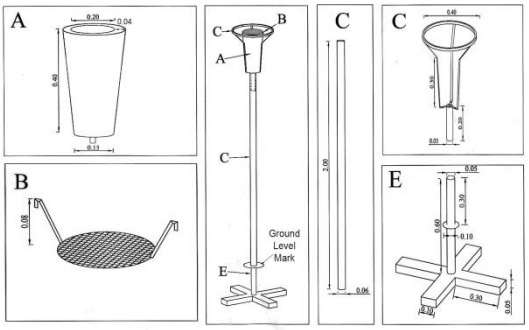
Table 35. (Cont'd.)

Dust Collector No.	GPS Coordinates		Area	Area Description
	Latitude (N)	Longitude (E)		
C26	28.5304°	47.98615°	Kuwait-Saudi Border	Rahiya Centre
C27	28.5392°	47.871567°	Kuwait-Saudi Border	Fawaris Centre
C28	28.660017°	47.614333°	Kuwait-Iraq Border	Grenees Centre
C29	28.9025°	47.54185°	Kuwait-Saudi Border	Radeefa Centre
C30	29.0234°	47.307883°	Kuwait-Saudi Border	Khabrat Shayea Centre
C31	29.04855°	47.0474°	Kuwait-Saudi Border	Golmat Ali centre
C32	29.080183°	46.774917°	Kuwait-Saudi Border	Nimriteen Centre (west)
C33	28.790883	48.035083	Sabah Al-Ahmed city	
C34	28.718883	47.945717	Al-Wafra Farms	
C35	28.610183	47.998217	Al-Wafra centre	Near the Meteorological station
C36	28.740017	48.379533	Ras Al-Zor	
C37	28.939967	48.19995	Al-Dhebaaea	
C38	29.590033	47.90955	Al-Subiah broadcast station	
C39	29.596083	48.141833	Al-Subiah police station	
C40	29.71405	48.101067	New Bubiyan bridge	
C41	29.919083	48.011883	The camp (Al-Beheeth)	
C42	29.955	47.828717	Al-Beheeth - Al-Abdulli road	
Liyah	29.58813	47.613180	Liyah Preserved Area – Central Kuwait	
Bubiyan	29.64886749580	48.31311518990	North East of Kuwait	
Al-Bahra	29.5822763132	47.9865565358	North of Kuwait	

*These locations are all seen in Plate 46 except Liyah, Bubiyan, and Al-Bahra.



a. **Installation.**



b. **Dust collector internals.**

Plate 47. Dust collector image and specification.

Kuwait is located in the northeastern corner of Arabian Peninsula and has a dry and arid climate. The dust storms are more frequent in summer than in other seasons. Dust storms are categorized based on the dust/sand particle sizes and prevalent meteorological conditions. The natural and man-made monthly dust fallout at different sites depends on the dust transported from short or long distances based on driving conditions (wind speed/wind direction). The dust has a large surface area and has high adsorbing characteristics bringing pollutants to move over rural/urban, industrial, agricultural, and mining areas, and some are generated by anthropogenic sources. Long distance transported dust has mercury contamination in dust fallout, which also constituted of ash emitted from combustion processes.

The dust collected in a month's period was brought to KISR's laboratory in one liter plastic bottles soaked in distilled water. Extra water was decanted and the remaining water with dust was transferred to glass beaker, where water was evaporated in the oven at 108^{o}C for about 18 h. Mercury loss could be worked out from the vapour pressure of mercury at 108^{o}C and was computed using the experimental data of Ambrose and Sprake (1967), which is plotted in Fig. 69. The evaporation losses were less than 5% due to the adsorption on the large uneven surface of dust. The dried dust samples were accurately weighed and preserved in plastic bottles for long-term storage (Al-Dousari and Al-Awadhi, 2012).

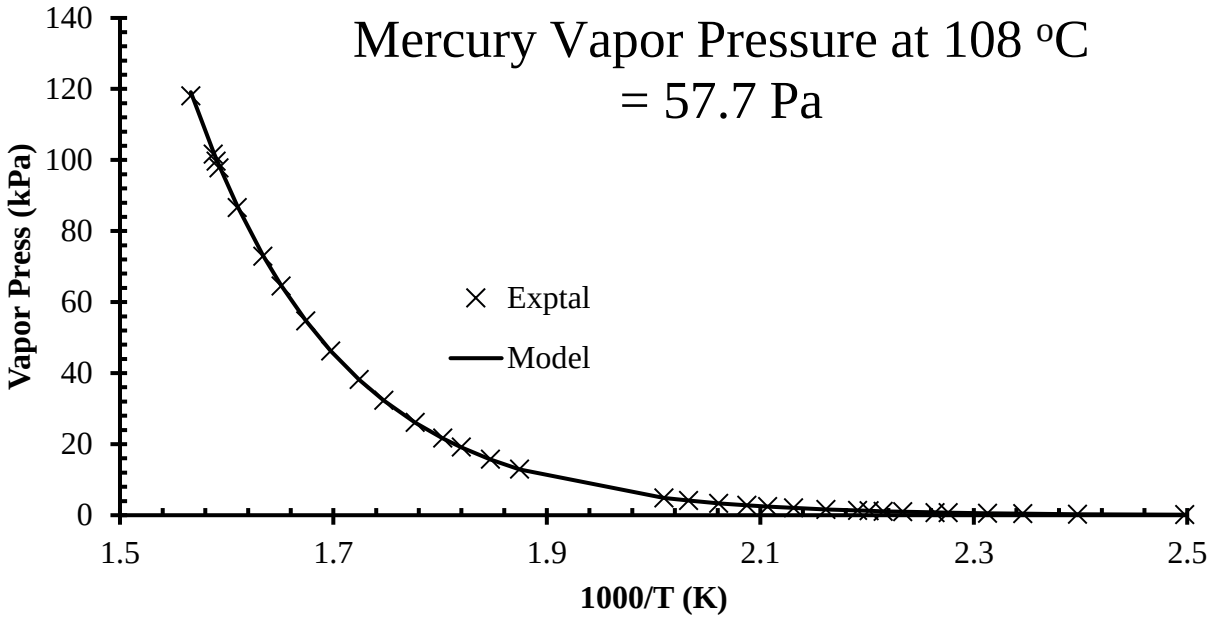


Fig. 69. Vapour pressure of mercury as a function of temperature.

In this study, historical and recent data for total particulate mercury from dust collector were analyzed. With reference to historical data, KISR's projects EC063C and EC085C (Al-Dousari et al., 2011, 2015) were completed in 2011 and 2015, respectively. The available historical monthly dust fallout samples of these projects were obtained from three sites, namely, Liyah, Al-Bahra area, and Bubiyan Island, for 2011 and 2012, and then were analyzed for mercury deposition flux as in Eqn (1).

$$\text{Hg deposition Flux} = \frac{total\ monthly\ collected\ dust\ weight}{(\pi D^2/4)} \ \frac{Mercury\ concentartion}{unit\ mass\ of\ dust} \frac{(ng)}{(g)} = \frac{(Hg\ ng)}{m^2.month} \quad (1)$$

Recent data were collected extensively over the entire official borders of Kuwait and analyzed for the period of 2017 till 2019. All available historical and recently collected monthly dust samples were analyzed for mercury contents and quantified using the cold vapor technique using the pyrolytic extension of Zeeman RA915+ analyzer. This section assesses the total particulate mercury levels from dust fallout in the air identifying the respective sources, also revealing the influence of seasonal variations on mercury levels in the ambient air in the State of Kuwait.

Dust fallout data for 2011 and 2012 were limited to three sites only, which showed the highest mercury flux at Liyah, indicative of major oil production activity in southern Iraqi and northern Kuwaiti oil fields. The dust fallout data for 2012 for Liyah was complete

for twelve months, while data for Al-Bahra, Bubiyan Island, and Liyah for 2011 were not available for a few months and have been extrapolated for the prediction of annual deposition flux. A thorough investigation of dust fallout samples from the entire official borders of the State of Kuwait for 2017 to 2019 had confirmed the presence of the same predominant mercury sources (Figs. 70 – 73).

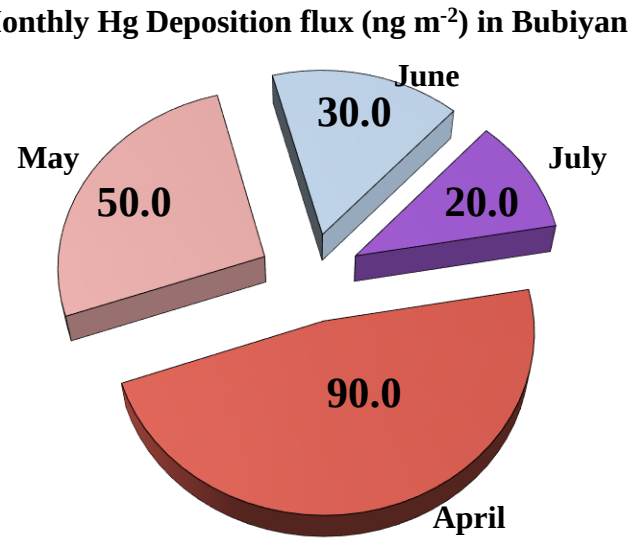


Fig. 70. Monthly mercury deposition flux for Al-Bahra in 2011.

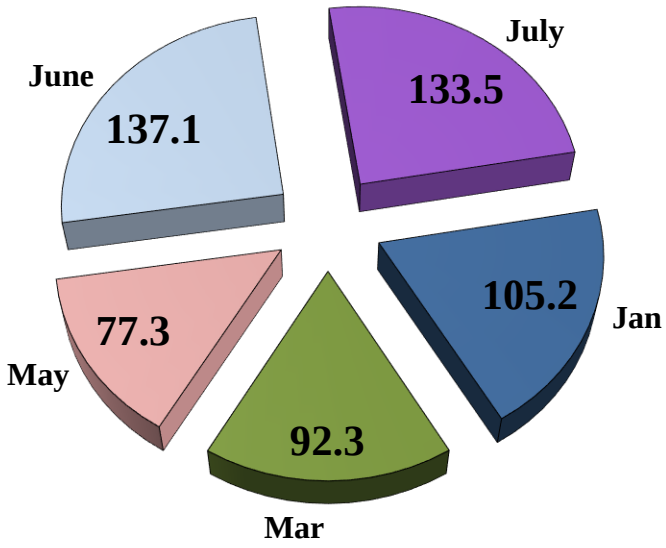


Fig. 71. Monthly mercury deposition flux in Bubiyan for 2011.

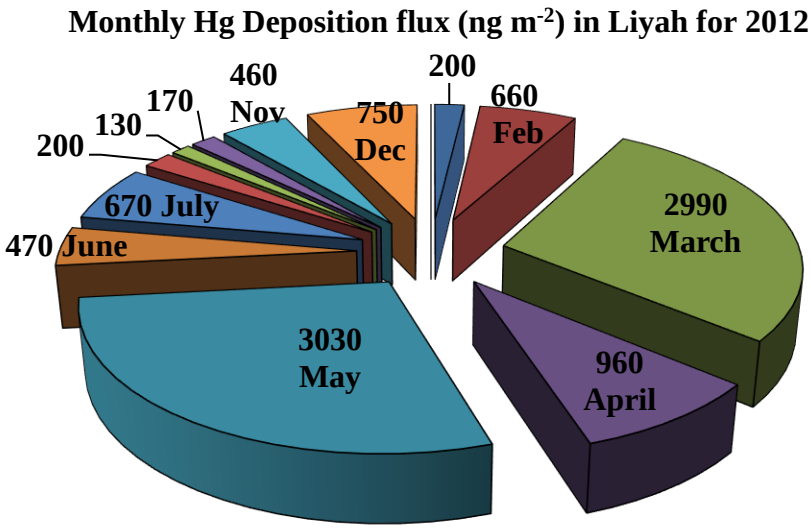


Fig. 72. Monthly mercury deposition flux in Liyah for 2012.

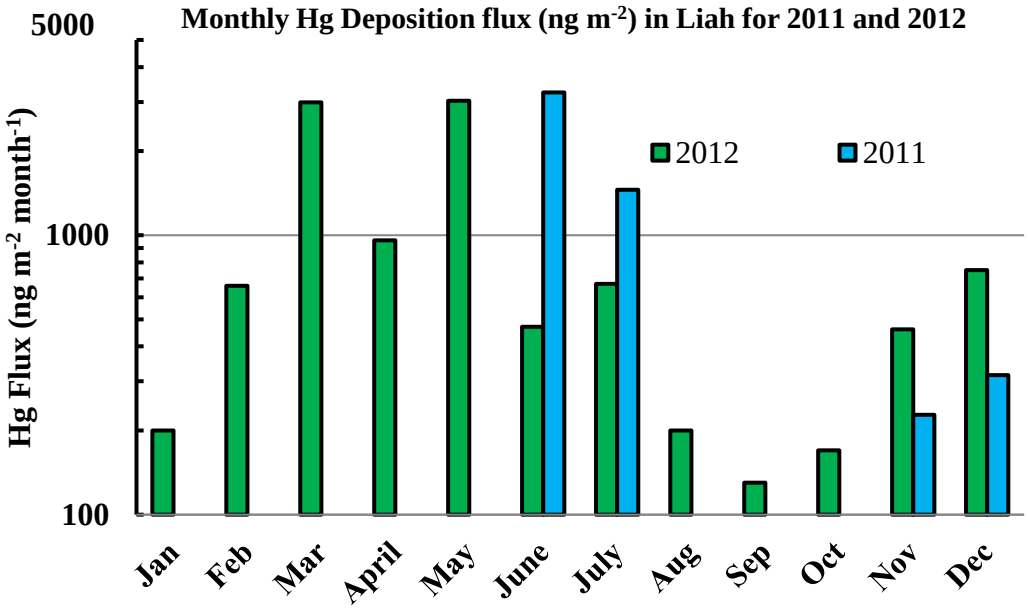


Fig. 73. Monthly mercury deposition flux in Liyah for 2011 and 2012.

Monthly mercury deposition fluxes depended on the prevalent meteorological conditions that controlled dusty events and also mercury concentrations from oil production and power generation facilities in the State of Kuwait. Monthly mercury

deposition fluxes for different locations are listed for a period of eight years in Table 36. Mercury deposition from the historical data showed narrow range of fluxes at Al-Bahra and Bubiyan Island locations, while the comprehensive measurement of mercury deposition fluxes showed elevated values in summer months compared to those in the winter season.

Table 36. Monthly Mercury Deposition Flux Ranges from Natural Dust Fallout at Different Locations in the State of Kuwait for 2011 to 2019

Year	Location	Mercury Deposition Flux Ranges (ng m^{-2} mo^{-1})	Mercury Deposition Fluxes in the Literature
2011	Bubiyan	77.3 – 137.1*	
2011	Liyah	227.9 – 3241.8	Monthly Dry 100-500 Monthly Wet >1000 (EC, 2001)
2011	Al-Bahra	20 – 90*	Seasonal variation was observed in China,
2012	Liyah	130 – 3030	elevated levels in winter and spring and
2017	All Locations	10.6 – 5878	low levels in summer
2018	All Locations	14 – 46087	(Wan et al., 2009, and Xu et al., 2013)
2019	All Locations	151 – 12667	

The dry deposition fluxes represented different mercury species (Hg^o, Hg^+, Hg^{++}, and Hg [part.]) explained by EC (2001), and this flux mainly occurred at high grounds nearby emission sources. Very low solubility of Hg^o was due to the fact that this was not considered as dry deposition with the exception of forestry where settling velocities were low and other mercury species like Hg^{++} and $Hg_{(p)}$ quickly deposited in the neighbourhood of the emission sources. The present findings of monthly mercury deposition flux ranges were higher than the reported monthly flux ranges over Europe (EC, 2001).

Annual maximum mercury deposition values in the natural dust fallout are given in Table 37 and are also shown in Fig. 74. The highest fluxes were at Shagaya for 2018 and 2019, while the rest of the flux values were comparable to the reported model predicted deposition, both dry and wet, in San Francisco Bay, i.e., 0.1 μg m^{-2} y^{-1} (100 ng m^{-2} y^{-1}) and 2-5μg m^{-2} y^{-1} (2000–5000 ng m^{-2} y^{-1}) (Seigneur et al., 2004; WSPA, 2009; Wan et al., 2009; Xu et al., 2013). Shagaya was in the downwind direction to the Kra'Almru oil fields

(Plate 24), which had reflected the activities resulting in elevated levels of deposition fluxes.

Table 37. Annual Maximum Deposition Fluxes from Natural Dust Fallout

Year	Location	Mercury Deposition Flux (ng m^{-2} y^{-1}) or (mg km^{-2} y^{-1})	Mercury Deposition Flux in Literature (ng m^{-2} y^{-1})
2011	Bubiyan	1,309*	2000-5000 wet (Seigneur et al., 2004)
2011	Liyah	10,690	
2011	Al-Bahra	570*	1700 to 11000 wet (Munthe et al., 2007)
2012	Liyah	15,717*	100 wet+dry (WSPA, 2009)
2017	Al-Buhaith	16,974*	
2018	Shagaya	140,412	16500 dry (Wan et al., 2009)
2019	Shagaya	93,071*	38300-58700 dry (Xu et al., 2013)

* Annual mercury deposition rates were calculated by extrapolation

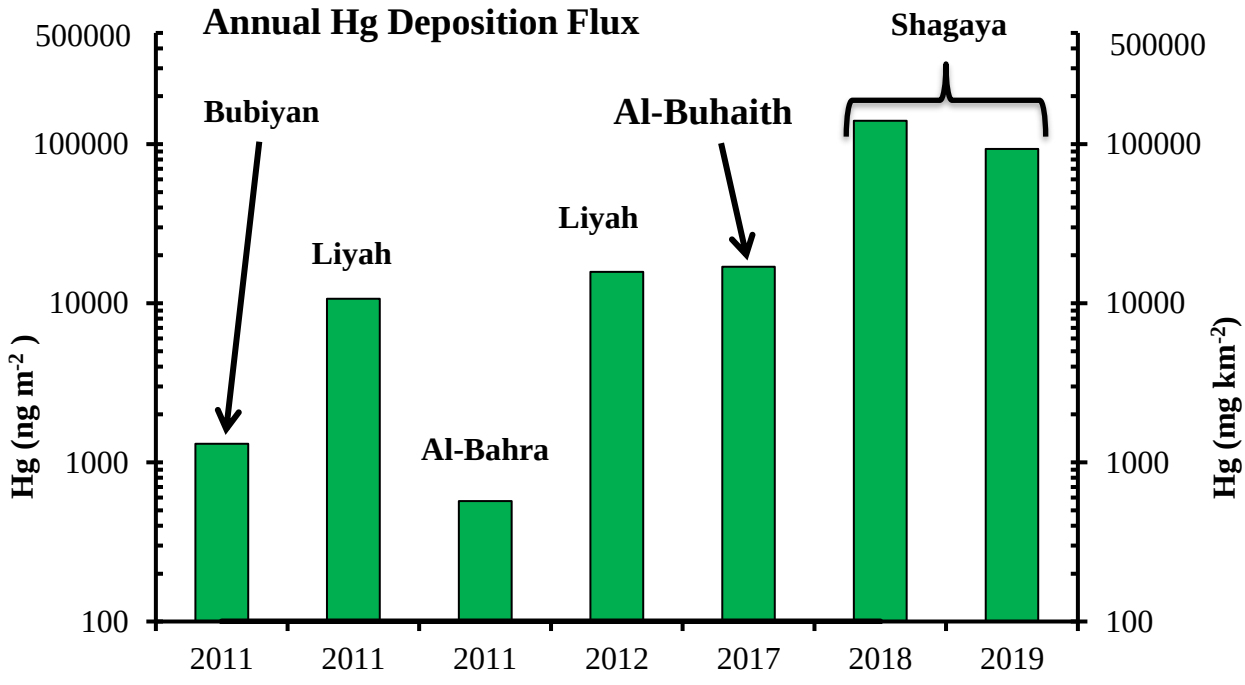


Fig. 74. Annual maximum mercury deposition (dry) fluxes from natural dust fallout in Kuwait.

Further analysis of monthly samples showed the maximum monthly deposition flux in June 2011 at Bubiyan Island, about 137.1 ng m^{-2} mo^{-1} (Fig. 71 and Table 36), and in June 2011 at Liyah, about 3241.8 ng m^{-2} mo^{-1} (Table 36). In 2017, the highest monthly mercury deposition flux was 5878 ng m^{-2} mo^{-1}, in December at Al-Buhaith, and the minimum deposition flux was 10.6 ng m^{-2} mo^{-1}, at Shagaya in November. High emissions were most likely from flares of either Southern Iraqi or Northern Kuwaiti oil fields. In 2018, the maximum monthly deposition flux was 46087 ng m^{-2} mo^{-1} at Shagaya in July and the minimum flux was 14 ng m^{-2} mo^{-1} at the police station at Al-Subiyah in June (Table 38). In 2019, the highest mercury deposition flux was 12667 ng m^{-2} mo^{-1} in March at Shagaya reflecting oil production activity at Kra'Almru fields, while the minimum flux was 151 ng m^{-2} mo^{-1} at Shagaya in January. The second highest mercury deposition flux in April 2019 was 11277 ng m^{-2} mo^{-1} at Shagaya due to the abovementioned reason.

Table 38. Monthly Maximum Mercury Deposition Rate from Natural Dust Fallout for 2018

Months in 2018	Location	Monthly Mercury Deposition Rate (ng m^{-2} Mo^{-1}) or (mg km^{-2} mo^{-1})
January	Shagaya (C19)	2,332
February	Kuwait-Saudi Border (C29)	5,170
March	Kuwait-Saudi Border (C29)	7,013
April	Shagaya (C16)	12,404
May	Shagaya (C17)	23,932
June	Shagaya (C17)	20,206
July	Shagaya (C17)	46,087
August	Shagaya (C18)	6,065
September	KISR Al-Shuwaikh (C21)	1,215
October	Al-Wafra (C35)	6,443
November	KISR Al-Shuwaikh (C21)	2,908
December	Al-Subiyah BC* Station (C38)	3,181

* BC - Broadcast

All monthly and annual mercury deposition rates from 2017 to 2019 are presented in Plates 48 – 75 and Tables 39 – 66.

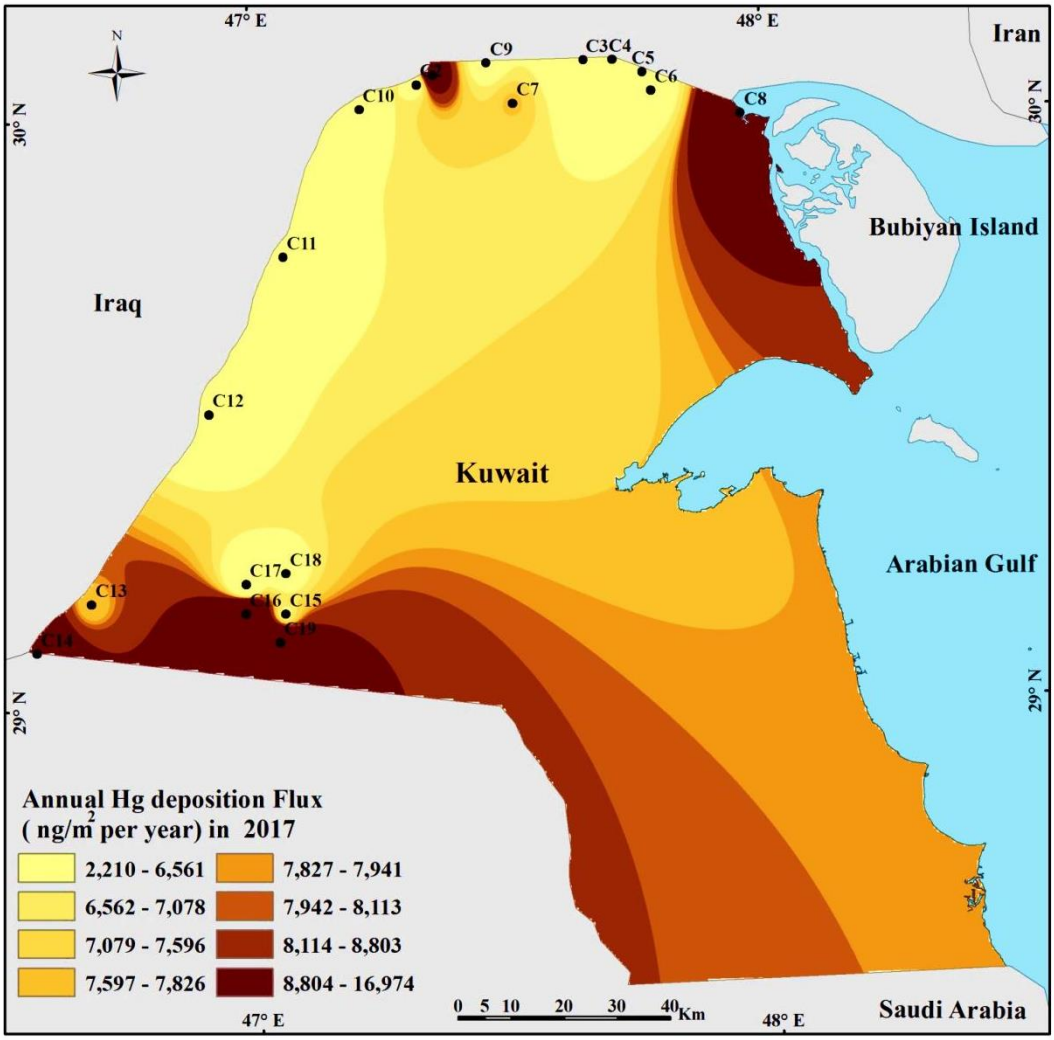


Plate 48. Annual Hg deposition flux at different locations in Kuwait in 2017.

Table 39. Annual Hg Deposition Flux at Different Locations in Kuwait in 2017

Dust Collector	Latitude-N	Longitude-E	Hg per Year (ng/m^2)
C1	30.0715096	47.3613074	11204
C2	30.05534	47.32869	5655
C3	30.0917393	47.655737	4657
C4	30.0912605	47.7122124	3465
C5	30.0694149	47.7700665	6481
C6	30.0376106	47.7857968	5077
C7	30.02071	47.51591	7760
C8	29.9957776	47.9594236	16974
C9	30.0898839	47.4661286	5569
C10	30.0149398	47.2162539	5327
C11	29.7668371	47.0631178	5241
C12	29.5012389	46.9138662	3993
C13	29.1813058	46.6808855	7585
C14	29.0991676	46.5743071	12159
C15	29.160281	47.056431	6072
C16	29.161405	46.979464	16685
C17	29.212119	46.980339	2210
C18	29.229152	47.05784	5071
C19	29.112582	47.045027	14611

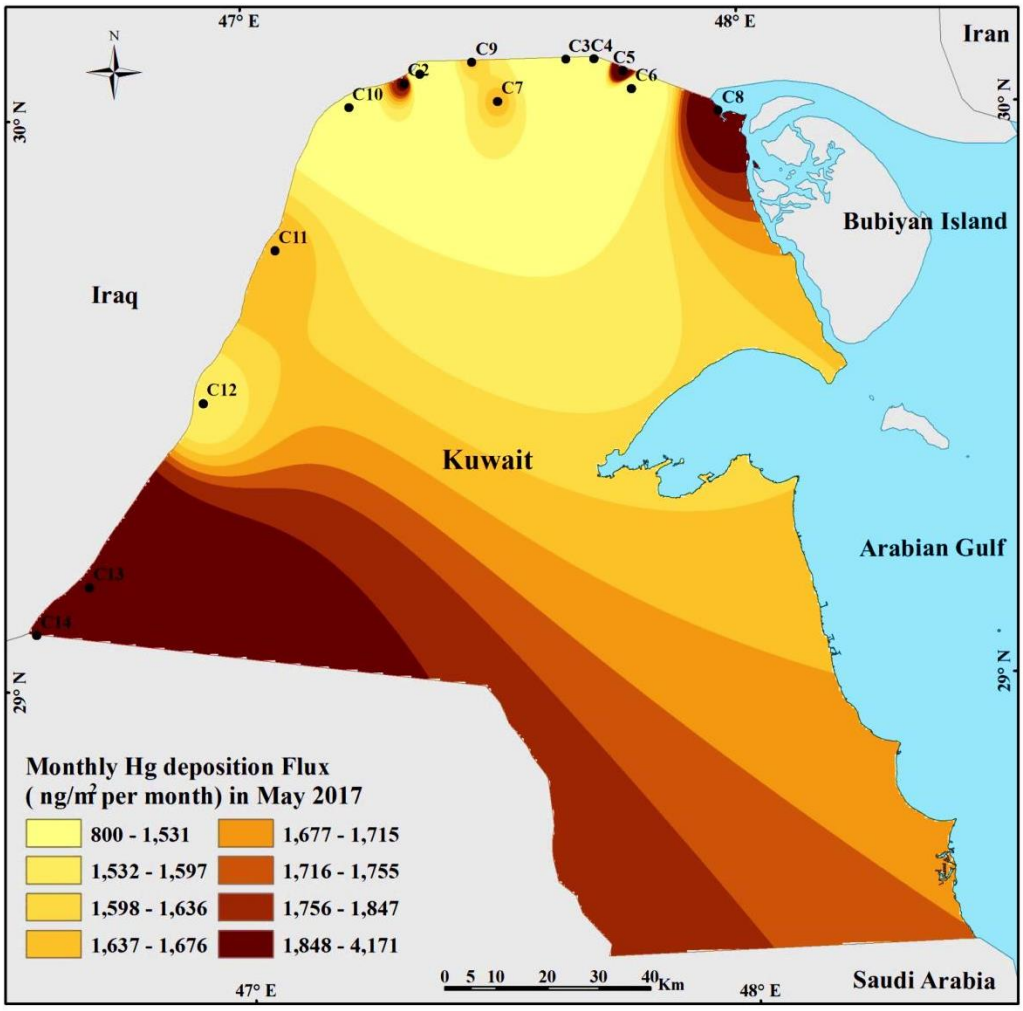


Plate 49. Monthly Hg deposition flux at different locations in Kuwait in May 2017.

Table 40. Monthly Hg Deposition Flux at Different Locations in Kuwait in May 2017

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	800
C2	30.05534	47.32869	1954
C3	30.0917393	47.655737	1176
C4	30.0912605	47.7122124	913
C5	30.0694149	47.7700665	2396
C6	30.0376106	47.7857968	891
C7	30.02071	47.51591	1670
C8	29.9957776	47.9594236	2164
C9	30.0898839	47.4661286	1648
C10	30.0149398	47.2162539	1350
C11	29.7668371	47.0631178	1676
C12	29.5012389	46.9138662	1529
C13	29.1813058	46.6808855	1979
C14	29.0991676	46.5743071	4171

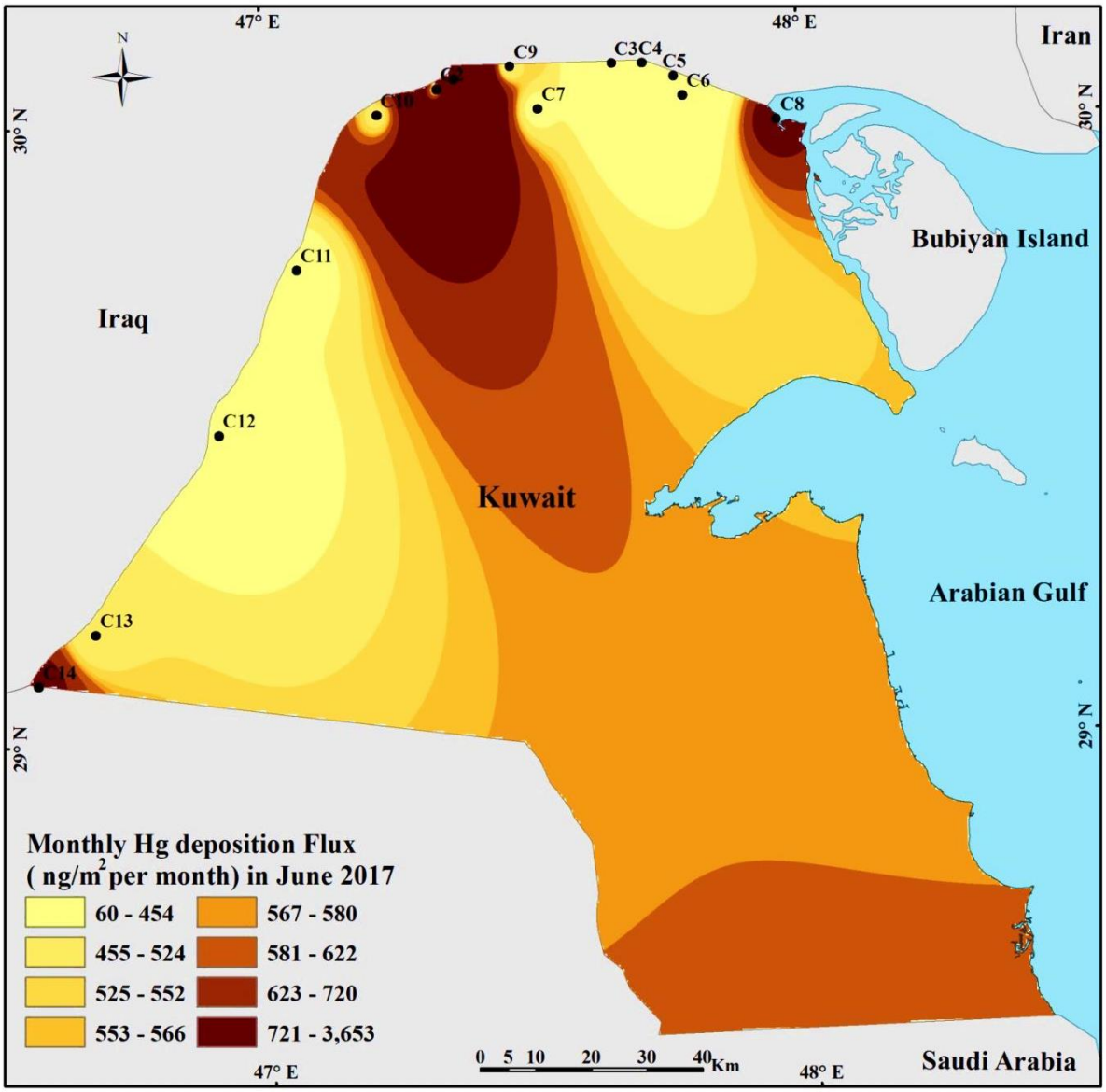


Plate 50. Monthly Hg deposition flux at different locations in Kuwait in June 2017.

Table 41. Monthly Hg Deposition Flux at Different Locations in Kuwait in June 2017

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	3653
C2	30.05534	47.32869	405
C3	30.0917393	47.655737	60
C4	30.0912605	47.7122124	143
C5	30.0694149	47.7700665	124
C6	30.0376106	47.7857968	242
C7	30.02071	47.51591	384
C8	29.9957776	47.9594236	841
C9	30.0898839	47.4661286	441
C10	30.0149398	47.2162539	484
C11	29.7668371	47.0631178	345
C12	29.5012389	46.9138662	126
C13	29.1813058	46.6808855	467
C14	29.0991676	46.5743071	800

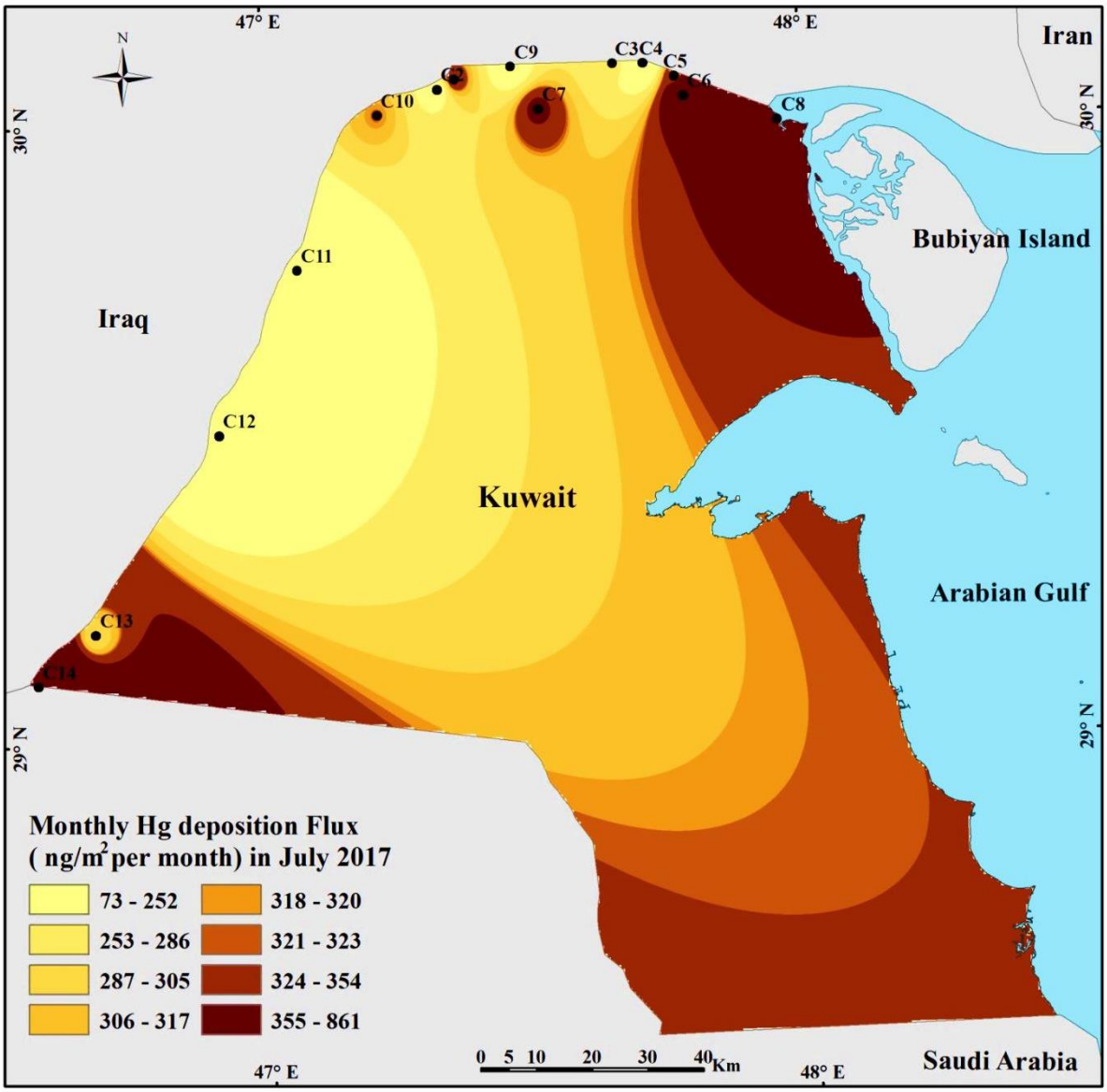


Plate 51. Monthly Hg deposition flux at different locations in Kuwait in July 2017.

Table 42. Monthly Hg Deposition Flux at Different Locations in Kuwait in July 2017

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	354
C2	30.05534	47.32869	207
C3	30.0917393	47.655737	273
C4	30.0912605	47.7122124	102
C5	30.0694149	47.7700665	340
C6	30.0376106	47.7857968	471
C7	30.02071	47.51591	370
C8	29.9957776	47.9594236	534
C9	30.0898839	47.4661286	193
C10	30.0149398	47.2162539	321
C11	29.7668371	47.0631178	73
C12	29.5012389	46.9138662	122
C13	29.1813058	46.6808855	288
C14	29.0991676	46.5743071	861

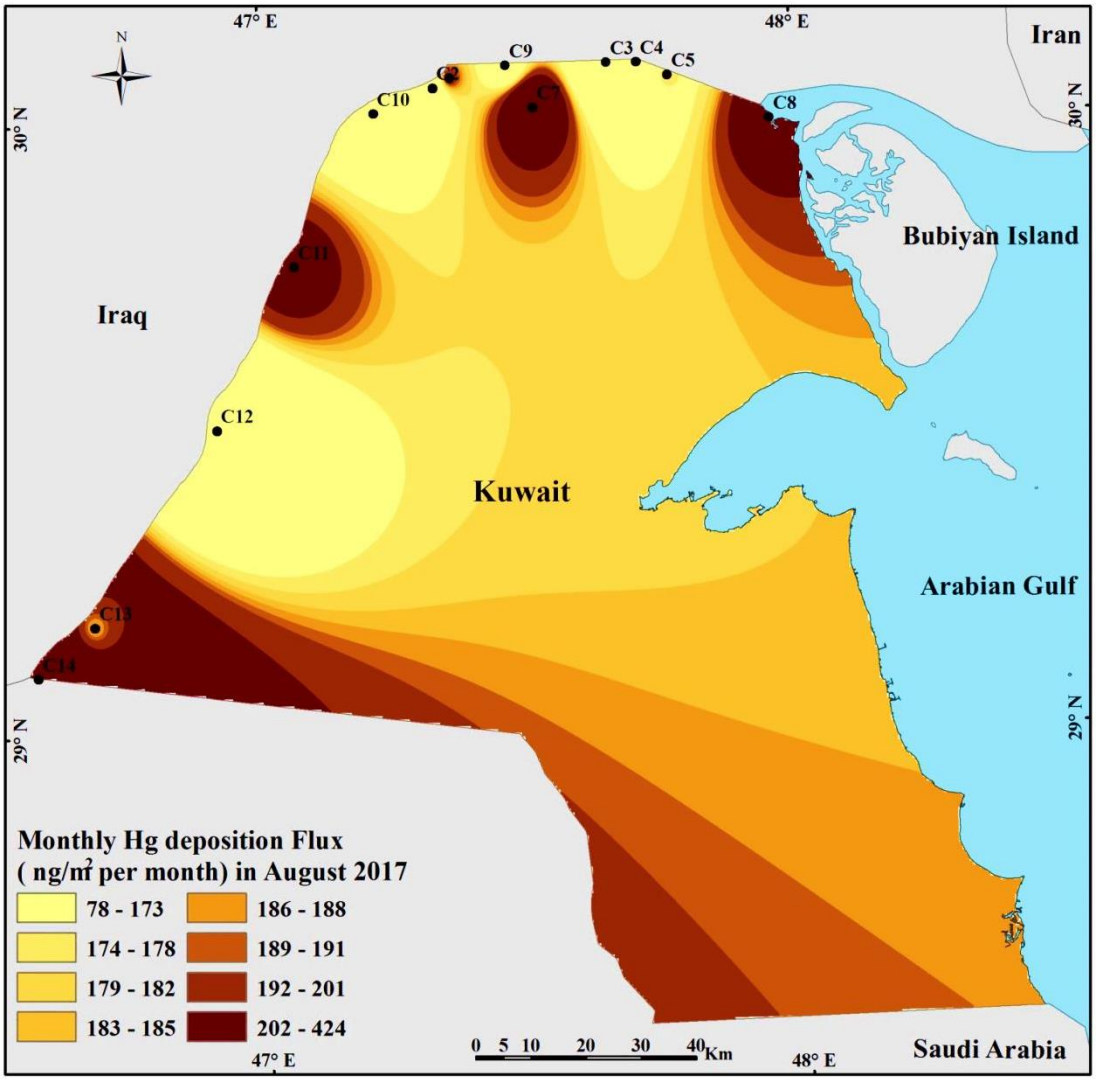


Plate 52. Monthly Hg deposition flux at different locations in Kuwait in August 2017.

Table 43. Monthly Hg Deposition Flux at Different Locations in Kuwait in August2017

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	197
C2	30.05534	47.32869	137
C3	30.0917393	47.655737	103
C4	30.0912605	47.7122124	138
C5	30.0694149	47.7700665	176
C7	30.02071	47.51591	273
C8	29.9957776	47.9594236	229
C9	30.0898839	47.4661286	145
C10	30.0149398	47.2162539	145
C11	29.7668371	47.0631178	221
C12	29.5012389	46.9138662	78
C13	29.1813058	46.6808855	185
C14	29.0991676	46.5743071	424

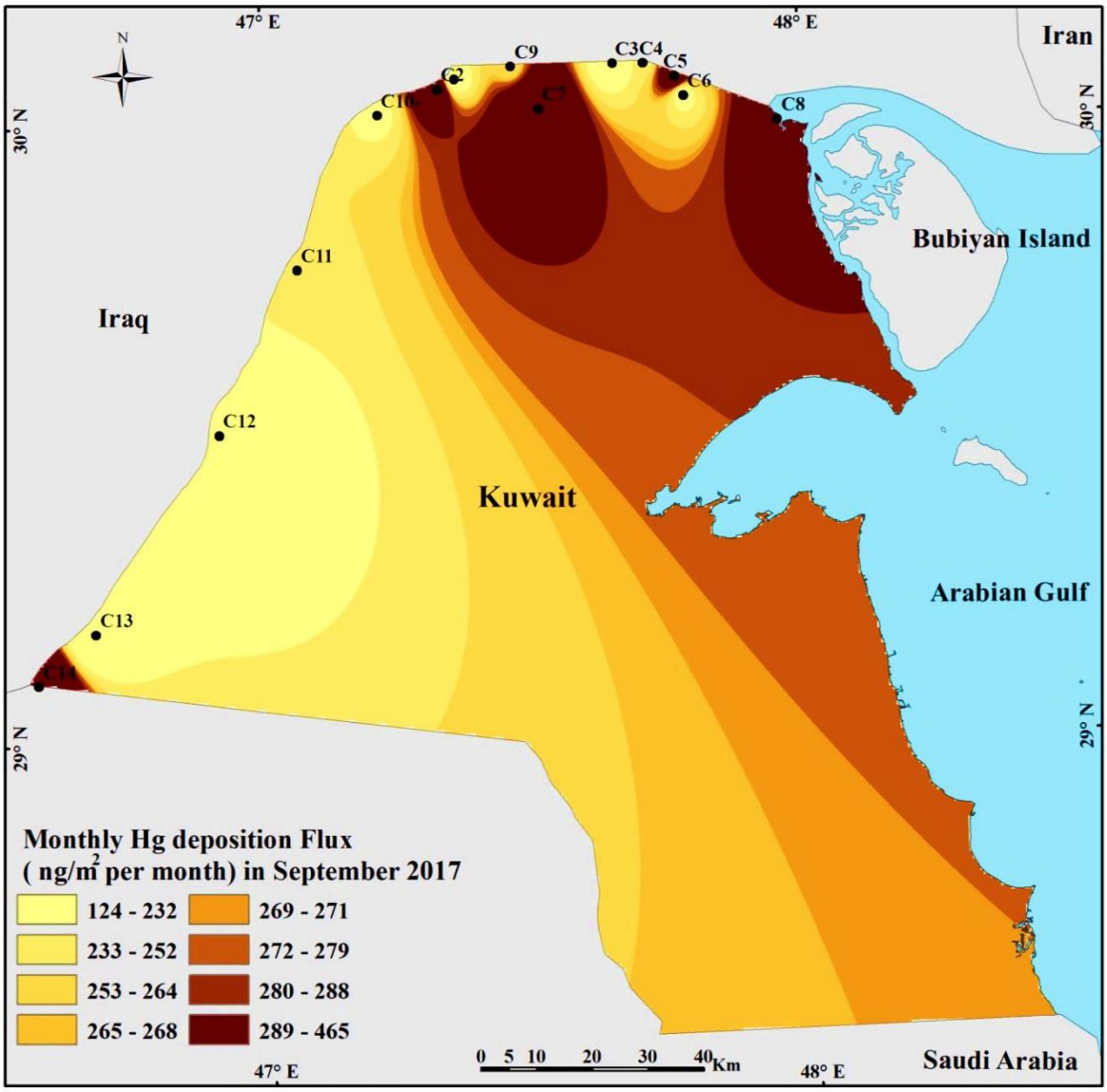


Plate 53. Monthly Hg deposition flux at different locations in Kuwait in September 2017.

Table 44. Monthly Hg Deposition Flux at Different Locations in Kuwait in September 2017

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	179
C2	30.05534	47.32869	375
C3	30.0917393	47.655737	177
C4	30.0912605	47.7122124	237
C5	30.0694149	47.7700665	359
C6	30.0376106	47.7857968	203
C7	30.02071	47.51591	465
C8	29.9957776	47.9594236	351
C9	30.0898839	47.4661286	250
C10-	30.0149398	47.2162539	217
C11	29.7668371	47.0631178	243
C12	29.5012389	46.9138662	124
C13	29.1813058	46.6808855	176
C14	29.0991676	46.5743071	398

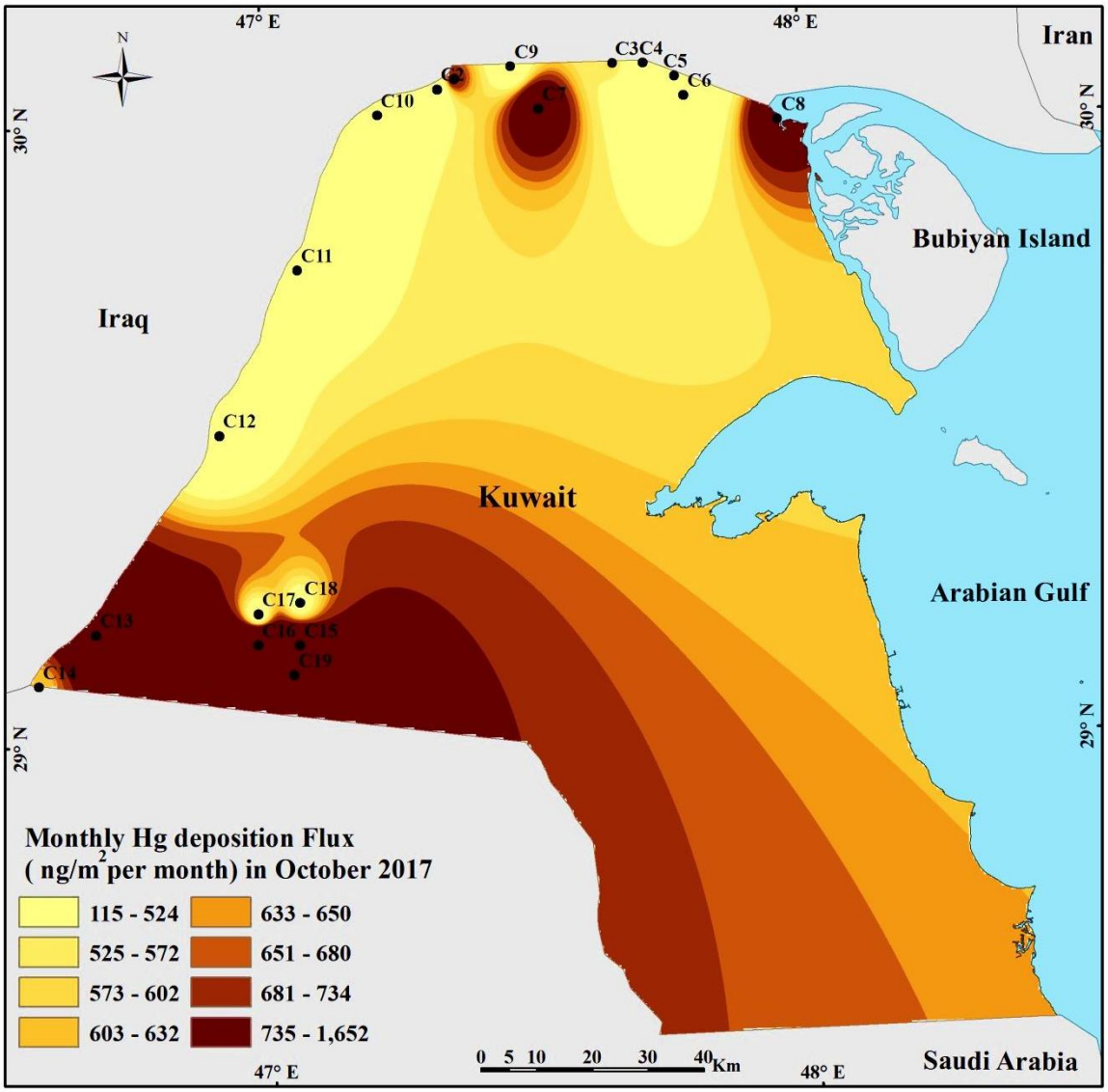


Plate 54. Monthly Hg deposition flux at different locations in Kuwait in October 2017.

Table 45. Monthly Hg Deposition Flux at Different Locations in Kuwait in October 2017

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	761
C2	30.05534	47.32869	299
C3	30.0917393	47.655737	590
C4	30.0912605	47.7122124	115
C5	30.0694149	47.7700665	332
C6	30.0376106	47.7857968	315
C7	30.02071	47.51591	1051
C8	29.9957776	47.9594236	911
C9	30.0898839	47.4661286	354
C10	30.0149398	47.2162539	418
C11	29.7668371	47.0631178	396
C12	29.5012389	46.9138662	244
C13	29.1813058	46.6808855	1025
C14	29.0991676	46.5743071	604
C15	29.160281	47.056431	1036
C16	29.161405	46.979464	1652
C17	29.212119	46.980339	358
C18	29.229152	47.05784	415
C19	29.112582	47.045027	834

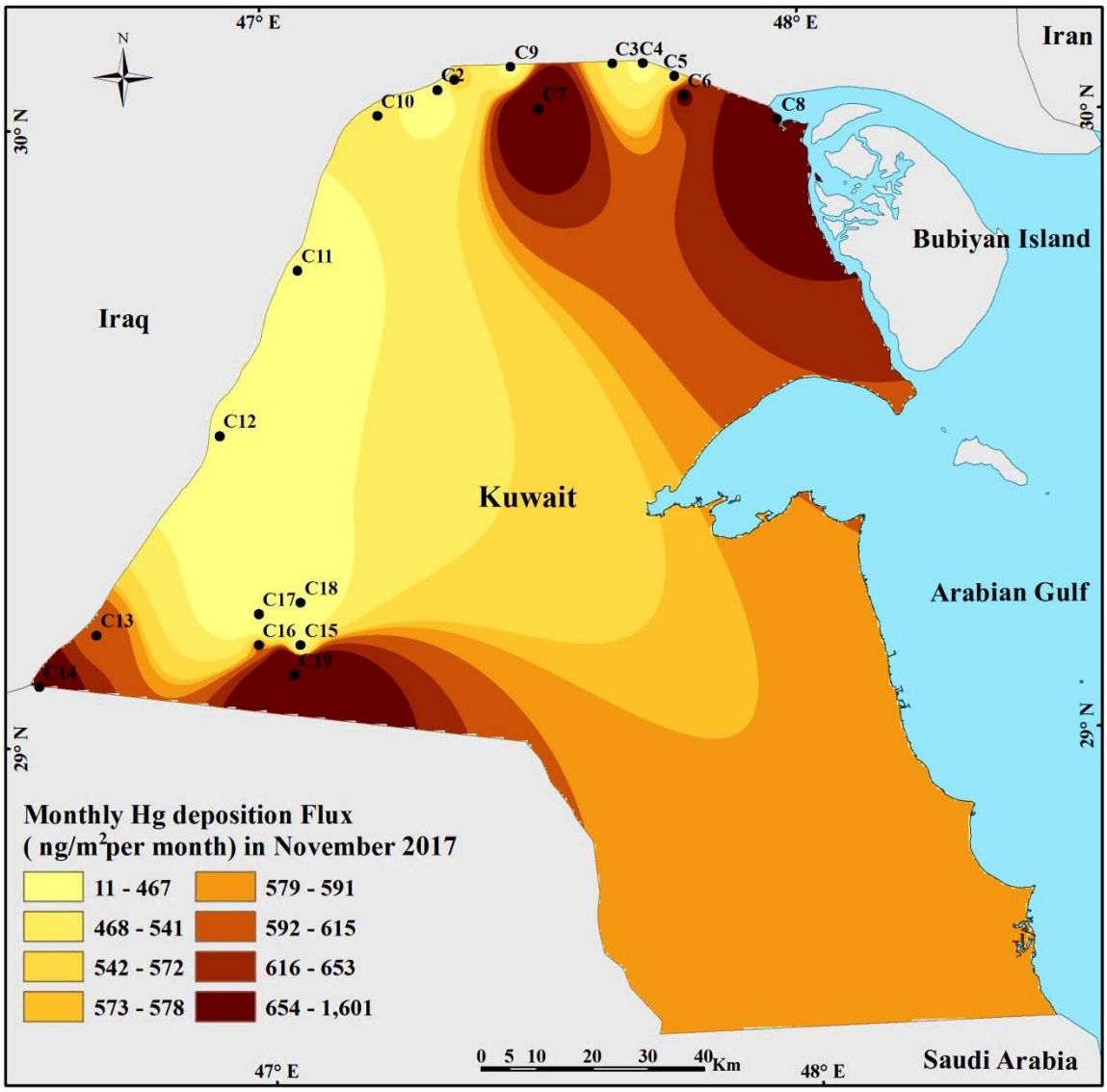


Plate 55. Monthly Hg deposition flux at different locations in Kuwait in November 2017.

Table 46. Monthly Hg Deposition Flux at Different Locations in Kuwait in November 2017

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	591
C2	30.05534	47.32869	299
C3	30.0917393	47.655737	540
C4	30.0912605	47.7122124	373
C5	30.0694149	47.7700665	512
C6	30.0376106	47.7857968	678
C7	30.02071	47.51591	1051
C8	29.9957776	47.9594236	911
C9	30.0898839	47.4661286	426
C10	30.0149398	47.2162539	482
C11	29.7668371	47.0631178	349
C12	29.5012389	46.9138662	264
C13	29.1813058	46.6808855	603
C14	29.0991676	46.5743071	740
C15	29.160281	47.056431	400
C16	29.161405	46.979464	597
C17	29.212119	46.980339	11
C18	29.229152	47.05784	279
C19	29.112582	47.045027	1601

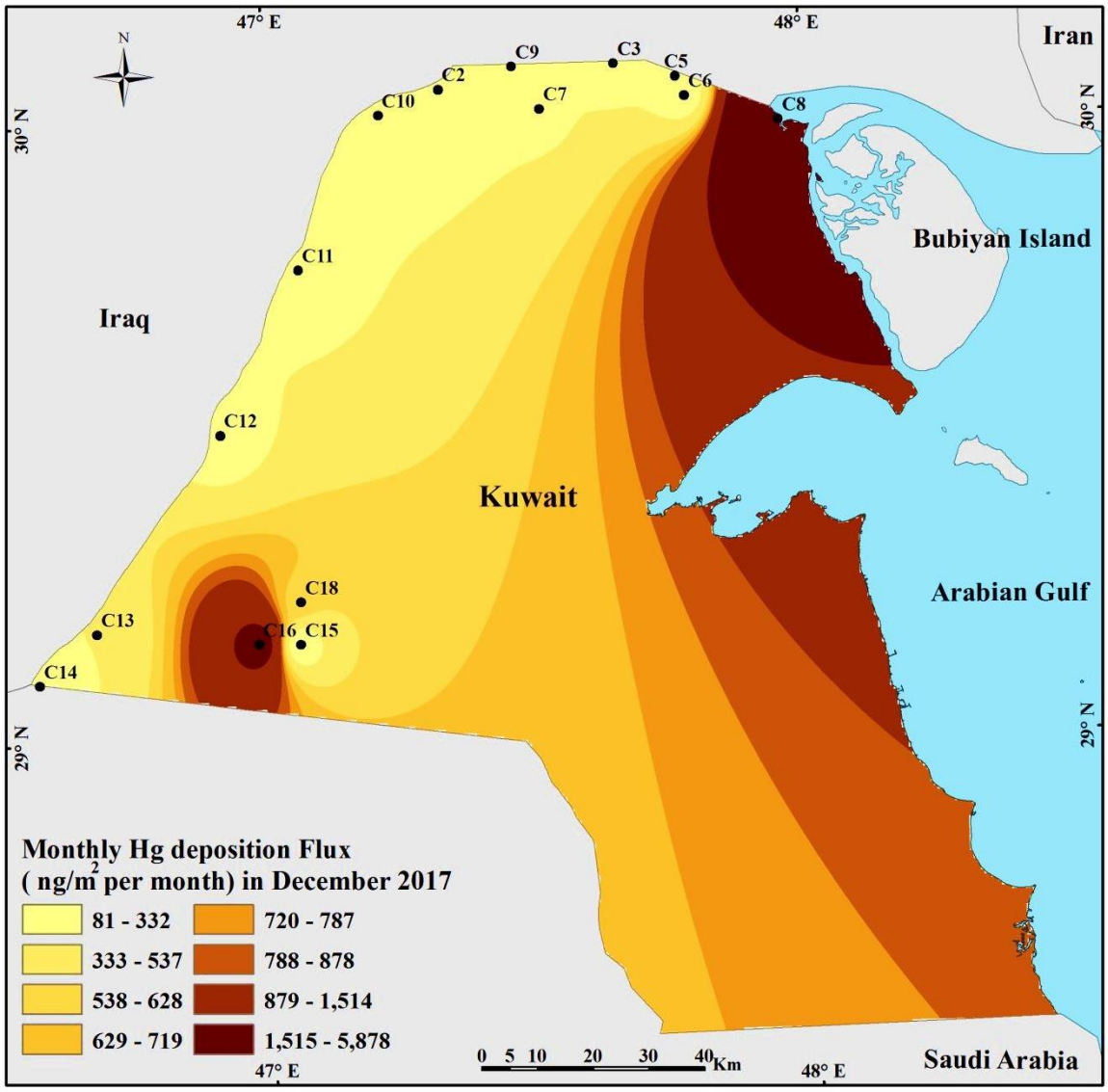


Plate 56. Monthly Hg deposition flux at different locations in Kuwait in December 2017.

Table 47. Monthly Hg Deposition Flux at Different Locations in Kuwait in December 2017

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C2	30.05534	47.32869	94
C3	30.0917393	47.655737	185
C5	30.0694149	47.7700665	81
C6	30.0376106	47.7857968	162
C7	30.02071	47.51591	273
C8	29.9957776	47.9594236	5878
C9	30.0898839	47.4661286	255
C10	30.0149398	47.2162539	135
C11	29.7668371	47.0631178	190
C12	29.5012389	46.9138662	173
C13	29.1813058	46.6808855	333
C14	29.0991676	46.5743071	108
C15	29.160281	47.056431	81
C16	29.161405	46.979464	1923
C18	29.229152	47.05784	573

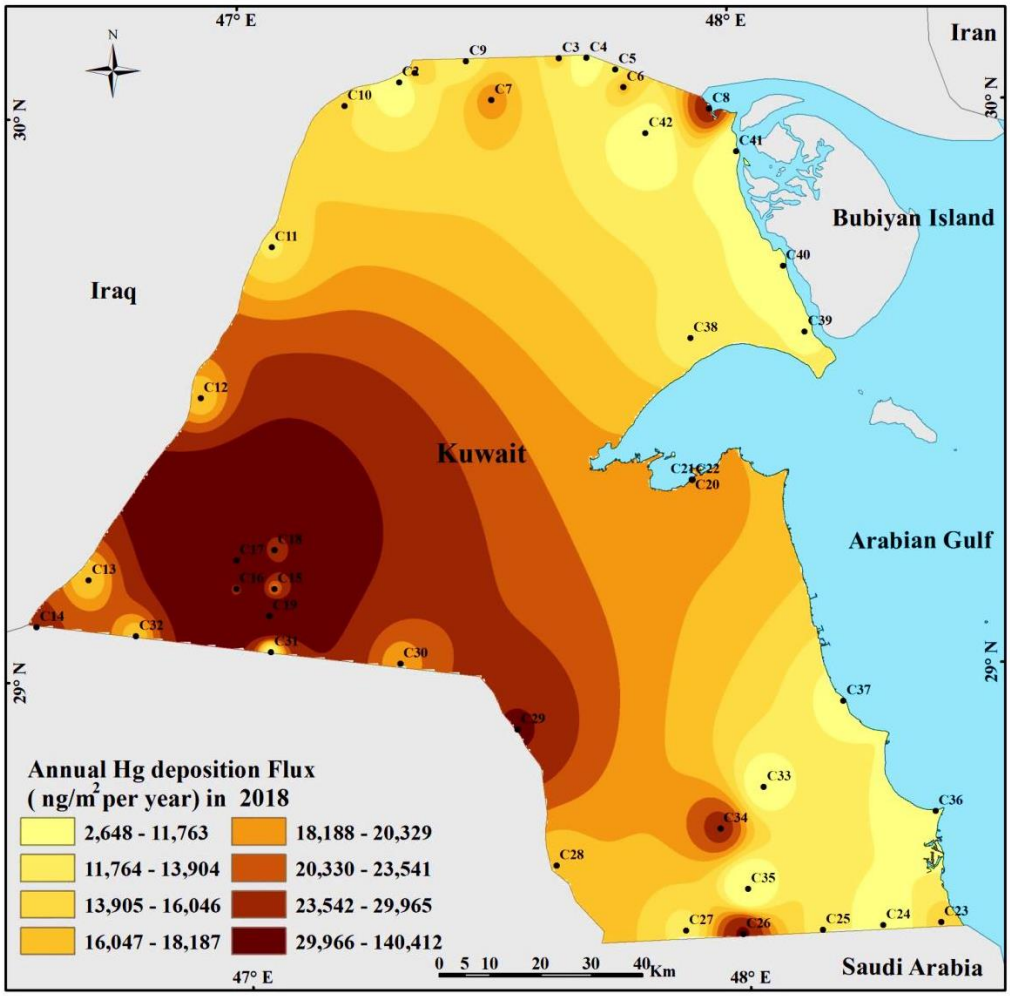


Plate 57. Annual Hg deposition flux at different locations in Kuwait in 2018.

Table 48. Annual Hg Deposition Flux at Different Locations in Kuwait in 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Year (ng/m^2)
C1	30.0715096	47.3613074	16085
C2	30.05534	47.32869	6300
C3	30.0917393	47.655737	14435
C4	30.0912605	47.7122124	6627
C5	30.0694149	47.7700665	13073
C6	30.0376106	47.7857968	16841
C7	30.02071	47.51591	19930
C8	29.9957776	47.9594236	27354
C9	30.0898839	47.4661286	12065
C10	30.0149398	47.2162539	14025
C11	29.7668371	47.0631178	13580
C12	29.5012389	46.9138662	16366
C13	29.1813058	46.6808855	15907
C14	29.0991676	46.5743071	24595
C15	29.160281	47.056431	18593
C16	29.161405	46.979464	26120
C17	29.212119	46.980339	140412
C18	29.229152	47.05784	23880
C19	29.112582	47.045027	58215
C20	29.337883	47.9059	17240
C21	29.339033	47.905533	24767
C22	29.33895	47.906567	16378
C23	28.542567	48.38475	14652
C24	28.5403	48.267717	7989
C25	28.5345	48.1464	13264
C26	28.5304	47.98615	31367
C27	28.5392	47.871567	12423
C28	28.660017	47.614333	16577
C29	28.9025	47.54185	31232
C30	29.0234	47.307883	18445
C31	29.04855	47.0474	10536
C32	29.080183	46.774917	16571
C33	28.790883	48.035083	8629
C34	28.718883	47.945717	26173
C35	28.610183	47.998217	2648
C36	28.740017	48.379533	5691
C37	28.939967	48.19995	10265
C38	29.590033	47.90955	12506
C39	29.596083	48.141833	11263
C40	29.71405	48.101067	7156
C41	29.919083	48.011883	3291
C42	29.955	47.828717	4692

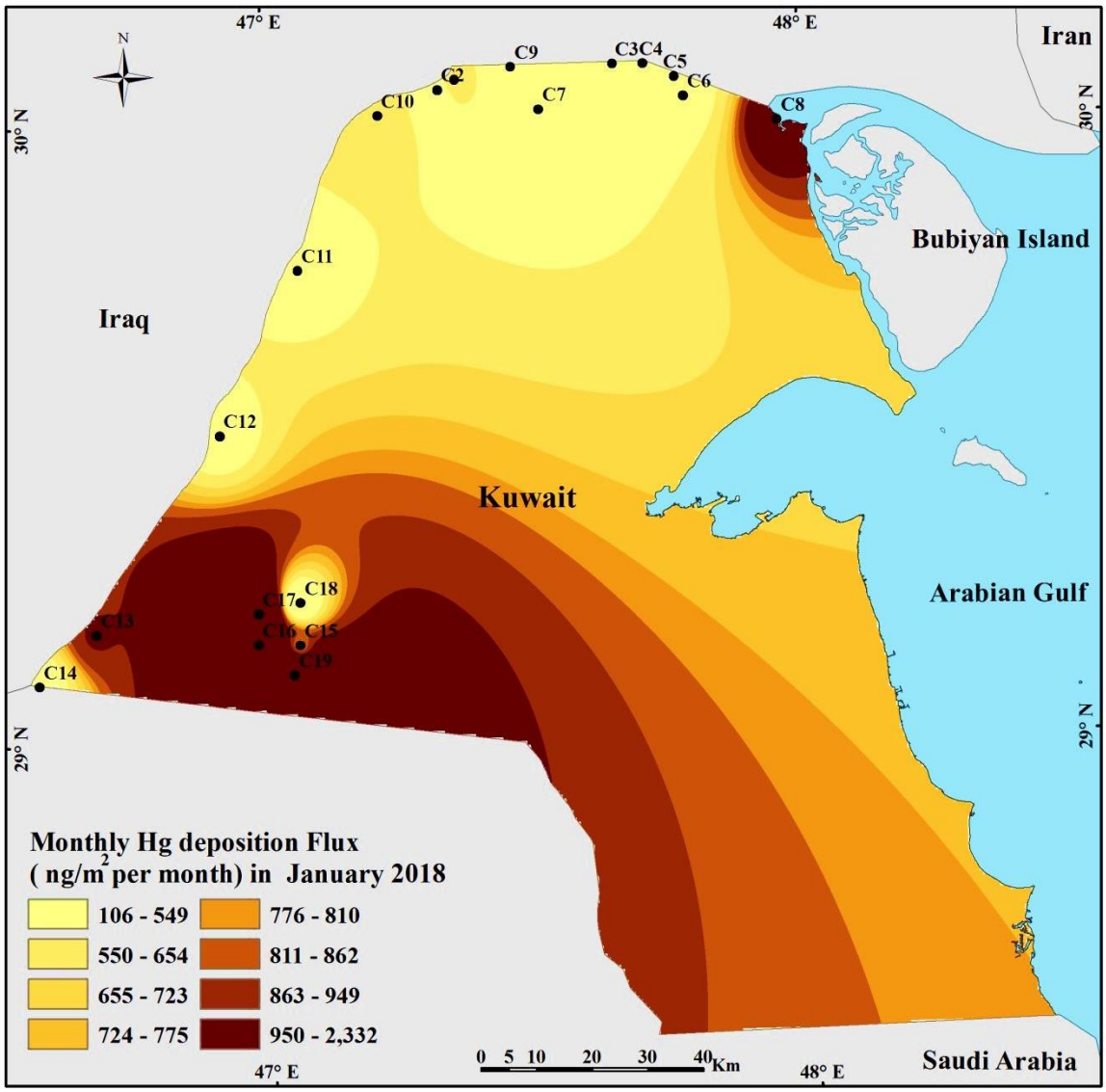


Plate 58. Monthly Hg deposition flux at different locations in Kuwait in January 2018.

Table 49. Monthly Hg Deposition Flux at Different Locations in Kuwait in January 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	675
C2	30.05534	47.32869	412
C3	30.0917393	47.655737	466
C4	30.0912605	47.7122124	302
C5	30.0694149	47.7700665	557
C6	30.0376106	47.7857968	413
C7	30.02071	47.51591	325
C8	29.9957776	47.9594236	1256
C9	30.0898839	47.4661286	394
C10	30.0149398	47.2162539	643
C11	29.7668371	47.0631178	412
C12	29.5012389	46.9138662	383
C13	29.1813058	46.6808855	966
C14	29.0991676	46.5743071	366
C15	29.160281	47.056431	768
C16	29.161405	46.979464	1173
C17	29.212119	46.980339	1878
C18	29.229152	47.05784	106
C19	29.112582	47.045027	2332

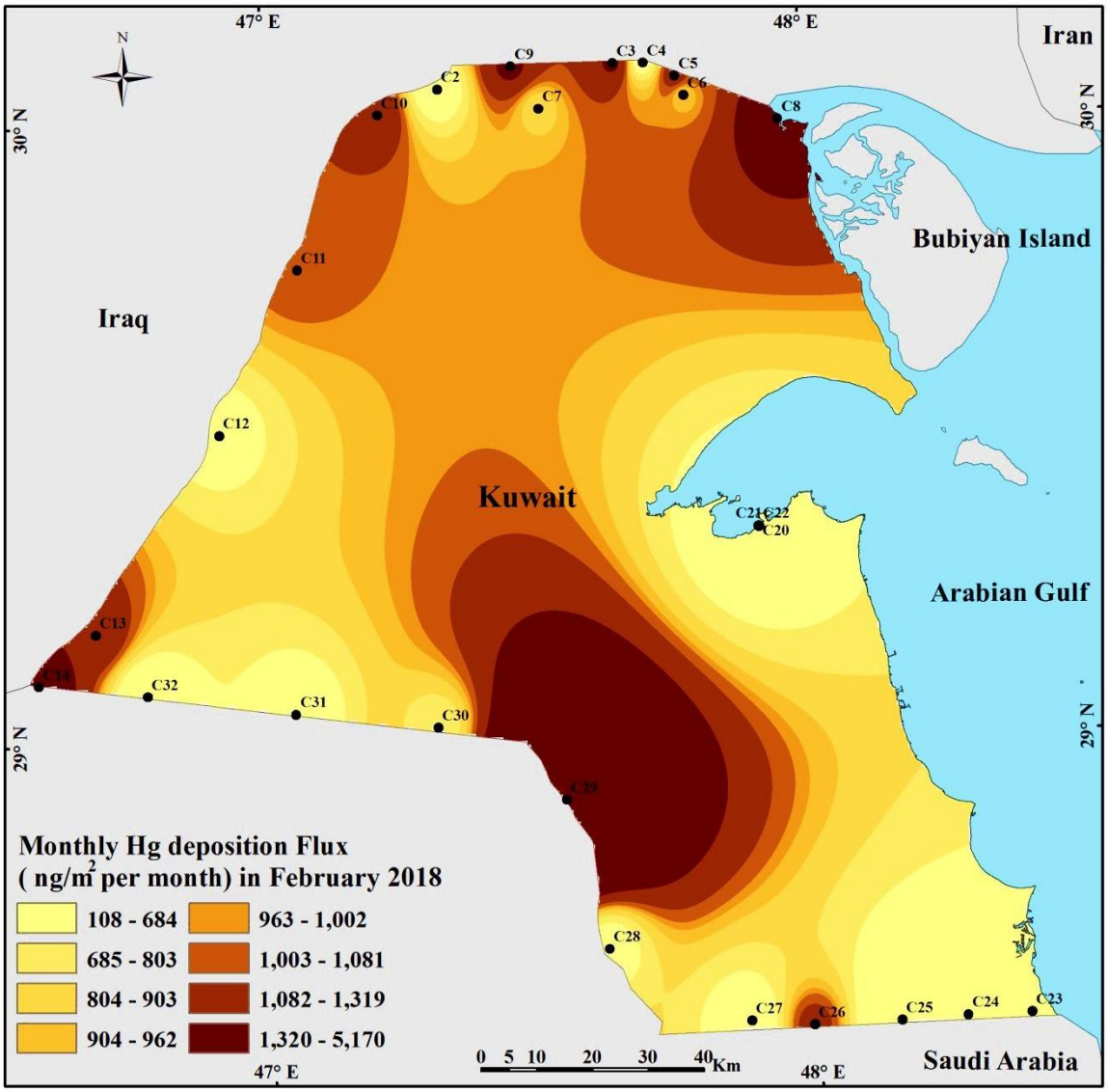


Plate 59. Monthly Hg deposition flux at different locations in Kuwait in February 2018.

Table 50. Monthly Hg Deposition Flux at Different Locations in Kuwait in February 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C2	30.05534	47.32869	413
C3	30.0917393	47.655737	1384
C4	30.0912605	47.7122124	531
C5	30.0694149	47.7700665	1216
C6	30.0376106	47.7857968	900
C7	30.02071	47.51591	823
C8	29.9957776	47.9594236	1809
C9	30.0898839	47.4661286	1408
C10	30.0149398	47.2162539	1283
C11	29.7668371	47.0631178	1052
C12	29.5012389	46.9138662	543
C13	29.1813058	46.6808855	1278
C14	29.0991676	46.5743071	1659
C20	29.337883	47.9059	483
C21	29.339033	47.905533	584
C22	29.33895	47.906567	321
C23	28.542567	48.38475	438
C24	28.5403	48.267717	573
C25	28.5345	48.1464	108
C26	28.5304	47.98615	1179
C27	28.5392	47.871567	449
C28	28.660017	47.614333	508
C29	28.9025	47.54185	5170
C30	29.0234	47.307883	676
C31	29.04855	47.0474	459
C32	29.080183	46.774917	316

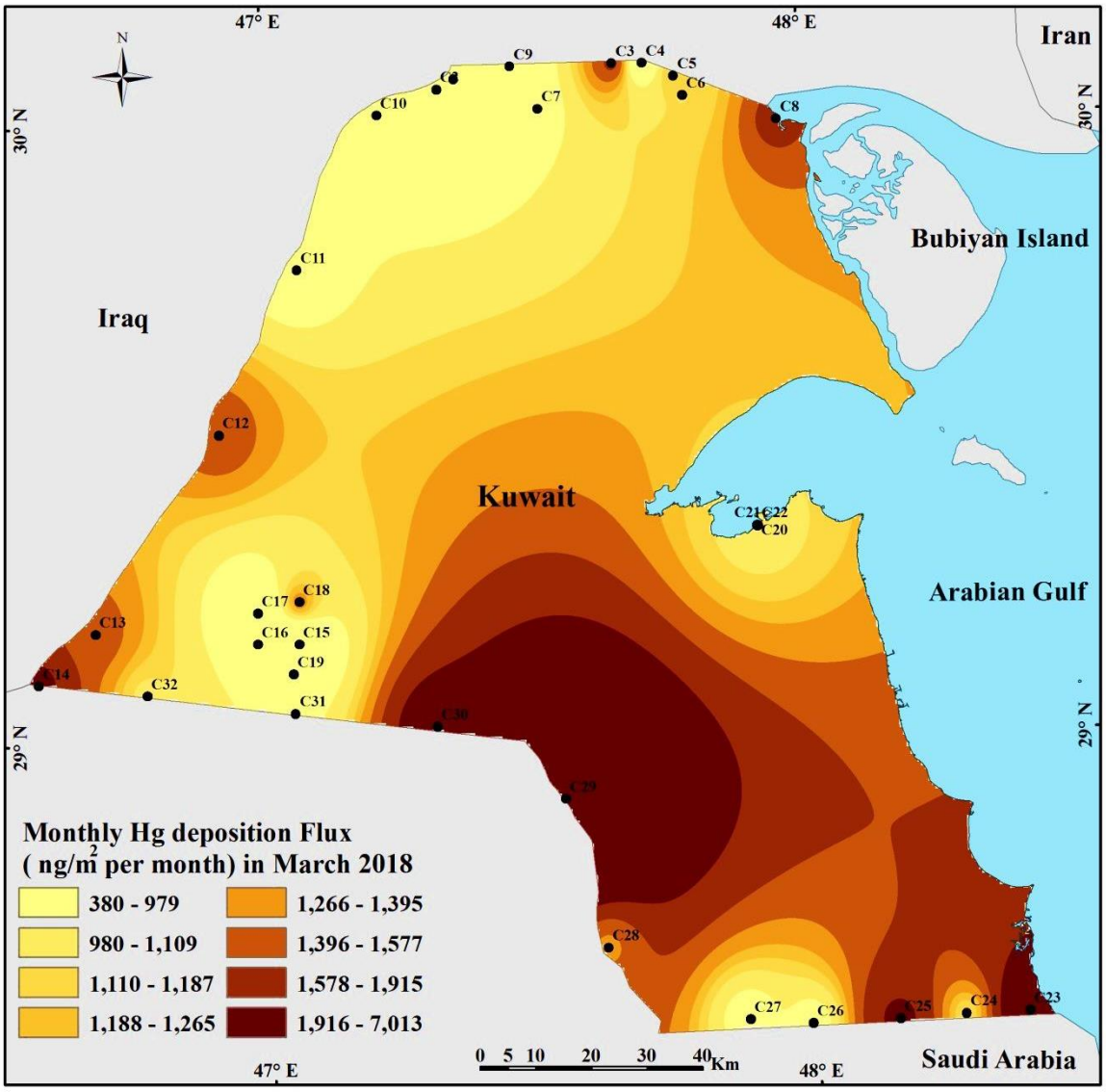


Plate 60. Monthly Hg deposition flux of different locations in Kuwait in March 2018.

Table 51. Monthly Hg Deposition Flux at Different Locations in Kuwait in March 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	904
C2	30.05534	47.32869	380
C3	30.0917393	47.655737	1637
C4	30.0912605	47.7122124	630
C5	30.0694149	47.7700665	1197
C6	30.0376106	47.7857968	1104
C7	30.02071	47.51591	925
C8	29.9957776	47.9594236	1681
C9	30.0898839	47.4661286	614
C10	30.0149398	47.2162539	923
C11	29.7668371	47.0631178	804
C12	29.5012389	46.9138662	1557
C13	29.1813058	46.6808855	1499
C14	29.0991676	46.5743071	2020
C15	29.160281	47.056431	383
C16	29.161405	46.979464	981
C17	29.212119	46.980339	519
C18	29.229152	47.05784	1325
C19	29.112582	47.045027	855
C20	29.337883	47.9059	1060
C21	29.339033	47.905533	861
C22	29.33895	47.906567	1231
C23	28.542567	48.38475	2543
C24	28.5403	48.267717	1120
C25	28.5345	48.1464	2011
C26	28.5304	47.98615	880
C27	28.5392	47.871567	859
C28	28.660017	47.614333	1357
C29	28.9025	47.54185	7013
C30	29.0234	47.307883	2386
C31	29.04855	47.0474	931
C32	29.080183	46.774917	1077

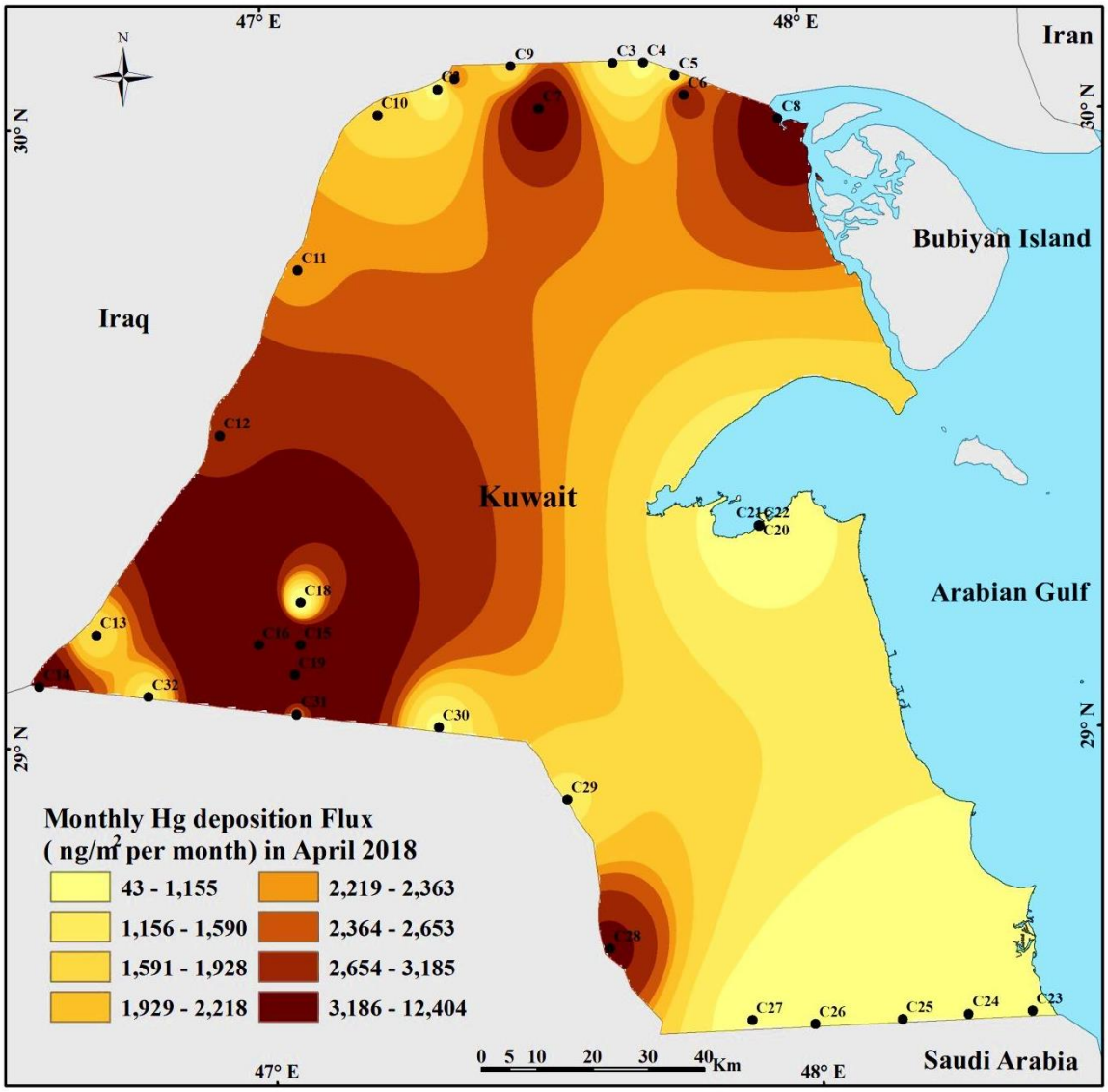


Plate 61. Monthly Hg deposition flux at different locations in Kuwait in April 2018.

Table 52. Monthly Hg Deposition Flux at Different Locations in Kuwait in April 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C1	30.0715096	47.3613074	2442
C2	30.05534	47.32869	895
C3	30.0917393	47.655737	1325
C4	30.0912605	47.7122124	746
C5	30.0694149	47.7700665	1388
C6	30.0376106	47.7857968	3196
C7	30.02071	47.51591	4570
C8	29.9957776	47.9594236	4372
C9	30.0898839	47.4661286	1606
C10	30.0149398	47.2162539	1826
C11	29.7668371	47.0631178	2259
C12	29.5012389	46.9138662	2972
C13	29.1813058	46.6808855	1560
C14	29.0991676	46.5743071	4152
C15	29.160281	47.056431	3771
C16	29.161405	46.979464	12404
C18	29.229152	47.05784	394
C19	29.112582	47.045027	8042
C20	29.337883	47.9059	823
C21	29.339033	47.905533	1442
C22	29.33895	47.906567	405
C23	28.542567	48.38475	452
C24	28.5403	48.267717	201
C25	28.5345	48.1464	43
C26	28.5304	47.98615	107
C27	28.5392	47.871567	992
C28	28.660017	47.614333	3416
C29	28.9025	47.54185	1470
C30	29.0234	47.307883	1018
C31	29.04855	47.0474	2308
C32	29.080183	46.774917	1366

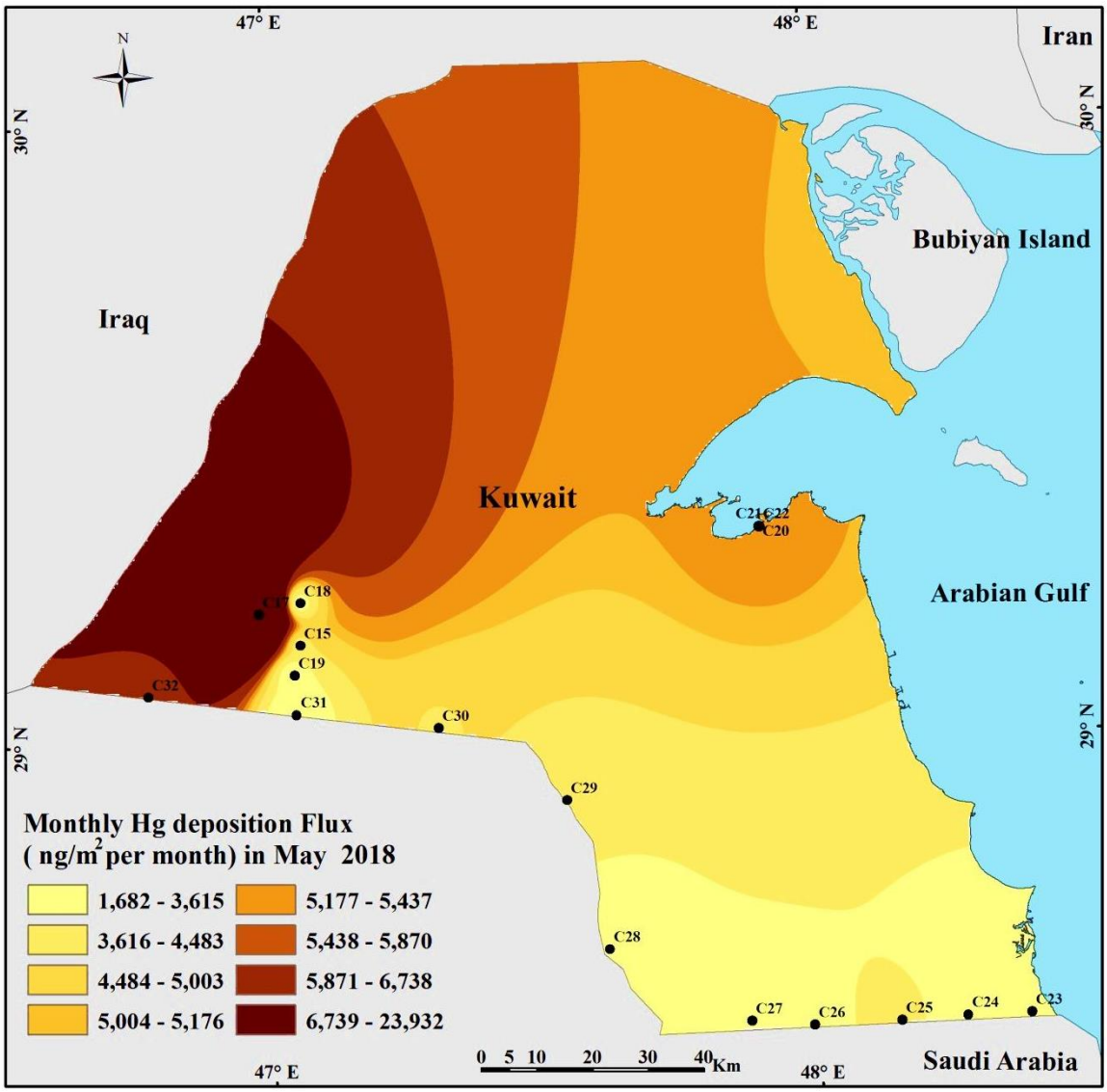


Plate 62. Monthly Hg deposition flux at different locations in Kuwait in May 2018.

Table 53. Monthly Hg Deposition Flux at Different Locations in Kuwait in May 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	4179
C17	29.212119	46.980339	23932
C18	29.229152	47.05784	3036
C19	29.112582	47.045027	2501
C20	29.337883	47.9059	3811
C21	29.339033	47.905533	6970
C22	29.33895	47.906567	5174
C23	28.542567	48.38475	3444
C24	28.5403	48.267717	2041
C25	28.5345	48.1464	4141
C26	28.5304	47.98615	3398
C27	28.5392	47.871567	3227
C28	28.660017	47.614333	2235
C29	28.9025	47.54185	3901
C30	29.0234	47.307883	4425
C31	29.04855	47.0474	1682
C32	29.080183	46.774917	6014

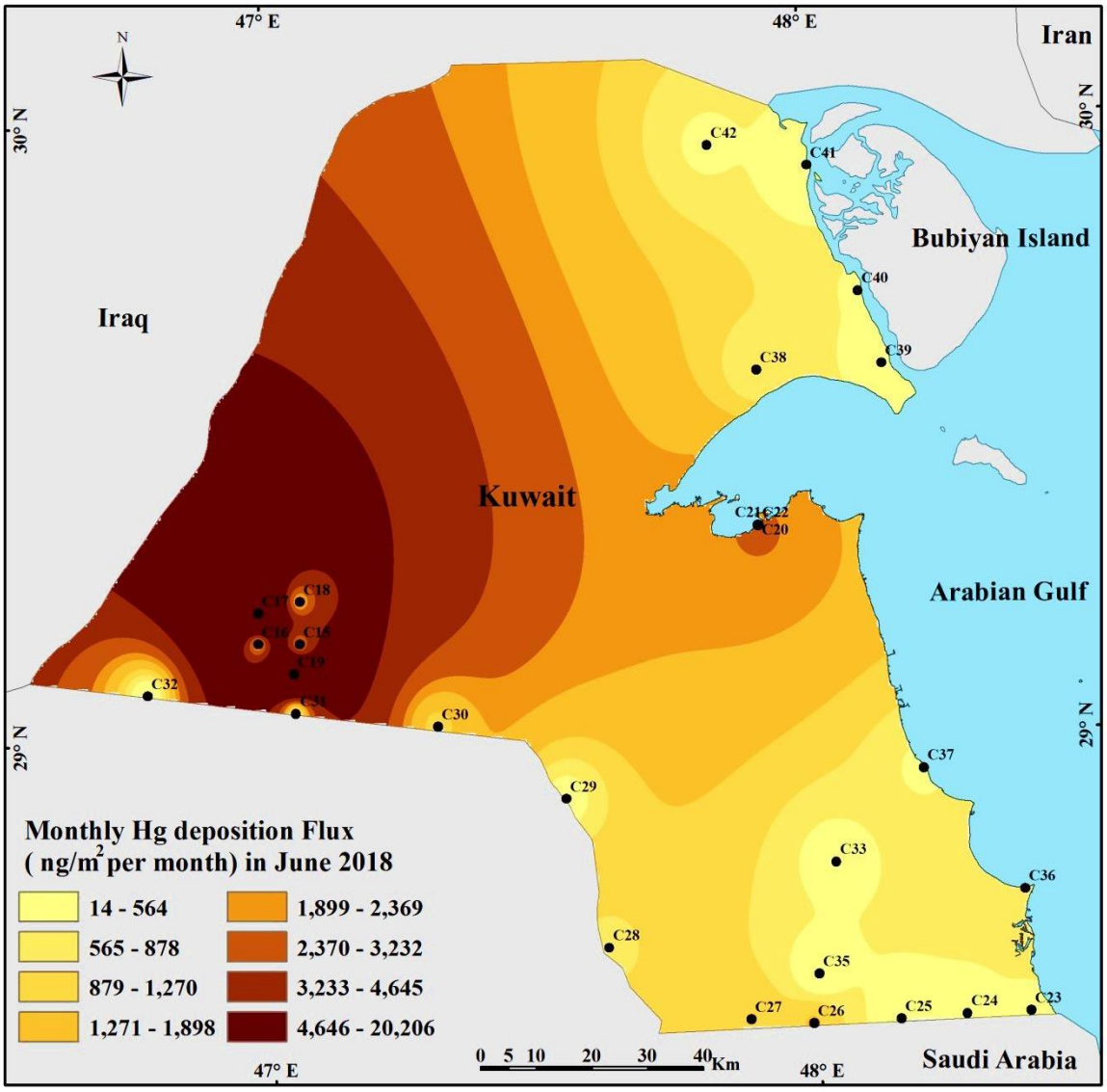


Plate 63. Monthly Hg deposition flux at different locations in Kuwait in June 2018.

Table 54. Monthly Hg Deposition Flux at Different Locations in Kuwait in June 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	2312
C16	29.161405	46.979464	1669
C17	29.212119	46.980339	20206
C18	29.229152	47.05784	1758
C19	29.112582	47.045027	14692
C20	29.337883	47.9059	3761
C21	29.339033	47.905533	1332
C22	29.33895	47.906567	2143
C23	28.542567	48.38475	529
C24	28.5403	48.267717	460
C25	28.5345	48.1464	239
C26	28.5304	47.98615	1317
C27	28.5392	47.871567	1100
C28	28.660017	47.614333	747
C29	28.9025	47.54185	367
C30	29.0234	47.307883	1097
C31	29.04855	47.0474	555
C32	29.080183	46.774917	145
C33	28.790883	48.035083	306
C35	28.610183	47.998217	139
C36	28.740017	48.379533	575
C37	28.939967	48.19995	491
C38	29.590033	47.90955	571
C39	29.596083	48.141833	14
C40	29.71405	48.101067	531
C41	29.919083	48.011883	191
C42	29.955	47.828717	485

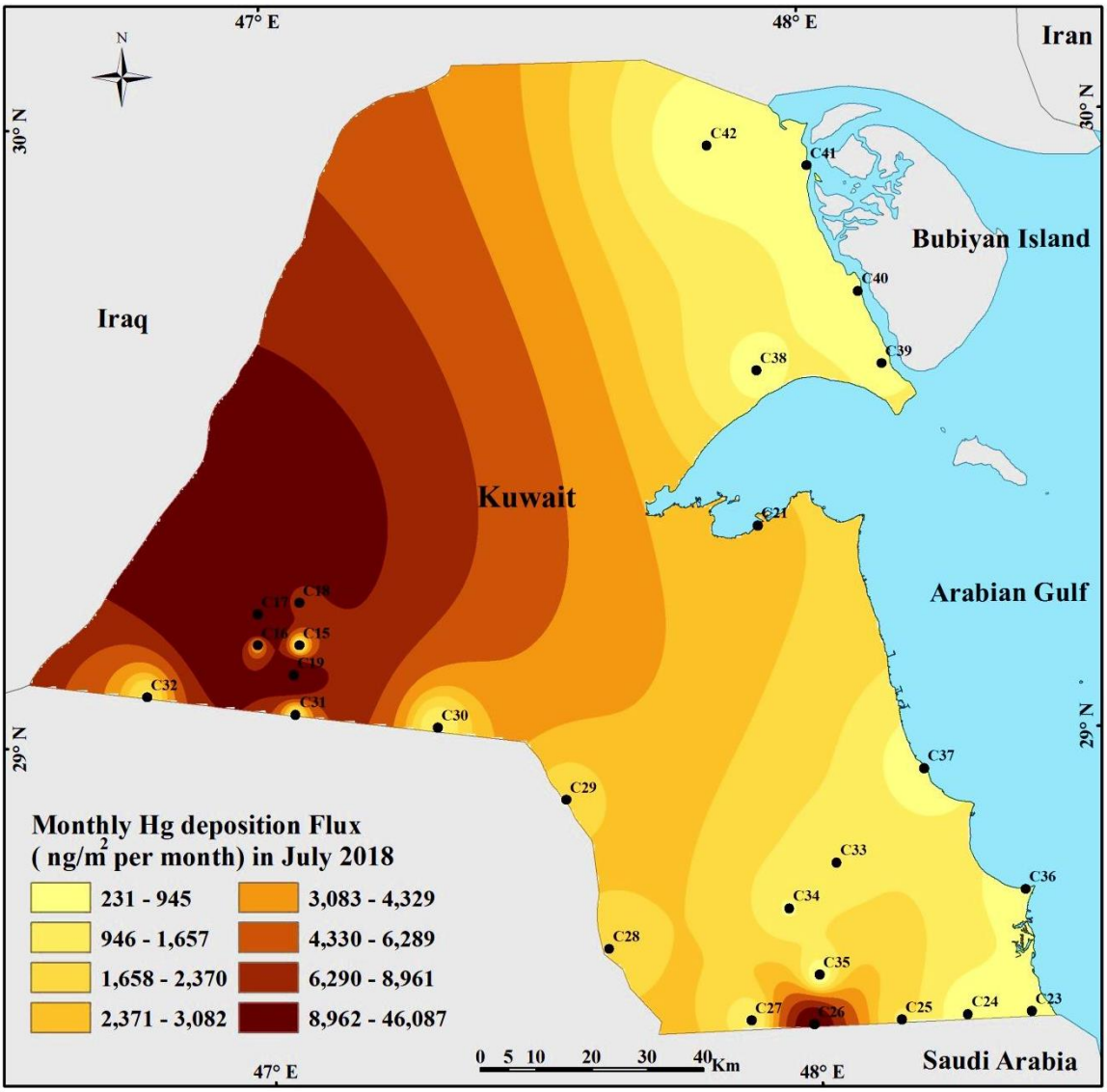


Plate 64. Monthly Hg Deposition Flux at Different Locations in Kuwait in July 2018.

Table 55. Monthly Hg Deposition Flux at Different Locations in Kuwait in July 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	415
C16	29.161405	46.979464	2392
C17	29.212119	46.980339	46087
C18	29.229152	47.05784	6836
C19	29.112582	47.045027	17764
C21	29.339033	47.905533	2568
C23	28.542567	48.38475	301
C24	28.5403	48.267717	326
C25	28.5345	48.1464	1589
C26	28.5304	47.98615	12523
C27	28.5392	47.871567	855
C28	28.660017	47.614333	1832
C29	28.9025	47.54185	1926
C30	29.0234	47.307883	1000
C31	29.04855	47.0474	1035
C32	29.080183	46.774917	1512
C33	28.790883	48.035083	1084
C34	28.718883	47.945717	875
C35	28.610183	47.998217	278
C36	28.740017	48.379533	413
C37	28.939967	48.19995	306
C38	29.590033	47.90955	733
C39	29.596083	48.141833	821
C40	29.71405	48.101067	231
C41	29.919083	48.011883	255
C42	29.955	47.828717	352

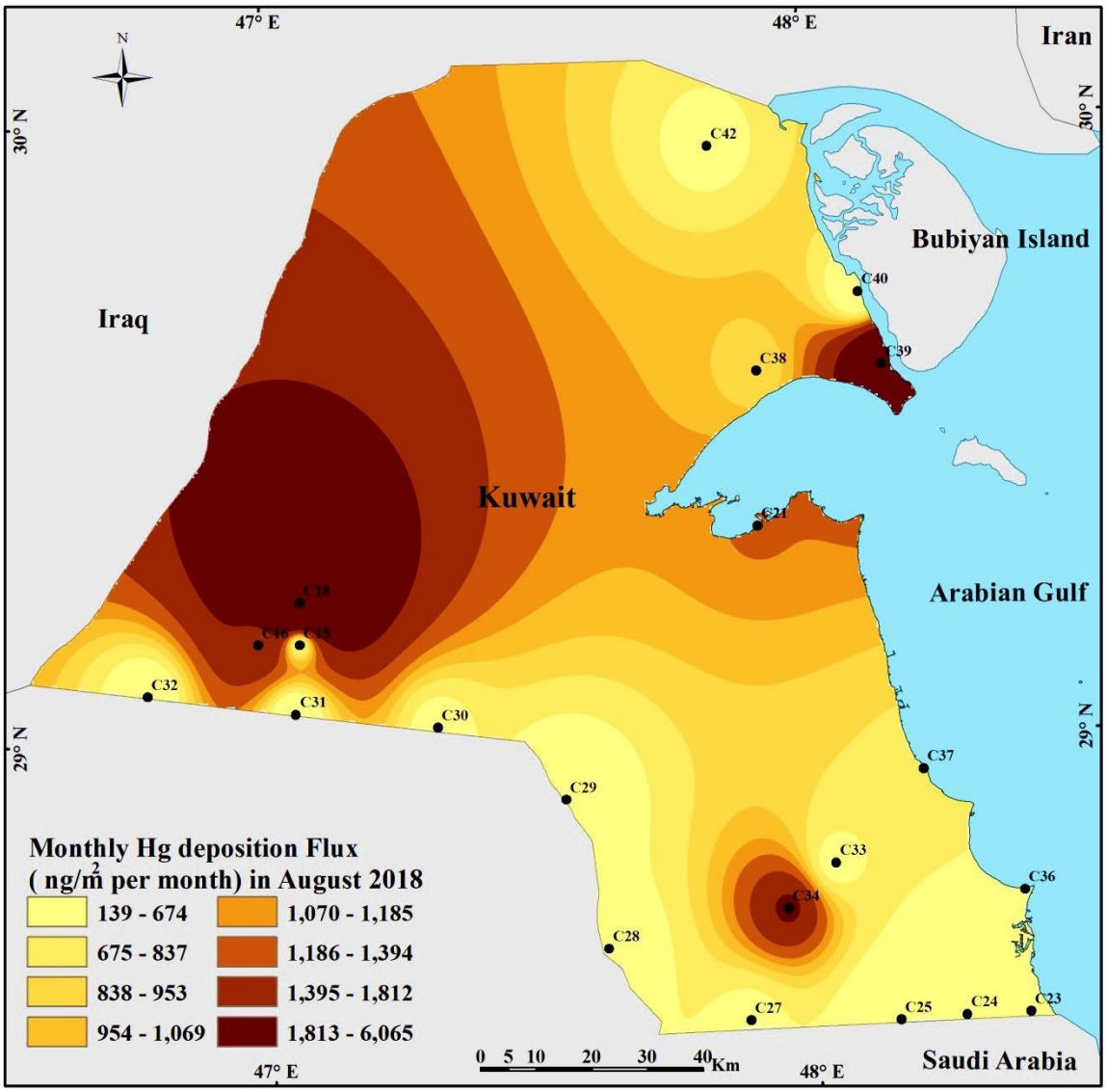


Plate 65. Monthly Hg deposition flux at different locations in Kuwait in August 2018.

Table 56. Monthly Hg Deposition Flux at Different Locations in Kuwait in August 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	576
C16	29.161405	46.979464	1583
C18	29.229152	47.05784	6065
C21	29.339033	47.905533	1208
C23	28.542567	48.38475	325
C24	28.5403	48.267717	256
C25	28.5345	48.1464	139
C27	28.5392	47.871567	558
C28	28.660017	47.614333	385
C29	28.9025	47.54185	216
C30	29.0234	47.307883	528
C31	29.04855	47.0474	253
C32	29.080183	46.774917	367
C33	28.790883	48.035083	544
C34	28.718883	47.945717	1923
C36	28.740017	48.379533	631
C37	28.939967	48.19995	790
C38	29.590033	47.90955	845
C39	29.596083	48.141833	3025
C40	29.71405	48.101067	303
C42	29.955	47.828717	573

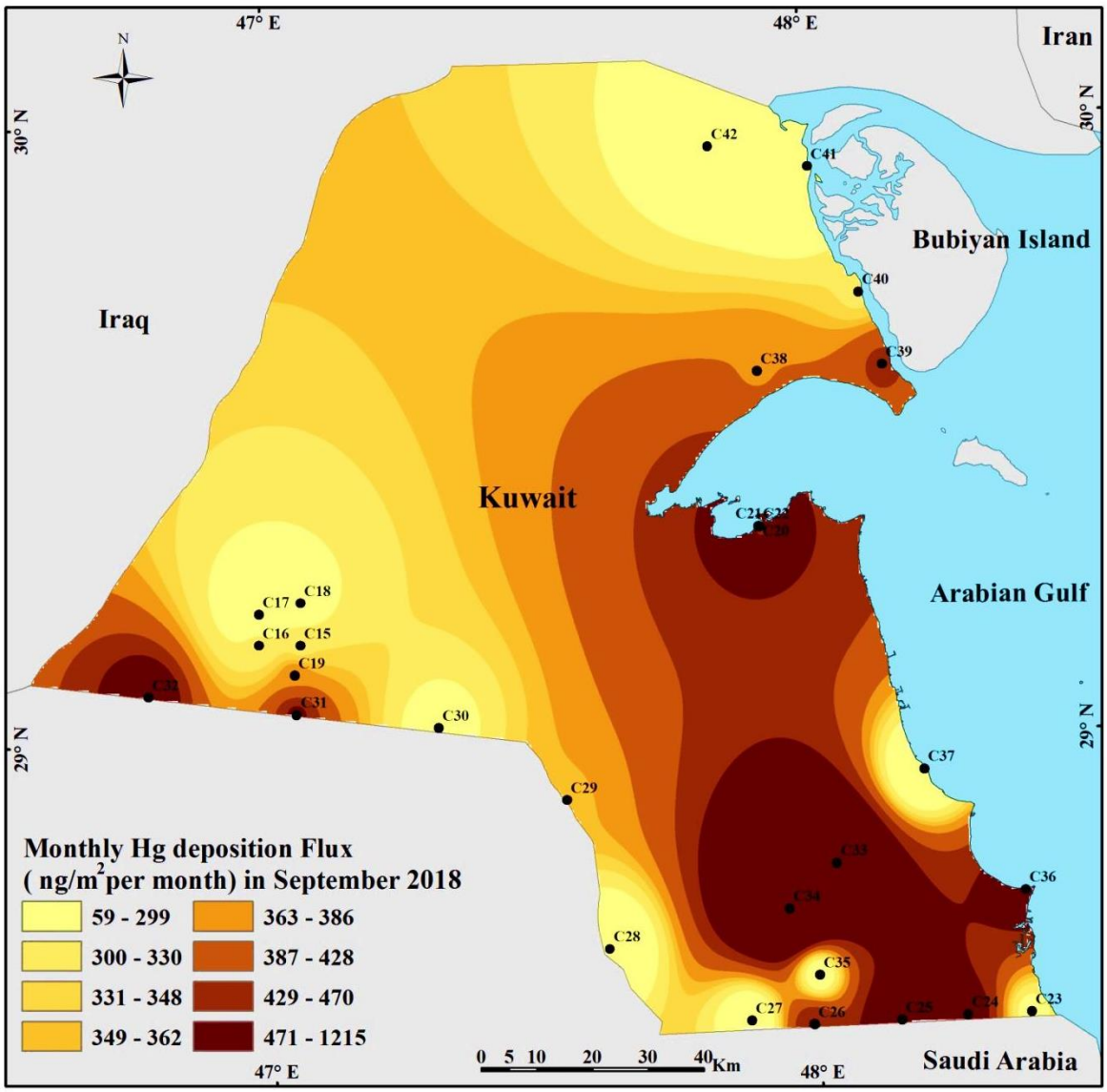


Plate 66. Monthly Hg deposition flux at different locations in Kuwait in September 2018.

Table 57. Monthly Hg Deposition Flux at Different Locations in Kuwait in September 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	230
C16	29.161405	46.979464	319
C17	29.212119	46.980339	178
C18	29.229152	47.05784	250
C19	29.112582	47.045027	384
C20	29.337883	47.9059	59
C21	29.339033	47.905533	1215
C22	29.33895	47.906567	218
C23	28.542567	48.38475	273
C24	28.5403	48.267717	516
C25	28.5345	48.1464	579
C26	28.5304	47.98615	475
C27	28.5392	47.871567	194
C28	28.660017	47.614333	166
C29	28.9025	47.54185	358
C30	29.0234	47.307883	252
C31	29.04855	47.0474	489
C32	29.080183	46.774917	546
C33	28.790883	48.035083	703
C34	28.718883	47.945717	969
C35	28.610183	47.998217	235
C36	28.740017	48.379533	524
C37	28.939967	48.19995	157
C38	29.590033	47.90955	384
C39	29.596083	48.141833	438
C40	29.71405	48.101067	321
C41	29.919083	48.011883	79
C42	29.955	47.828717	231

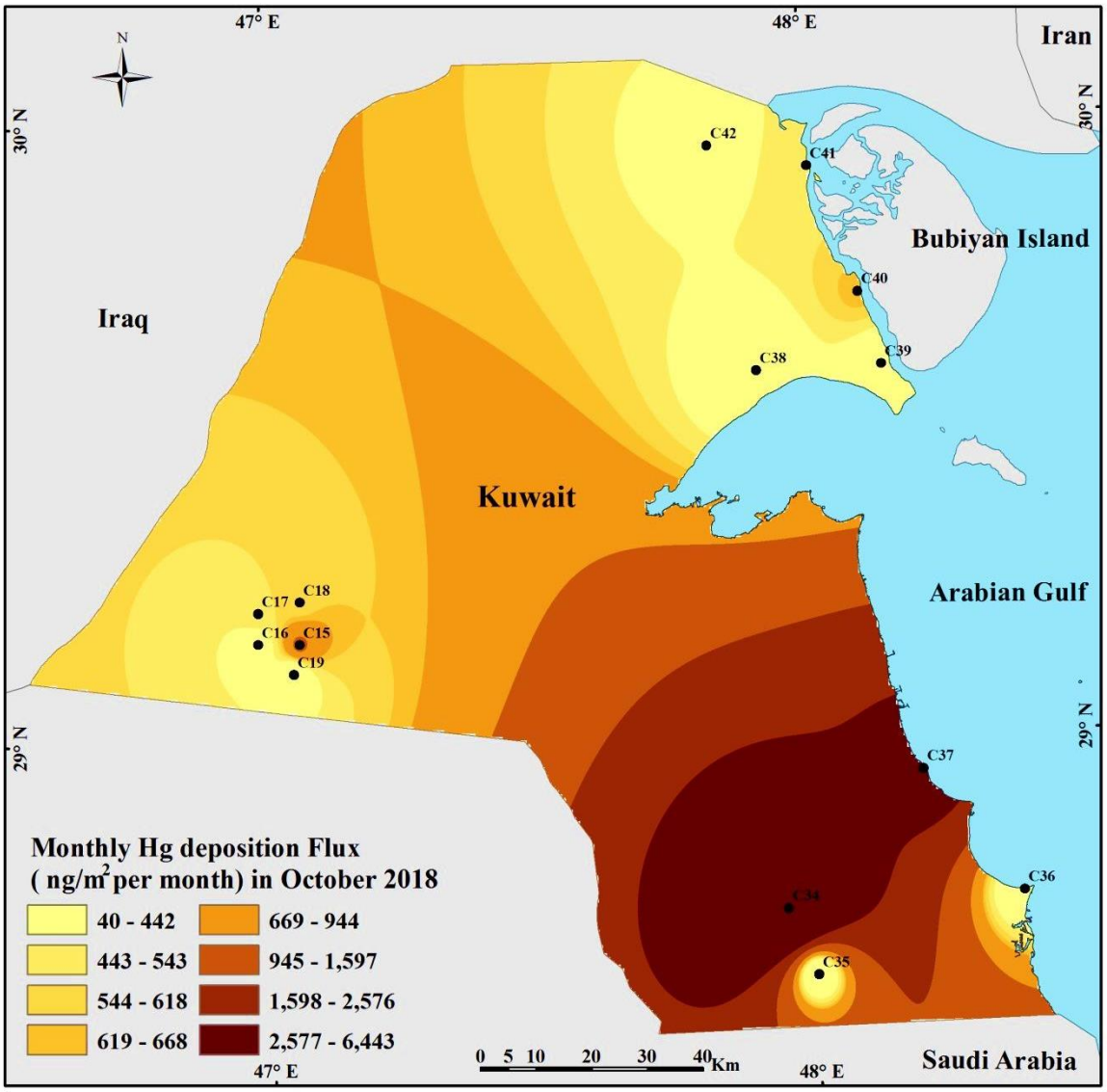


Plate 67. Monthly Hg deposition flux at different locations in Kuwait in October 2018.

Table 58. Monthly Hg Deposition Flux at Different Locations in Kuwait in October 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	1045
C16	29.161405	46.979464	268
C17	29.212119	46.980339	527
C18	29.229152	47.05784	570
C19	29.112582	47.045027	132
C34	28.718883	47.945717	6443
C35	28.610183	47.998217	40
C36	28.740017	48.379533	171
C37	28.939967	48.19995	3157
C38	29.590033	47.90955	148
C39	29.596083	48.141833	257
C40	29.71405	48.101067	651
C41	29.919083	48.011883	511
C42	29.955	47.828717	292

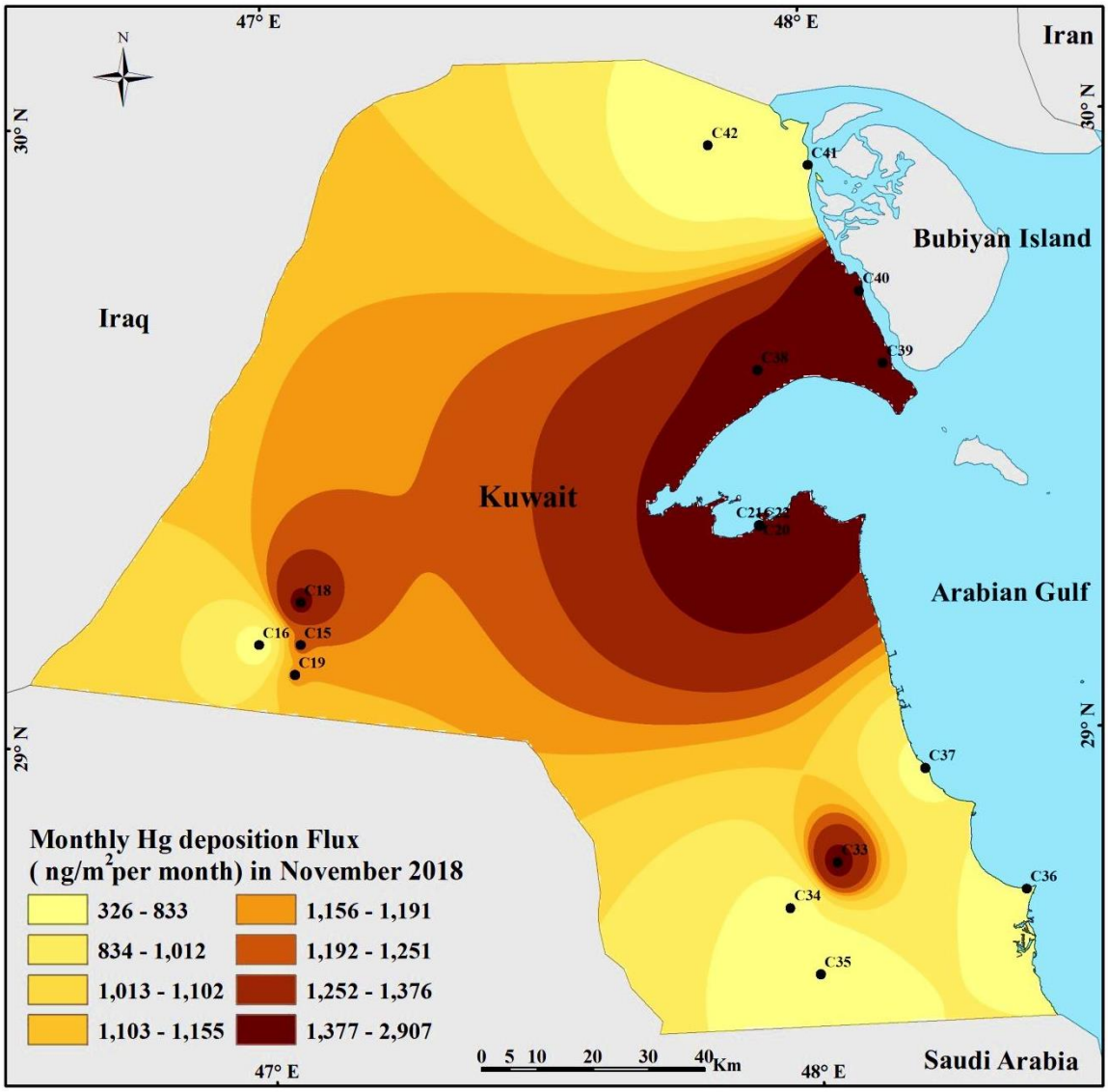


Plate 68. Monthly Hg deposition flux at different locations in Kuwait in November 2018.

Table 59. Monthly Hg Deposition Flux at Different Locations in Kuwait in November 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	1204
C16	29.161405	46.979464	683
C18	29.229152	47.05784	1421
C19	29.112582	47.045027	1164
C20	29.337883	47.9059	587
C21	29.339033	47.905533	2907
C22	29.33895	47.906567	1047
C33	28.790883	48.035083	1439
C34	28.718883	47.945717	696
C35	28.610183	47.998217	458
C36	28.740017	48.379533	653
C37	28.939967	48.19995	773
C38	29.590033	47.90955	1432
C39	29.596083	48.141833	1761
C40	29.71405	48.101067	1847
C41	29.919083	48.011883	326
C42	29.955	47.828717	470

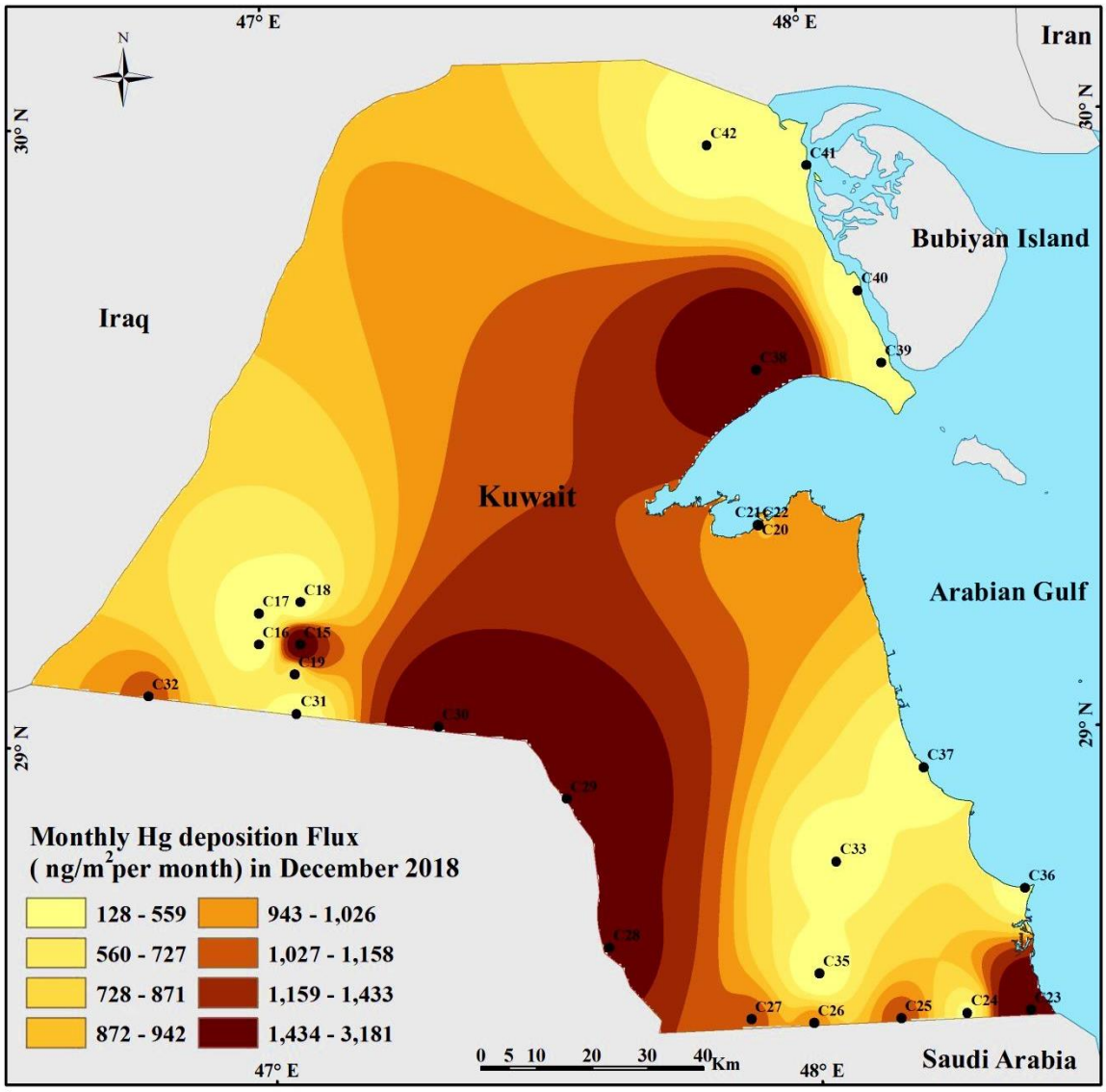


Plate 69. Monthly Hg deposition flux of different locations in Kuwait in December 2018.

Table 60. Monthly Hg Deposition Flux at Different Locations in Kuwait in December 2018

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	2162
C16	29.161405	46.979464	294
C17	29.212119	46.980339	281
C18	29.229152	47.05784	128
C19	29.112582	47.045027	646
C20	29.337883	47.9059	911
C21	29.339033	47.905533	1550
C22	29.33895	47.906567	380
C23	28.542567	48.38475	2685
C24	28.5403	48.267717	499
C25	28.5345	48.1464	1100
C26	28.5304	47.98615	1032
C27	28.5392	47.871567	1081
C28	28.660017	47.614333	1787
C29	28.9025	47.54185	3002
C30	29.0234	47.307883	2451
C31	29.04855	47.0474	189
C32	29.080183	46.774917	1085
C33	28.790883	48.035083	238
C35	28.610183	47.998217	174
C36	28.740017	48.379533	353
C37	28.939967	48.19995	315
C38	29.590033	47.90955	3181
C39	29.596083	48.141833	255
C40	29.71405	48.101067	290
C41	29.919083	48.011883	283
C42	29.955	47.828717	333

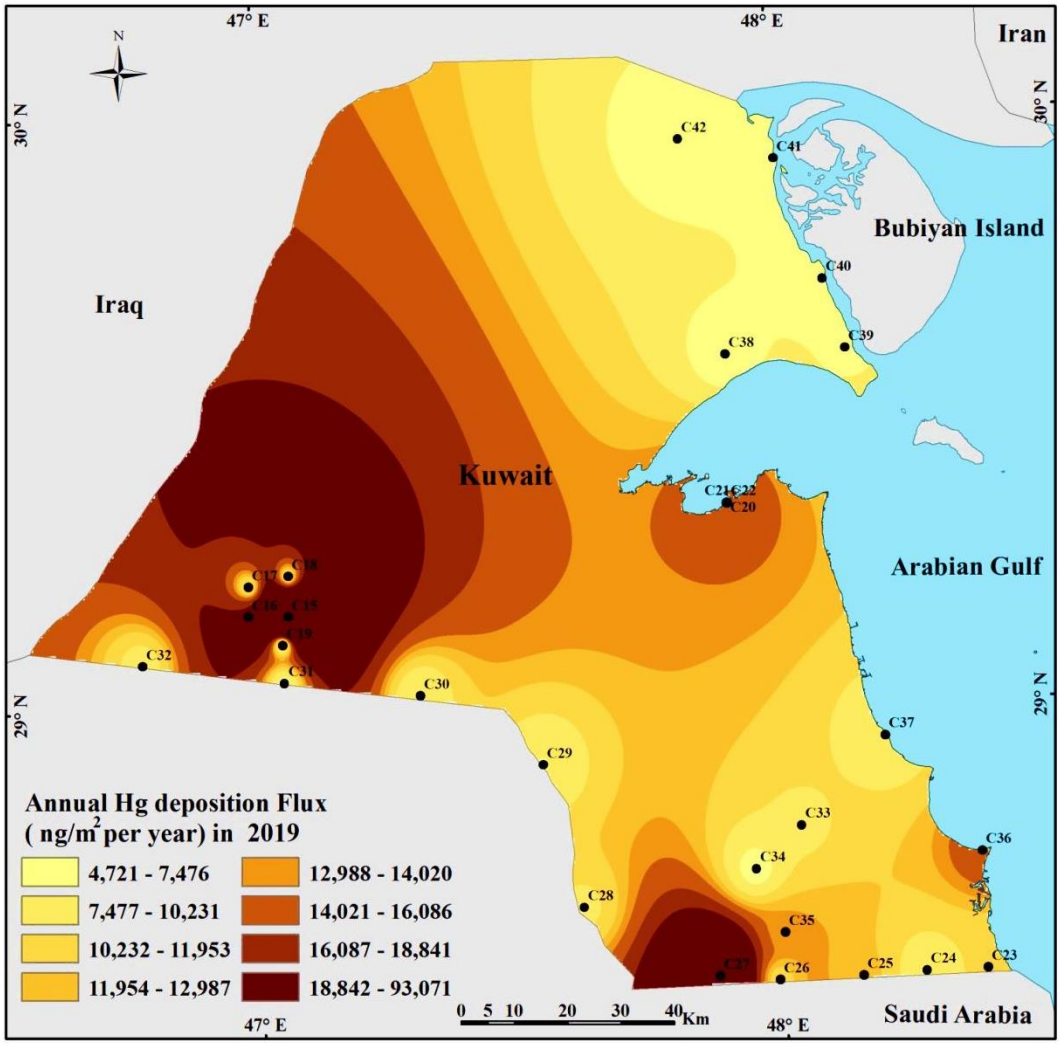


Plate 70. Annual Hg deposition flux at different locations in Kuwait in 2019.

Table 61. Annual Hg Deposition Flux at Different Locations in Kuwait in 2019

Dust Collector	Latitude-N	Longitude-E	Hg per Year (ng/m^2)
C15	29.160281	47.056431	93071
C16	29.161405	46.979464	18924
C17	29.212119	46.980339	9294
C18	29.229152	47.05784	10028
C19	29.112582	47.045027	6384
C20	29.337883	47.9059	12097
C21	29.339033	47.905533	23678
C22	29.33895	47.906567	9831
C23	28.542567	48.38475	10355
C24	28.5403	48.267717	7998
C25	28.5345	48.1464	12268
C26	28.5304	47.98615	10745
C27	28.5392	47.871567	46828
C28	28.660017	47.614333	9542
C29	28.9025	47.54185	7388
C30	29.0234	47.307883	7495
C31	29.04855	47.0474	6390
C32	29.080183	46.774917	8810
C33	28.790883	48.035083	9316
C34	28.718883	47.945717	5642
C35	28.610183	47.998217	13222
C36	28.740017	48.379533	15660
C37	28.939967	48.19995	7436
C38	29.590033	47.90955	5097
C39	29.596083	48.141833	6894
C40	29.71405	48.101067	4927
C41	29.919083	48.011883	6388
C42	29.955	47.828717	4721

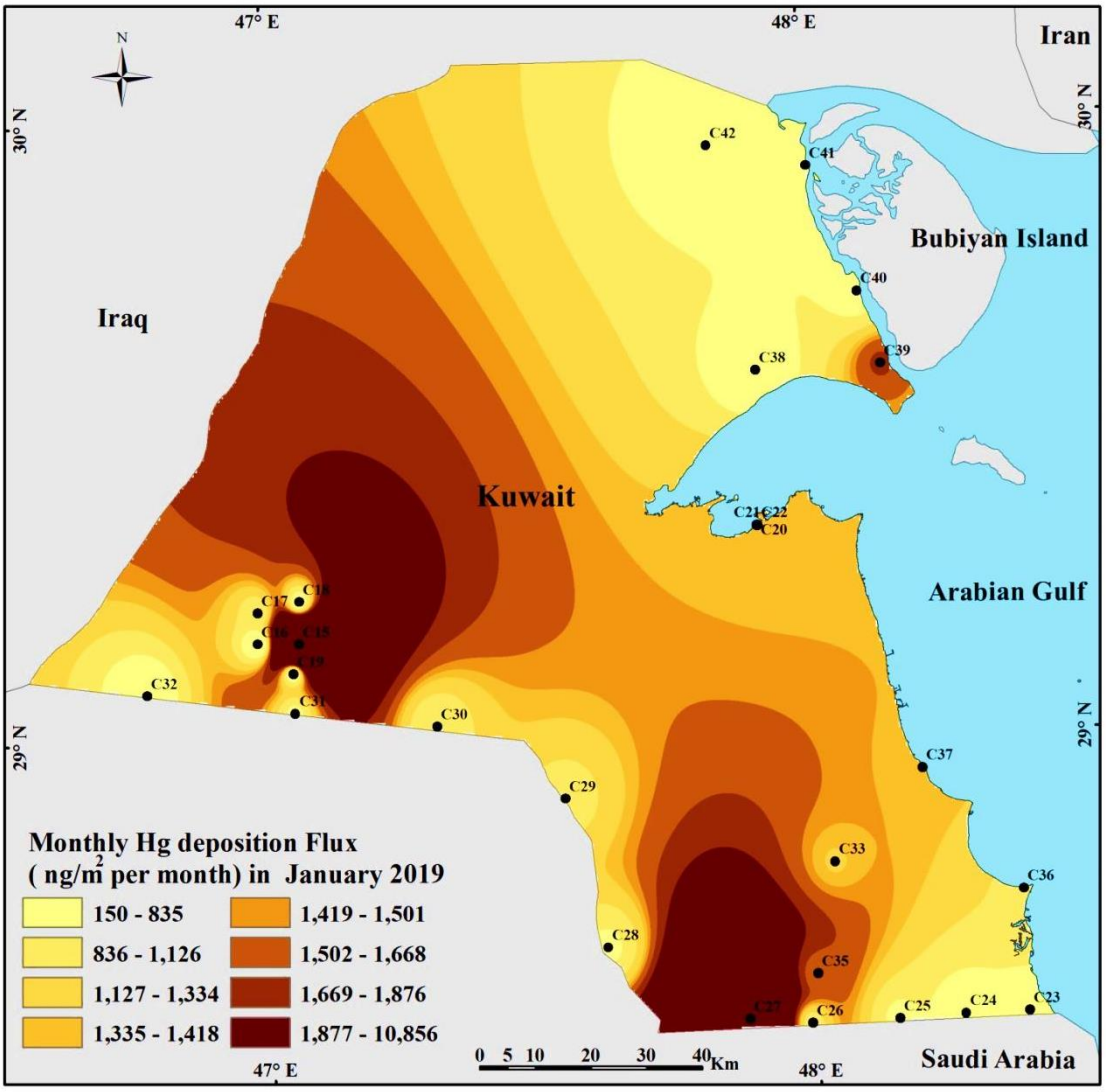


Plate 71. Monthly Hg deposition flux at different locations in Kuwait in January 2019.

Table 62. Monthly Hg Deposition Flux at Different Locations in Kuwait in January 2019

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	10856
C16	29.161405	46.979464	150
C17	29.212119	46.980339	775
C18	29.229152	47.05784	480
C19	29.112582	47.045027	363
C20	29.337883	47.9059	600
C21	29.339033	47.905533	2780
C22	29.33895	47.906567	842
C23	28.542567	48.38475	618
C24	28.5403	48.267717	491
C25	28.5345	48.1464	721
C26	28.5304	47.98615	927
C27	28.5392	47.871567	8770
C28	28.660017	47.614333	734
C29	28.9025	47.54185	960
C30	29.0234	47.307883	821
C31	29.04855	47.0474	689
C32	29.080183	46.774917	379
C33	28.790883	48.035083	1312
C35	28.610183	47.998217	1514
C36	28.740017	48.379533	1083
C37	28.939967	48.19995	1357
C38	29.590033	47.90955	355
C39	29.596083	48.141833	1711
C40	29.71405	48.101067	620
C41	29.919083	48.011883	587
C42	29.955	47.828717	384

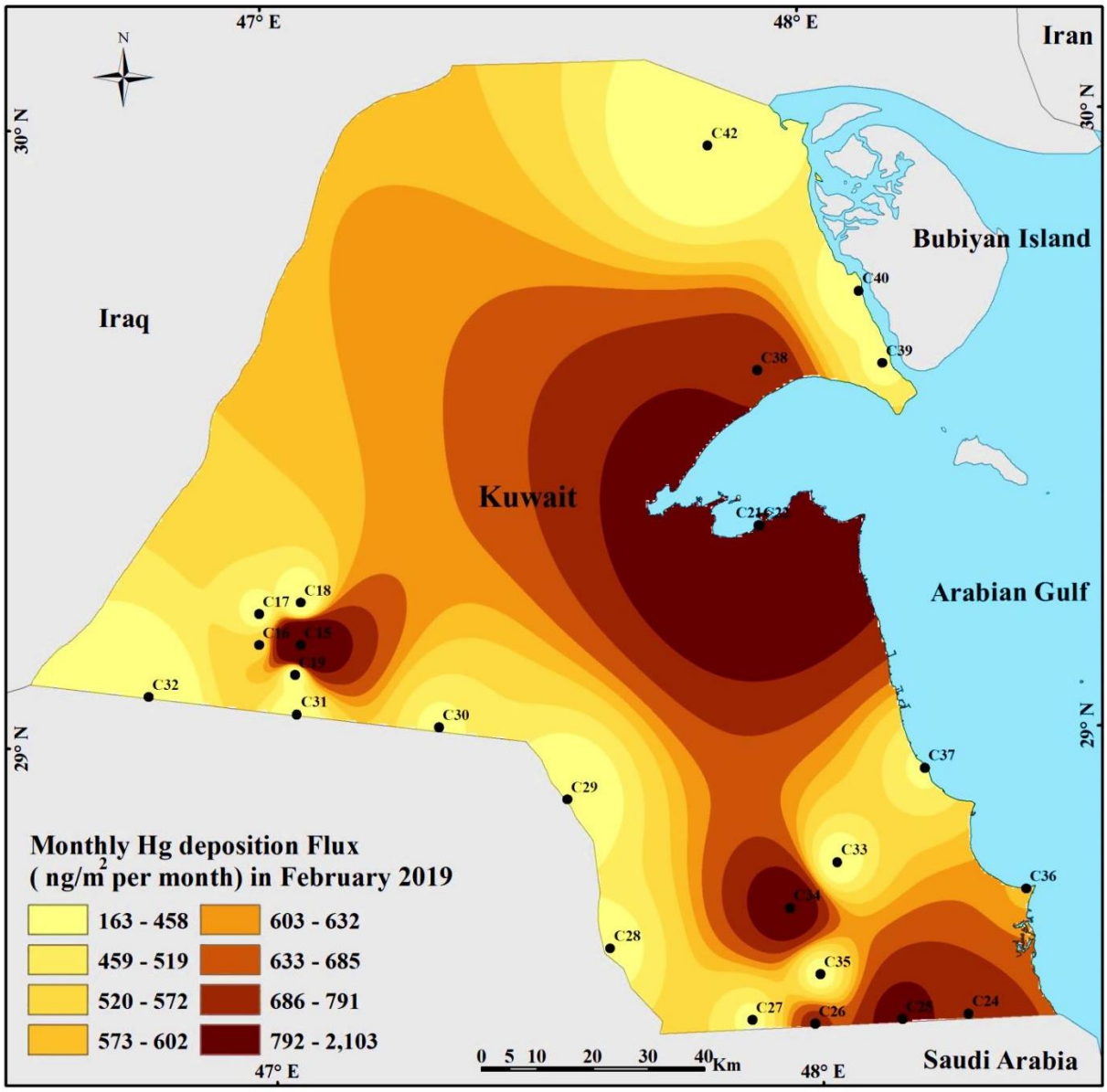


Plate 72. Monthly Hg deposition flux at different locations in Kuwait in February 2019.

Table 63. Monthly Hg Deposition Flux at Different Locations in Kuwait in February 2019

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	2103
C16	29.161405	46.979464	527
C17	29.212119	46.980339	351
C18	29.229152	47.05784	163
C19	29.112582	47.045027	284
C21	29.339033	47.905533	1886
C22	29.33895	47.906567	901
C24	28.5403	48.267717	723
C25	28.5345	48.1464	932
C26	28.5304	47.98615	725
C27	28.5392	47.871567	425
C28	28.660017	47.614333	403
C29	28.9025	47.54185	295
C30	29.0234	47.307883	429
C31	29.04855	47.0474	298
C32	29.080183	46.774917	192
C33	28.790883	48.035083	360
C34	28.718883	47.945717	1103
C35	28.610183	47.998217	386
C36	28.740017	48.379533	596
C37	28.939967	48.19995	436
C38	29.590033	47.90955	742
C39	29.596083	48.141833	431
C40	29.71405	48.101067	349
C42	29.955	47.828717	243

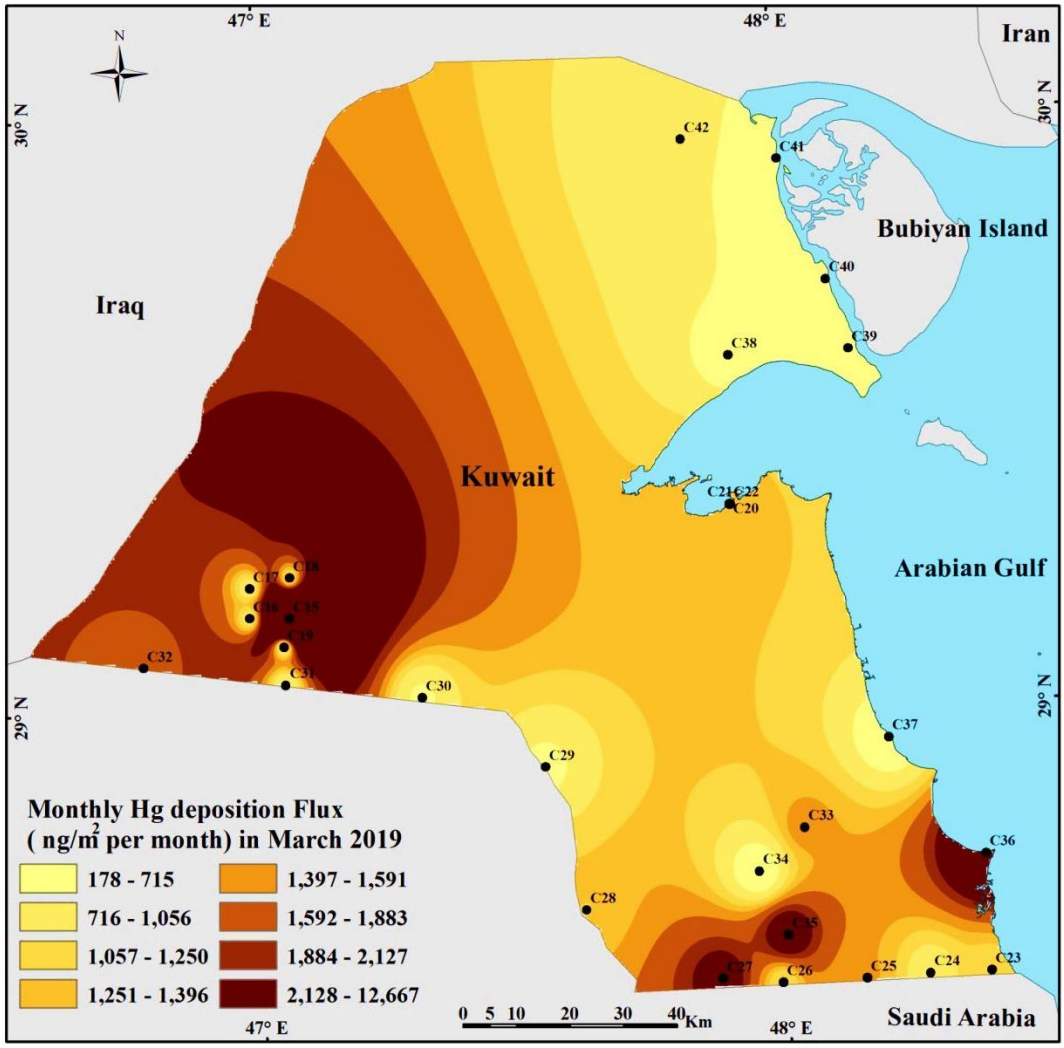


Plate 73. Monthly Hg deposition flux at different locations in Kuwait in March 2019.

Table 64. Monthly Hg Deposition Flux at Different Locations in Kuwait in March 2019

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	12667
C16	29.161405	46.979464	830
C17	29.212119	46.980339	743
C18	29.229152	47.05784	939
C19	29.112582	47.045027	560
C20	29.337883	47.9059	1455
C21	29.339033	47.905533	1909
C22	29.33895	47.906567	676
C23	28.542567	48.38475	1108
C24	28.5403	48.267717	786
C25	28.5345	48.1464	1414
C26	28.5304	47.98615	1034
C27	28.5392	47.871567	2513
C28	28.660017	47.614333	1248
C29	28.9025	47.54185	591
C30	29.0234	47.307883	623
C31	29.04855	47.0474	611
C32	29.080183	46.774917	1631
C33	28.790883	48.035083	1512
C34	28.718883	47.945717	178
C35	28.610183	47.998217	2788
C36	28.740017	48.379533	3536
C37	28.939967	48.19995	273
C38	29.590033	47.90955	522
C39	29.596083	48.141833	262
C40	29.71405	48.101067	198
C41	29.919083	48.011883	457
C42	29.955	47.828717	775

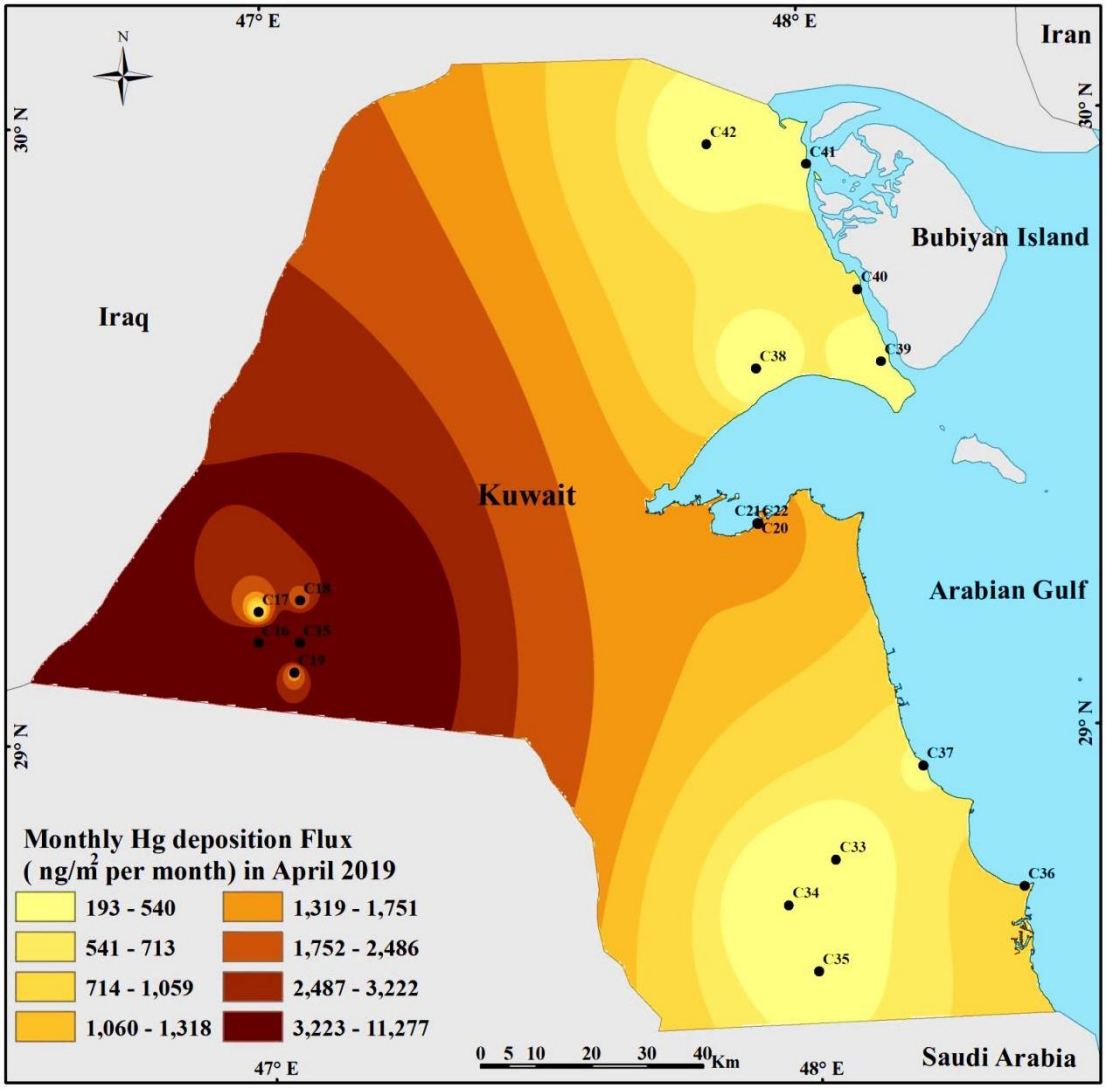


Plate 74. Monthly Hg deposition flux at different locations in Kuwait in April 2019.

Table 65. Monthly Hg Deposition Flux at Different Locations in Kuwait in April 2019

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	11277
C16	29.161405	46.979464	5603
C17	29.212119	46.980339	375
C18	29.229152	47.05784	1975
C19	29.112582	47.045027	1178
C20	29.337883	47.9059	1239
C21	29.339033	47.905533	2040
C22	29.33895	47.906567	954
C33	28.790883	48.035083	376
C34	28.718883	47.945717	193
C35	28.610183	47.998217	408
C36	28.740017	48.379533	889
C37	28.939967	48.19995	508
C38	29.590033	47.90955	258
C39	29.596083	48.141833	251
C40	29.71405	48.101067	579
C41	29.919083	48.011883	475
C42	29.955	47.828717	311

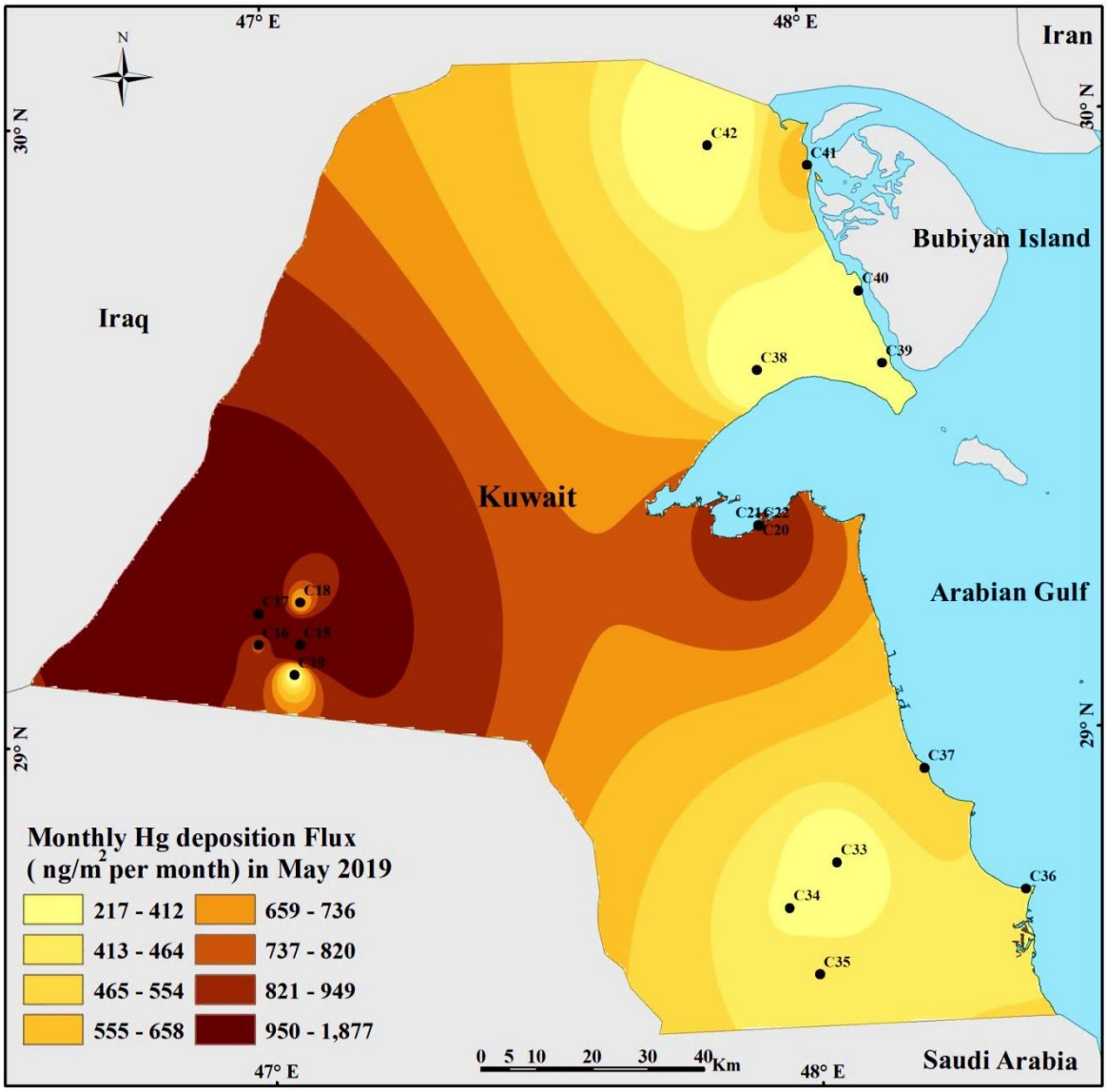


Plate 75. Monthly Hg deposition flux at different locations in Kuwait in May 2019.

Table 66. Monthly Hg Deposition Flux at Different Locations in Kuwait in May 2019

Dust Collector	Latitude-N	Longitude-E	Hg per Month (ng/m^2)
C15	29.160281	47.056431	1877
C16	29.161405	46.979464	774
C17	29.212119	46.980339	1628
C18	29.229152	47.05784	620
C19	29.112582	47.045027	275
C20	29.337883	47.9059	739
C21	29.339033	47.905533	1251
C22	29.33895	47.906567	724
C33	28.790883	48.035083	322
C34	28.718883	47.945717	407
C35	28.610183	47.998217	413
C36	28.740017	48.379533	422
C37	28.939967	48.19995	524
C38	29.590033	47.90955	246
C39	29.596083	48.141833	217
C40	29.71405	48.101067	306
C41	29.919083	48.011883	610
C42	29.955	47.828717	255

Conclusion

The analysis of the historical data showed that the monthly maximum mercury deposition flux (MDF) was 3242 ng m^{-2} mo^{-1} in June 2011 at Liyah and the second highest flux was 3030 ng m^{-2} mo^{-1} in May 2012 at Liyah, while at Al-Bahra and Bubiyan, the MDF was lower than that at Liyah. The complete 12-month data of 2012 for Liyah had a maximum MDF in May, which was almost of the same order of magnitude as that of the previous year.

The annual maximum MDF was calculated for 2011 as the data were incomplete, i.e., short of a few months, and was measured at 10690 ng m^{-2} y^{-1} at Liyah, while the MDF was the lowest at 570 ng m^{-2} y^{-1} at Al-Bahra location. For 2012, the dust fallout data were complete at Liyah and showed a similar value of maximum MDF of 15717 ng m^{-2} y^{-1}

reflecting identical operations in the neighbouring Southern Iraqi and Northern Kuwaiti oil fields. There were random seasonal variations, mainly depicting the activities associated with mercury emissions. In China and Europe, winter season had elevated levels of mercury deposition due to a high coal consumption in heating and high energy demand, being fulfilled by fossil fuels (Wan et al., 2009; Xu et al., 2013; EC, 2001).

The comprehensive measurements of monthly natural dust fallout at different locations in the State of Kuwait were conducted for 2017 to 2019, to identify the most probable sources of mercury emissions. In 2017, dust from nineteen locations was sampled for the period of seven months (May to December 2017). The calculated annual average MDF was about 7673 ng m^{-2} yr^{-1} and median value was 5655.3 ng m^{-2} yr^{-1} from all of the selected locations and the annual maximum MDF was almost 2.2 times the annual average MDF, which was observed at Al-Buhaith, assuring the predominant source from the flares of Southern Iraqi and Northern Kuwaiti Oil Fields' activities. The monthly MDFs were high from October to November at Shagaya location and the highest was noted in December at Al-Buhaith, which was strongly influenced by the prevailing meteorological conditions. There were significant values of MDF at Al-Shaheed Jerman in May and Al-Tahreer in June.

In 2018, dust from 42 locations, most of which along the international border of Kuwait, were sampled for the entire year. The annual average MDF was about 19242 ng m^{-2} y^{-1}, and the median value was 15280 ng m^{-2} y^{-1} from all of the selected border locations, and the annual maximum MDF was almost 7.3 times the annual average MDF, which was observed at Shagaya, assuring the predominant source from Kra'Almru Oil Fields' activities. The monthly MDFs were high from April and August at Shagaya, the highest being in July, which was strongly influenced by the prevailing meteorological conditions.

In 2019, dust from 28 locations was sampled for the period of five months (January to May 2019). The calculated annual average MDF was around 13944 ng m^{-2} y^{-1} and the median value was 9305 ng m^{-2} y^{-1}, observed at all of the selected locations. The annual maximum MDF was almost 6.7 times the annual average MDF, which was observed at Shagaya assuring the predominant source from the flares of Kra'Amru Oil Fields' activities. The monthly MDFs were high from January to May at Shagaya location, the highest being in March, which was strongly influenced by the prevailing meteorological conditions.

Annual mercury deposition fluxes were calculated from the annual dust fallout values at different locations and had an increasing trend based on three years' data (2017–2019), mainly due to increased petroleum upstream activities.

Shagaya's remote site was chosen to produce power using renewable sources, which were present in abundance and were utilized to the maximum availability. This site has a very strong and gusty wind. The average wind speed for the Shagaya Wind Farm for 2017 and 2018 was 8.11 m/s and 8.15 m/s, respectively (Table 67) (Al Nassar et al., 2019; Al-Nassar and Neelamani, 2018), for most of the period making it suitable for harvesting excessive energy to convert to power to be utilized by Kuwait's population. Strong wind and gust transported large amounts of dust/sand from distant sources carrying different pollutants originating from distant sources.

Table 67. Wind Speed (m/s) from the Shagaya Wind Farm for 2018 and 2019

Month	Wind Speed (m/s) at 80 m Height*			
	10-min		Instantaneous	
	Average	Maximum	Average	Maximum
August 2019	10.74	37.02	14.91	NA
July 2019	11.175	19.4	13.61	23.4
June 2019	8.65	17.01	10.71	25.9
May 2019	6.91	20.64	8.45	25.2
April 2019	7.8	21.89	9.43	26.3
March 2019	7.91	21.89	9.4	26.3
February 2019	7.3	22.17	8.39	25.4
January 2019	7.23	17.2	8.17	18.6
December 2018	6.64	16.1	7.45	14.6
November 2018	6.72	23.56	7.71	30.7
October 2018	7.921	21.1	NA	NA
September 2018	7.5	15.47	NA	NA

*Al Nassar et al., 2019 and Al-Nassar and Neelamani, 2018

Limitations

The collected data have been limited due to practical difficulties and strict restrictions, which had obstructed monitoring and measuring mercury freely at all locations to assure the most probable sources. These regulations had resulted in limited sampling reflecting restricted specific spatial and temporal trends in mercury levels as well as dry MDF. To observe the spatial and temporal trends, experimental work has to be extended to cover the entire State of Kuwait for longer periods of time, and proposed models in the literature have to be implemented to evaluate the exact trends of mercury pollution in the

State of Kuwait. Annual mercury deposition fluxes were calculated from the annual dust fallout values at different locations and had an increasing trend based on three years' limited incomplete data (2017-2019), which have to be re-evaluated for an extended period, that is a minimum of five years, for a complete annual dust fallout measured data to give a more elaborative trend.

Section 9 - Measurement of Total Mercury in Ground Soil/Sand from Different Important Locations in Kuwait

Kuwait is located in the northeastern corner of Arabian Peninsula and has a dry and arid climate. The dust storms are more frequent in summer than in other seasons. Dust storms are categorized based on the dust/sand particle sizes and prevalent meteorological conditions. The natural and man-made monthly dust fallout at different sites depends on the dust transported from short or long distances based on driving conditions (wind speed/wind direction). Al-Dousari and Al-Awadhi (2012) discussed the amount of dust fallout and movement of sand dunes in the desert of Kuwait. Gaffney and Marley (2014) discussed the chemistry of mercury to understand the mercury cycle on the globe, which was complex. Aba et al. (2018) reported atmospheric fluxes of cesium isotope $^{137}_{55}Cs$ associated with dust fallout in the northern Arabian Gulf, where the correlations with the monthly dust fallout and the $^{137}_{55}Cs$ deposition fluxes and precipitation rate were approximately 0.95 and 0.84, respectively. The dust has a large surface area and has high adsorbing characteristics bringing pollutants to move over rural/urban, industrial, agricultural, and mining areas, and some are generated by anthropogenic sources. Long distance transported dust has mercury contamination in dust fallout, which also constituted of ash emitted from combustion processes.

Dust fallout containing ash from combustion processes might have high levels of mercury. Ground soil/sand were obtained by the grab sampling method from many locations during passive sampling and dust collecting campaigns were conducted at various locations in Kuwait for a period of three years (2017–2019). The GPS locations were similar to those of the dust collector locations but have been referred to as GS1 through GS42 with the addition of ground soil/sand from landfills, urban areas, and restricted KNPC and KOC sites (Table 68), to quantify mercury levels in the top ground

dust at selected sampling sites. Plume from ground flares were usually short and all the soot and ash that settled in the vicinity of the flare were controlled by wind and temperature encompassing convective buoyancy due to the difference in density caused by flame temperature. For tall stacks, with over temperature and wind speed, the stability class had a strong influence on dispersion and touchdown location, where ash and soot got deposited thus varying the concentration of mercury.

Table 68. Raw Data Showing the Maximum Concentration of Mercury (ng/g) Measured from the Ground Soil/Sand Collected from Selected Locations in Kuwait from 2017 to 2019

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-City	GS-21	KISR	12.1
GS-City	GS-21	KISR	12.5
GS-City	GS-21	KISR	3.3
GS-City	GS-21	KISR	16.1
GS-City	GS-21	KISR	16.3
GS-City	GS-21	KISR	4
GS-City	GS-21	KISR	11.3
GS-City	GS-21	KISR	6.9
GS-City	GS-21	KISR	11.4
GS-City	GS-21	KISR	28.4
GS-KNPC	GS-KNPC-1	KNPC	17.5
GS-KNPC	GS-KNPC-10	KNPC	20.3
GS-KNPC	GS-KNPC-10	KNPC	4.9
GS-KNPC	GS-KNPC-2	KNPC	6.2
GS-KNPC	GS-KNPC-3	KNPC	27.2
GS-KNPC	GS-KNPC-4	KNPC	9.8
GS-KNPC	GS-KNPC-5	KNPC	32.5
GS-KNPC	GS-KNPC-6	KNPC	7
GS-KNPC	GS-KNPC-7	KNPC	4.1
GS-KNPC	GS-KNPC-8	KNPC	17.6
GS-KNPC	GS-KNPC-9	KNPC	5.6
GS-KNPC	GS-KNPC-north road near tank	KNPC	9.9
GS-KNPC	GS-KNPC-spent catalyst	KNPC	11.6
GS-KNPC	GS-KNPC-store	KNPC	2.2
GS-KOC	GS-KOC-BS	KOC	14.8
GS-KOC	GS-KOC-NTF	KOC	37.3
GS-KOC	GS-KOC-roof	KOC	11.3

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-Landfill	GS-L1	Al-Jahra	14.1
GS-Landfill	GS-L11	Shuaiba	18.6
GS-Landfill	GS-L12	Mina Abdullah	20
GS-Landfill	GS-L15	Yarmouk	15.9
GS-Landfill	GS-L2	Al-Sulaibiyah	19.1
GS-Landfill	GS-L4a	South Seventh Ring Road	12.5
GS-Landfill	GS-L4b	South Seventh Ring Road	6.6
GS-Landfill	GS-L5	Jleeb Al-Shuyoukh	13.7
GS-Landfill	GS-L6	North Seventh Ring Road	9.9
GS-Landfill	GS-L7	Kabd	21.2
GS-Landfill	GS-L9	Qurain	18.9
GS-North	GS-1	Al-Tahreer Center	16.1
GS-North	GS-1	Al-Tahreer Center	10
GS-North	GS-1	Al-Tahreer Center	40.8
GS-North	GS-1	Al-Tahreer Center	24.8
GS-North	GS-1	Al-Tahreer Center	7.1
GS-North	GS-1	Al-Tahreer Center	8.3
GS-North	GS-1	Al-Tahreer Center	2
GS-North	GS-2	Al Sukhaibri Center	11.2
GS-North	GS-2	Al Sukhaibri Center	13.1
GS-North	GS-2	Al Sukhaibri Center	12.4
GS-North	GS-2	Al Sukhaibri Center	20.5
GS-North	GS-2	Al Sukhaibri Center	4.7
GS-North	GS-2	Al Sukhaibri Center	4.7
GS-North	GS-2	Al Sukhaibri Center	6.6
GS-North	GS-2	Al Sukhaibri Center	16.4
GS-North	GS-3	Um Sudairah Center	13.7
GS-North	GS-3	Um Sudairah Center	8.2
GS-North	GS-3	Um Sudairah Center	24.8
GS-North	GS-3	Um Sudairah Center	10
GS-North	GS-3	Um Sudairah Center	13.6
GS-North	GS-3	Um Sudairah Center	14.4

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-North	GS-4	Al Abdali Center	28.4
GS-North	GS-4	Al Abdali Center	5.8
GS-North	GS-4	Al Abdali Center	4.8
GS-North	GS-4	Al Abdali Center	6.8
GS-North	GS-4	Al Abdali Center	11.9
GS-North	GS-4	Al Abdali Center	9.2
GS-North	GS-4	Al Abdali Center	7.3
GS-North	GS-4	Al Abdali Center	7.1
GS-North	GS-5	Al Mazarea' Center	8.3
GS-North	GS-5	Al Mazarea' Center	10.1
GS-North	GS-5	Al Mazarea' Center	48.9
GS-North	GS-5	Al Mazarea' Center	12.2
GS-North	GS-5	Al Mazarea' Center	1.8
GS-North	GS-5	Al Mazarea' Center	5.3
GS-North	GS-5	Al Mazarea' Center	9
GS-North	GS-6	Al Azmiya Center	7.8
GS-North	GS-6	Al Azmiya Center	9.3
GS-North	GS-6	Al Azmiya Center	23
GS-North	GS-6	Al Azmiya Center	13.2
GS-North	GS-6	Al Azmiya Center	18.9
GS-North	GS-6	Al Azmiya Center	7.8
GS-North	GS-6	Al Azmiya Center	18.2
GS-North	GS-7	Um Niqa Center	5.4
GS-North	GS-7	Um Niqa Center	12.5
GS-North	GS-7	Um Niqa Center	7.6
GS-North	GS-7	Um Niqa Center	11.7
GS-North	GS-7	Um Niqa Center	12
GS-North	GS-7	Um Niqa Center	7.7
GS-North	GS-7	Um Niqa Center	9
GS-North	GS-7	Um Niqa Center	14.4
GS-North	GS-8	Al Buhaith Center	9.5
GS-North	GS-8	Al Buhaith Center	17.1
GS-North	GS-8	Al Buhaith Center	12.5
GS-North	GS-8	Al Buhaith Center	12.6
GS-North	GS-8	Al Buhaith Center	11.8
GS-North	GS-8	Al Buhaith Center	9.6
GS-North	GS-8	Al Buhaith Center	3.5

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-North	GS-9	Al Ritqa Center	4.5
GS-North	GS-9	Al Ritqa Center	17.9
GS-North	GS-9	Al Ritqa Center	29
GS-North	GS-9	Al Ritqa Center	9.3
GS-North	GS-9	Al Ritqa Center	3.3
GS-North	GS-9	Al Ritqa Center	17.7
GS-North	GS-9	Al Ritqa Center	14.7
GS-North	GS-10	Bahrat Hoshan Center	16.7
GS-North	GS-10	Bahrat Hoshan Center	1.3
GS-North	GS-10	Bahrat Hoshan Center	17.1
GS-North	GS-10	Bahrat Hoshan Center	22.6
GS-North	GS-10	Bahrat Hoshan Center	6.7
GS-North	GS-10	Bahrat Hoshan Center	27
GS-North	GS-10	Bahrat Hoshan Center	18.2
GS-North	GS-11	Al-Somoud Center	28
GS-North	GS-11	Al-Somoud Center	1.1
GS-North	GS-11	Al-Somoud Center	50.6
GS-North	GS-11	Al-Somoud Center	2.1
GS-North	GS-11	Al-Somoud Center	5.5
GS-North	GS-11	Al-Somoud Center	27
GS-North	GS-11	Al-Somoud Center	2.8
GS-North	GS-38	Al-Subiah BS	4.2
GS-North	GS-38	Al-Subiah BS	24.3
GS-North	GS-38	Al-Subiah BS	72.2
GS-North	GS-38	Al-Subiah BS	10.3
GS-North	GS-38	Al-Subiah BS	10.4
GS-North	GS-38	Al-Subiah BS	8.4
GS-North	GS-38	Al-Subiah BS	13.9
GS-North	GS-38	Al-Subiah BS	9.9
GS-North	GS-38	Al-Subiah BS	8.1
GS-North	GS-38	Al-Subiah BS	0.6
GS-North	GS-38	Al-Subiah BS	6.9
GS-North	GS-38	Al-Subiah BS	15.3
GS-North	GS-38	Al-Subiah BS	18.9
GS-North	GS-38	Al-Subiah BS	15.5

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-North	GS-39	Al-Subiah police station	16.5
GS-North	GS-39	Al-Subiah police station	26.9
GS-North	GS-39	Al-Subiah police station	13.4
GS-North	GS-39	Al-Subiah police station	12.7
GS-North	GS-39	Al-Subiah police station	4.6
GS-North	GS-39	Al-Subiah police station	4.5
GS-North	GS-39	Al-Subiah police station	5.9
GS-North	GS-39	Al-Subiah police station	5.5
GS-North	GS-39	Al-Subiah police station	5
GS-North	GS-39	Al-Subiah police station	7.3
GS-North	GS-39	Al-Subiah police station	11.4
GS-North	GS-40	New Bubiyan bridge	15.2
GS-North	GS-40	New Bubiyan bridge	3.8
GS-North	GS-40	New Bubiyan bridge	10.8
GS-North	GS-40	New Bubiyan bridge	25.9
GS-North	GS-40	New Bubiyan bridge	49.7
GS-North	GS-40	New Bubiyan bridge	44.5
GS-North	GS-40	New Bubiyan bridge	17
GS-North	GS-40	New Bubiyan bridge	14.2
GS-North	GS-40	New Bubiyan bridge	6.9
GS-North	GS-40	New Bubiyan bridge	14
GS-North	GS-40	New Bubiyan bridge	17.6
GS-North	GS-40	New Bubiyan bridge	13
GS-North	GS-41	The camp (Al-Beheeth)	7.6
GS-North	GS-41	The camp (Al-Beheeth)	3.2
GS-North	GS-41	The camp (Al-Beheeth)	12.6
GS-North	GS-41	The camp (Al-Beheeth)	2.6
GS-North	GS-41	The camp (Al-Beheeth)	11.8
GS-North	GS-41	The camp (Al-Beheeth)	56
GS-North	GS-41	The camp (Al-Beheeth)	30.6
GS-North	GS-41	The camp (Al-Beheeth)	16.6
GS-North	GS-41	The camp (Al-Beheeth)	19
GS-North	GS-41	The camp (Al-Beheeth)	8
GS-North	GS-41	The camp (Al-Beheeth)	21.3
GS-North	GS-41	The camp (Al-Beheeth)	18.5
GS-North	GS-41	The camp (Al-Beheeth)	3

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	5.8
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	24.7
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	6.3
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	21.5
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	7.9
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	3
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	4.3
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	10.1
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	11.7
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	26.9
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	21
GS-North	GS-42	Al-Beheeth-Al-Abdulli Road	5.6
GS-South	GS-23	Nuwaiseeb Centre (South)	9.5
GS-South	GS-23	Nuwaiseeb Centre (South)	17.2
GS-South	GS-23	Nuwaiseeb Centre (South)	4.5
GS-South	GS-23	Nuwaiseeb Centre (South)	5.5
GS-South	GS-23	Nuwaiseeb Centre (South)	25
GS-South	GS-23	Nuwaiseeb Centre (South)	19.3
GS-South	GS-23	Nuwaiseeb Centre (South)	15.6
GS-South	GS-23	Nuwaiseeb Centre (South)	6.8
GS-South	GS-23	Nuwaiseeb Centre (South)	28.6
GS-South	GS-23	Nuwaiseeb Centre (South)	17.9
GS-South	GS-23	Nuwaiseeb Centre (South)	13.6
GS-South	GS-23	Nuwaiseeb Centre (South)	9.2
GS-South	GS-24	Jlaida Centre	2.6
GS-South	GS-24	Jlaida Centre	6.6
GS-South	GS-24	Jlaida Centre	7.6
GS-South	GS-24	Jlaida Centre	3.8
GS-South	GS-24	Jlaida Centre	12.6
GS-South	GS-24	Jlaida Centre	6.9
GS-South	GS-24	Jlaida Centre	14.6
GS-South	GS-24	Jlaida Centre	12.1
GS-South	GS-24	Jlaida Centre	10.6
GS-South	GS-24	Jlaida Centre	7.3
GS-South	GS-24	Jlaida Centre	13.2
GS-South	GS-24	Jlaida Centre	10.4

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-South	GS-25	Raghwa Centre	5
GS-South	GS-25	Raghwa Centre	16.1
GS-South	GS-25	Raghwa Centre	18.3
GS-South	GS-25	Raghwa Centre	15.1
GS-South	GS-25	Raghwa Centre	2.1
GS-South	GS-25	Raghwa Centre	24.3
GS-South	GS-25	Raghwa Centre	2.6
GS-South	GS-25	Raghwa Centre	7.4
GS-South	GS-25	Raghwa Centre	1.3
GS-South	GS-25	Raghwa Centre	32.6
GS-South	GS-25	Raghwa Centre	6.5
GS-South	GS-26	Rahiya Centre	11.3
GS-South	GS-26	Rahiya Centre	8
GS-South	GS-26	Rahiya Centre	25
GS-South	GS-26	Rahiya Centre	14.6
GS-South	GS-26	Rahiya Centre	16.1
GS-South	GS-26	Rahiya Centre	6.6
GS-South	GS-26	Rahiya Centre	15
GS-South	GS-26	Rahiya Centre	49.5
GS-South	GS-26	Rahiya Centre	11.5
GS-South	GS-26	Rahiya Centre	19.7
GS-South	GS-26	Rahiya Centre	29.9
GS-South	GS-26	Rahiya Centre	16.4
GS-South	GS-27	Fawaris Centre	1.7
GS-South	GS-27	Fawaris Centre	13.7
GS-South	GS-27	Fawaris Centre	16.3
GS-South	GS-27	Fawaris Centre	3.3
GS-South	GS-27	Fawaris Centre	4.5
GS-South	GS-27	Fawaris Centre	11.2
GS-South	GS-27	Fawaris Centre	4.4
GS-South	GS-27	Fawaris Centre	14.8
GS-South	GS-27	Fawaris Centre	8.4
GS-South	GS-27	Fawaris Centre	24.4
GS-South	GS-27	Fawaris Centre	37.1

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-South	GS-28	Grenees Centre	3.3
GS-South	GS-28	Grenees Centre	8.7
GS-South	GS-28	Grenees Centre	5.2
GS-South	GS-28	Grenees Centre	1.1
GS-South	GS-28	Grenees Centre	14.9
GS-South	GS-28	Grenees Centre	19.9
GS-South	GS-28	Grenees Centre	25
GS-South	GS-28	Grenees Centre	19.6
GS-South	GS-28	Grenees Centre	17.2
GS-South	GS-28	Grenees Centre	12
GS-South	GS-28	Grenees Centre	11.2
GS-South	GS-28	Grenees Centre	9
GS-South	GS-29	Radeefa Centre	10.3
GS-South	GS-29	Radeefa Centre	9
GS-South	GS-29	Radeefa Centre	17.5
GS-South	GS-29	Radeefa Centre	19.7
GS-South	GS-29	Radeefa Centre	9
GS-South	GS-29	Radeefa Centre	9.1
GS-South	GS-29	Radeefa Centre	23.3
GS-South	GS-29	Radeefa Centre	10.9
GS-South	GS-29	Radeefa Centre	24.3
GS-South	GS-29	Radeefa Centre	10.2
GS-South	GS-29	Radeefa Centre	31.2
GS-South	GS-29	Radeefa Centre	47.8
GS-South	GS-33	Sabah Al-Ahmed City	4.1
GS-South	GS-33	Sabah Al-Ahmed City	14.5
GS-South	GS-33	Sabah Al-Ahmed City	6.5
GS-South	GS-33	Sabah Al-Ahmed City	7.7
GS-South	GS-33	Sabah Al-Ahmed City	15.9
GS-South	GS-33	Sabah Al-Ahmed City	5
GS-South	GS-33	Sabah Al-Ahmed City	3.4
GS-South	GS-33	Sabah Al-Ahmed City	7.8
GS-South	GS-33	Sabah Al-Ahmed City	19.7
GS-South	GS-33	Sabah Al-Ahmed City	14.8
GS-South	GS-33	Sabah Al-Ahmed City	45.7
GS-South	GS-33	Sabah Al-Ahmed City	7.4
GS-South	GS-33	Sabah Al-Ahmed City	9.1

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-South	GS-34	Al-Wafra Farms	15
GS-South	GS-34	Al-Wafra Farms	4.5
GS-South	GS-34	Al-Wafra Farms	6.2
GS-South	GS-34	Al-Wafra Farms	16.1
GS-South	GS-34	Al-Wafra Farms	11.6
GS-South	GS-34	Al-Wafra Farms	12.9
GS-South	GS-34	Al-Wafra Farms	12.1
GS-South	GS-34	Al-Wafra Farms	9.2
GS-South	GS-34	Al-Wafra Farms	37.7
GS-South	GS-34	Al-Wafra Farms	13.8
GS-South	GS-34	Al-Wafra Farms	32.1
GS-South	GS-34	Al-Wafra Farms	2.6
GS-South	GS-34	Al-Wafra Farms	37.6
GS-South	GS-35	Al-Wafra Centre	29.3
GS-South	GS-35	Al-Wafra Centre	7.4
GS-South	GS-35	Al-Wafra Centre	13.9
GS-South	GS-35	Al-Wafra Centre	8.3
GS-South	GS-35	Al-Wafra Centre	13.7
GS-South	GS-35	Al-Wafra Centre	12.6
GS-South	GS-35	Al-Wafra Centre	7.9
GS-South	GS-35	Al-Wafra Centre	25.6
GS-South	GS-35	Al-Wafra Centre	13.2
GS-South	GS-35	Al-Wafra Centre	22
GS-South	GS-35	Al-Wafra Centre	13.6
GS-South	GS-35	Al-Wafra Centre	29.8
GS-South	GS-35	Al-Wafra Centre	6.8
GS-South	GS-36	Ras Al-Zor	26.9
GS-South	GS-36	Ras Al-Zor	11.6
GS-South	GS-36	Ras Al-Zor	21
GS-South	GS-36	Ras Al-Zor	27.8
GS-South	GS-36	Ras Al-Zor	33.1
GS-South	GS-36	Ras Al-Zor	18.4
GS-South	GS-36	Ras Al-Zor	37.1
GS-South	GS-36	Ras Al-Zor	30.1
GS-South	GS-36	Ras Al-Zor	25.1
GS-South	GS-36	Ras Al-Zor	31.6
GS-South	GS-36	Ras Al-Zor	28.1
GS-South	GS-36	Ras Al-Zor	21.3
GS-South	GS-36	Ras Al-Zor	43.5
GS-South	GS-36	Ras Al-Zor	10.3

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-South	GS-37	Al-Dhebaaea	10.9
GS-South	GS-37	Al-Dhebaaea	9.2
GS-South	GS-37	Al-Dhebaaea	14.9
GS-South	GS-37	Al-Dhebaaea	5.4
GS-South	GS-37	Al-Dhebaaea	28.3
GS-South	GS-37	Al-Dhebaaea	28
GS-South	GS-37	Al-Dhebaaea	15.7
GS-South	GS-37	Al-Dhebaaea	16.9
GS-South	GS-37	Al-Dhebaaea	11.5
GS-South	GS-37	Al-Dhebaaea	25
GS-South	GS-37	Al-Dhebaaea	12.8
GS-South	GS-37	Al-Dhebaaea	4.7
GS-South	GS-37	Al-Dhebaaea	15.7
GS-West	GS-12	Al-Abraq Center	17.5
GS-West	GS-12	Al-Abraq Center	68.5
GS-West	GS-12	Al-Abraq Center	11.9
GS-West	GS-12	Al-Abraq Center	4.4
GS-West	GS-12	Al-Abraq Center	6.1
GS-West	GS-12	Al-Abraq Center	7.1
GS-West	GS-13	Al-Shagaya Center	18.2
GS-West	GS-13	Al-Shagaya Center	17
GS-West	GS-13	Al-Shagaya Center	9.8
GS-West	GS-13	Al-Shagaya Center	5.9
GS-West	GS-13	Al-Shagaya Center	7
GS-West	GS-13	Al-Shagaya Center	16.9
GS-West	GS-14	Al-Shaheed Jerman Center	10.7
GS-West	GS-14	Al-Shaheed Jerman Center	39.5
GS-West	GS-14	Al-Shaheed Jerman Center	17.8
GS-West	GS-14	Al-Shaheed Jerman Center	12.6
GS-West	GS-14	Al-Shaheed Jerman Center	9.5
GS-West	GS-14	Al-Shaheed Jerman Center	22.9
GS-West	GS-14	Al-Shaheed Jerman Center	17.5

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-West	GS-15	Shagaya	48.7
GS-West	GS-15	Shagaya	31
GS-West	GS-15	Shagaya	7.1
GS-West	GS-15	Shagaya	3.8
GS-West	GS-15	Shagaya	10.2
GS-West	GS-15	Shagaya	11.7
GS-West	GS-15	Shagaya	21.5
GS-West	GS-15	Shagaya	12.9
GS-West	GS-15	Shagaya	9.9
GS-West	GS-15	Shagaya	21.8
GS-West	GS-15	Shagaya	1.6
GS-West	GS-15	Shagaya	7.9
GS-West	GS-15	Shagaya	12
GS-West	GS-15	Shagaya	8.9
GS-West	GS-15	Shagaya	38.8
GS-West	GS-15	Shagaya	34.4
GS-West	GS-15	Shagaya	5.6
GS-West	GS-15	Shagaya	10.9
GS-West	GS-15	Shagaya	17.2
GS-West	GS-15	Shagaya	2.9
GS-West	GS-15	Shagaya	6.9
GS-West	GS-16	Shagaya	15.8
GS-West	GS-16	Shagaya	22.8
GS-West	GS-16	Shagaya	12
GS-West	GS-16	Shagaya	23.6
GS-West	GS-16	Shagaya	11.6
GS-West	GS-16	Shagaya	7.4
GS-West	GS-16	Shagaya	8.5
GS-West	GS-16	Shagaya	16
GS-West	GS-16	Shagaya	13.2
GS-West	GS-16	Shagaya	10.9
GS-West	GS-16	Shagaya	17
GS-West	GS-16	Shagaya	11
GS-West	GS-16	Shagaya	14.5
GS-West	GS-16	Shagaya	62

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-West	GS-16	Shagaya	11.5
GS-West	GS-16	Shagaya	15.3
GS-West	GS-16	Shagaya	21.6
GS-West	GS-16	Shagaya	19.1
GS-West	GS-16	Shagaya	30.3
GS-West	GS-16	Shagaya	12.5
GS-West	GS-16	Shagaya	11.8
GS-West	GS-17	Shagaya	12.9
GS-West	GS-17	Shagaya	7.3
GS-West	GS-17	Shagaya	4.2
GS-West	GS-17	Shagaya	2.5
GS-West	GS-17	Shagaya	0.8
GS-West	GS-17	Shagaya	10.6
GS-West	GS-17	Shagaya	10.6
GS-West	GS-17	Shagaya	18.6
GS-West	GS-17	Shagaya	14.5
GS-West	GS-17	Shagaya	9.5
GS-West	GS-17	Shagaya	17.4
GS-West	GS-17	Shagaya	13.5
GS-West	GS-17	Shagaya	11.4
GS-West	GS-17	Shagaya	8.7
GS-West	GS-17	Shagaya	24.8
GS-West	GS-17	Shagaya	49.4
GS-West	GS-17	Shagaya	9.1
GS-West	GS-17	Shagaya	10.7
GS-West	GS-17	Shagaya	5.7
GS-West	GS-17	Shagaya	12
GS-West	GS-18	Shagaya	15.2
GS-West	GS-18	Shagaya	34
GS-West	GS-18	Shagaya	8.8
GS-West	GS-18	Shagaya	8.4
GS-West	GS-18	Shagaya	10.1
GS-West	GS-18	Shagaya	30.5
GS-West	GS-18	Shagaya	3.8
GS-West	GS-18	Shagaya	7.9

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-West	GS-18	Shagaya	19.3
GS-West	GS-18	Shagaya	12.5
GS-West	GS-18	Shagaya	24.9
GS-West	GS-18	Shagaya	46.6
GS-West	GS-18	Shagaya	34.5
GS-West	GS-18	Shagaya	13.1
GS-West	GS-18	Shagaya	26.4
GS-West	GS-18	Shagaya	48.4
GS-West	GS-18	Shagaya	36.9
GS-West	GS-18	Shagaya	25.4
GS-West	GS-18	Shagaya	7.4
GS-West	GS-18	Shagaya	11.3
GS-West	GS-19	Shagaya	20.7
GS-West	GS-19	Shagaya	2.7
GS-West	GS-19	Shagaya	9
GS-West	GS-19	Shagaya	22.6
GS-West	GS-19	Shagaya	4.4
GS-West	GS-19	Shagaya	4.8
GS-West	GS-19	Shagaya	21.7
GS-West	GS-19	Shagaya	12.6
GS-West	GS-19	Shagaya	12.6
GS-West	GS-19	Shagaya	18.6
GS-West	GS-19	Shagaya	12.1
GS-West	GS-19	Shagaya	24
GS-West	GS-19	Shagaya	2.7
GS-West	GS-19	Shagaya	11.5
GS-West	GS-19	Shagaya	11.7
GS-West	GS-19	Shagaya	4.5
GS-West	GS-19	Shagaya	34.7
GS-West	GS-19	Shagaya	17.7
GS-West	GS-19	Shagaya	61
GS-West	GS-19	Shagaya	7.6
GS-West	GS-19	Shagaya	15.6

Table 68. (Cont'd.)

Clusters	Location	Area	Maximum Concentration (ng/g)
GS-West	GS-30	Khabrat Shayea Centre	15.4
GS-West	GS-30	Khabrat Shayea Centre	18.4
GS-West	GS-30	Khabrat Shayea Centre	8.7
GS-West	GS-30	Khabrat Shayea Centre	10.4
GS-West	GS-30	Khabrat Shayea Centre	7.7
GS-West	GS-30	Khabrat Shayea Centre	15
GS-West	GS-30	Khabrat Shayea Centre	61.8
GS-West	GS-30	Khabrat Shayea Centre	7.5
GS-West	GS-30	Khabrat Shayea Centre	10.7
GS-West	GS-30	Khabrat Shayea Centre	20.9
GS-West	GS-30	Khabrat Shayea Centre	2
GS-West	GS-30	Khabrat Shayea Centre	14.6
GS-West	GS-30	Khabrat Shayea Centre	4.5
GS-West	GS-31	Golmat Ali Centre	5.9
GS-West	GS-31	Golmat Ali Centre	12.2
GS-West	GS-31	Golmat Ali Centre	35.2
GS-West	GS-31	Golmat Ali Centre	16.5
GS-West	GS-31	Golmat Ali Centre	23.1
GS-West	GS-31	Golmat Ali Centre	13
GS-West	GS-31	Golmat Ali Centre	7.7
GS-West	GS-31	Golmat Ali Centre	22.3
GS-West	GS-31	Golmat Ali Centre	20.1
GS-West	GS-31	Golmat Ali Centre	21
GS-West	GS-31	Golmat Ali Centre	3.4
GS-West	GS-31	Golmat Ali Centre	17
GS-West	GS-32	Nimriteen Centre (west)	12.3
GS-West	GS-32	Nimriteen Centre (west)	8.4
GS-West	GS-32	Nimriteen Centre (west)	8.3
GS-West	GS-32	Nimriteen Centre (west)	23
GS-West	GS-32	Nimriteen Centre (west)	16
GS-West	GS-32	Nimriteen Centre (west)	6.5
GS-West	GS-32	Nimriteen Centre (west)	11
GS-West	GS-32	Nimriteen Centre (west)	7.2
GS-West	GS-32	Nimriteen Centre (west)	13.3
GS-West	GS-32	Nimriteen Centre (west)	4
GS-West	GS-32	Nimriteen Centre (west)	15.4

In this study, over 1000 ground soil/sand samples were collected from various locations from the entire State of Kuwait, mainly covering KOC petroleum upstream sites, KNPC petroleum downstream sites, landfills, and the entire official borders of Kuwait. All available dust samples were analyzed for mercury contents for accurate quantification using the cold vapor technique applying the pyrolytic extension of Zeeman RA915+ analyzer. This section describes the details of the total mercury levels measured from dust in the air deposited at different locations identifying the respective sources, also revealing the influence of yearly variations on mercury levels in the ground soil/sand in the State of Kuwait.

Over a 1000 samples of sand collected for the entire period were analyzed and mercury concentrations were determined. Cluster analysis was completed to identify major sources and their influence on the mercury levels in the ground soil/sand. There were seven clusters clearly marked where mercury concentrations were significant based on the average value of the maximums taken from the repeated samples that were analyzed in quadruplet way. Table 68 shows the Hg measurements from the pyrolytic extension of Zeeman RA915+ analyzer, which are above the detection limit (i.e., 0.5 ng/g).

Table 69 and Fig. 75 indicate that the highest average concentration of mercury was measured at KOC cluster (booster station and sludge treatment facilities) followed by the western oil fields as was the case of dust collectors reflecting flaring activity. Landfill sites have a significant level of mercury re-emission from scraped mercury appliances, batteries, tube lights, mercury bulbs, etc.

Table 69. Average Mercury Concentrations (ng/g) of Different Clusters in Kuwait

Clusters	Average Hg Concentration (ng/g)
GS-City	12.2
GS-KNPC	12.6
GS-KOC	21.1
GS-Landfill	15.5
GS-North	13.9
GS-South	15.5
GS-West	16.1

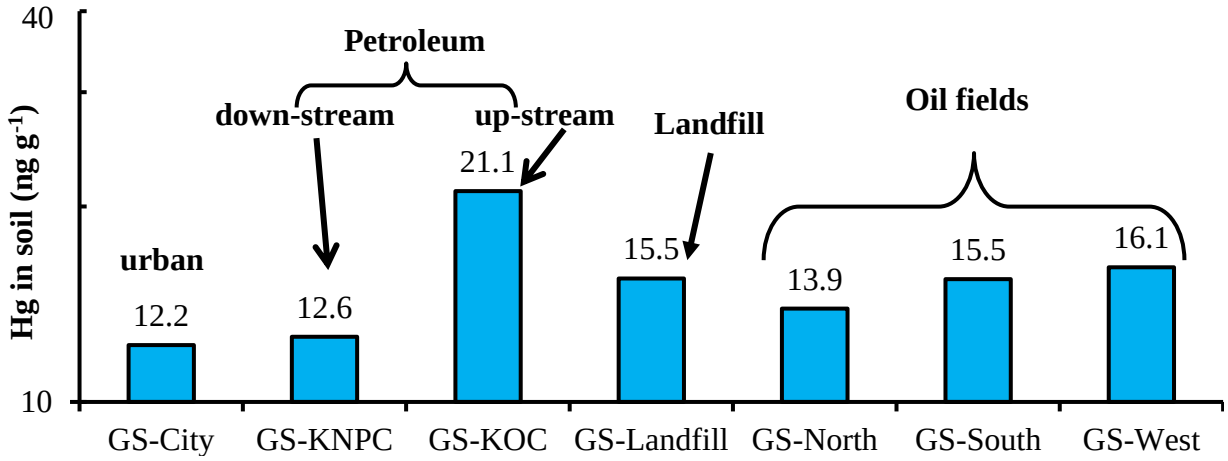


Fig. 75. Clusters of ground soil/sand samples indicating mercury levels in ng g^{-1} or ppb.

Yearly variation of mercury levels in ground soil/sand is described in Table 70 and Fig. 76. Average mercury levels in 2017 were the highest, and the highest mercury levels were observed at western oil fields (Magwa, Minagish, and Um-Qadir) cluster, followed by the northern oil fields, due to the flaring activities from western and southern Iraqi oil fields or northern Kuwaiti oil fields (Fig. 76).

Table 70. Average Mercury Concentrations (ng/g) in Ground Soil/Sand of Different Clusters in Kuwait

Year	Clusters	Average Hg Concentration (ng/g)
2017	Annual Average	17.1
	GS-KNPC	12.6
	GS-North	16.0
	GS-West	22.2
2018	Annual Average	13.7
	GS-City	12.1
	GS-Landfill	15.5
	GS-North	13.1
	GS-South	13.6
	GS-West	14.2
2019	Annual Average	16.8
	GS-City	12.4
	GS-KOC	21.1
	GS-North	13.6
	GS-South	18.7
	GS-West	17.6

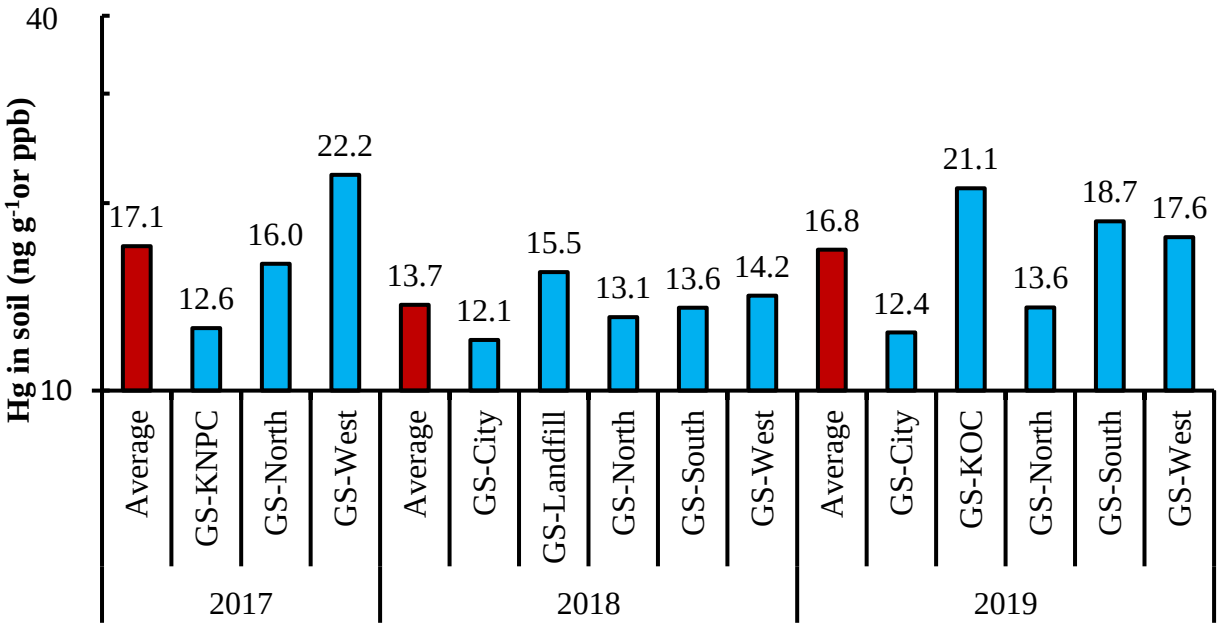


Fig. 76. Yearly mercury levels (ng g^{-1} or ppb) in ground soil/sand samples in different locations in Kuwait from 2017 to 2019.

The average mercury level in the ground soil/sand in 2018 decreased from the previous year's value (of 2017) due to very high precipitation washing all deposition to the Arabian Gulf. The highest value of mercury in the ground dust/sand was measured from the landfill cluster, as it mainly contains lots of waste products having mercury contaminations. The second highest was measured from western oil fields (Managesh, Magwa, and Um-Qadir) cluster contributing to the buildup of mercury through flaring operations. In 2019, there was a substantial increase in the average value compared to 2018, which was similar to the value of 2017. The highest mercury concentration was measured from the KOC cluster, mainly from oil spills (disposal pit) and sludge treatment facility. KISR's team had limited access to upstream petroleum activities. KOC's safety, health, and environment department arranged a visit to the booster station and the oil recovery facility from which sludge and ground soil/sand were sampled, to quantify mercury levels in that specific area.

The second highest value was measured from the southern oil fields' "Joint Operation" cluster, mainly from Wafra area. Petroleum downstream KNPC cluster (refining and usage) had a large-scale activity with gaseous or oil fugitive emission handled by flaring, resulting in combustion products containing mercury as a major pollutant. Therefore, whereever there was combustion of fossil fuel liquid or gas, this was associated with mercury emissions. The emissions due to petroleum downstream were substantially lower than all other clusters and were not noticed in the comparative emissions of 2018 and 2019.

Conclusion

The cluster analysis of mercury levels in the ground contaminated soil/sand showed seven major probable sources: petroleum upstream activities in the north, south, and west contributing to the mercury pollution through the flaring of gas, oil, oil-water emulsion, and sludge containing oil, water, and sand; landfill sites; KOC; KNPC petroleum downstream sites; and urban societal emissions. The highest average mercury level was observed in 2017 comprising western oil field production followed by northern oil field production and petroleum downstream at KNPC. In 2018, the average mercury levels decreased, consisting of the contribution from landfill sites and petroleum upstream from northern, southern, and western oil fields. In 2019, the average mercury levels increased from 2018 and reached almost the same levels of 2017, consisting of KOC where the site of sampling was limited, and only covered booster station and oil recovery facility from sludge followed by petroleum upstream from southern, western, and northern oil fields.

Section 10 - Measurments of Elemental Mercury (Hg^0) in Air Using Portable Atomic Absorption Spectrometer (Zeeman RA915+)

Direct reading mercury analyzer (i.e., Zeeman RA 915+ mercury portable atomic absorption spectrometer), which belongs to KISR and was reserved for this research study, was used to measure the mercury levels instantaneously for selected sites (Plate 76). The RA 915+ analyzer (base unit) is intended for measuring mercury vapor concentration in ambient air. The analyzer can be used for the onstream measurement of the total mercury concentration in the air, both in a stationary mode and in a continuous mode in vehicles (car, helicopter, and boat to cover a wide area for the accurate assessment of mercury levels). The RA 915+ analyzer is a part of a mercury analytical system, which enables the determination of mercury content continuously in air samples with a minimum detection limit of ≤ 2 ng/m^3.

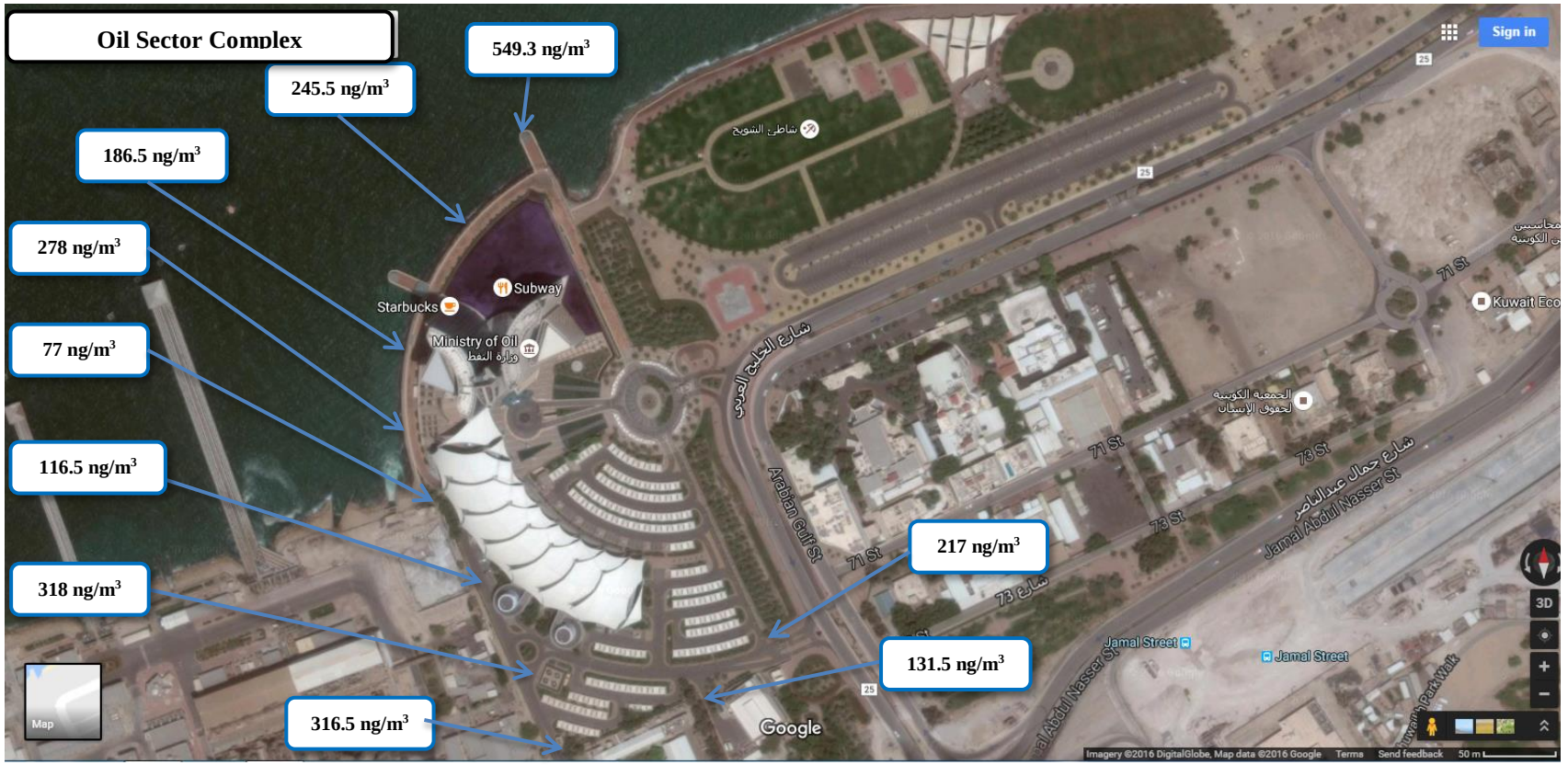
Two continuous mercury monitoring analyzers were supposed to be used in this research study, but unfortunately, only one was used due to some difficulties, which are mentioned subsequently, under the limitations section.



Plate 76. Zeeman RA-915 mercury portable atomic absorption spectrometer.

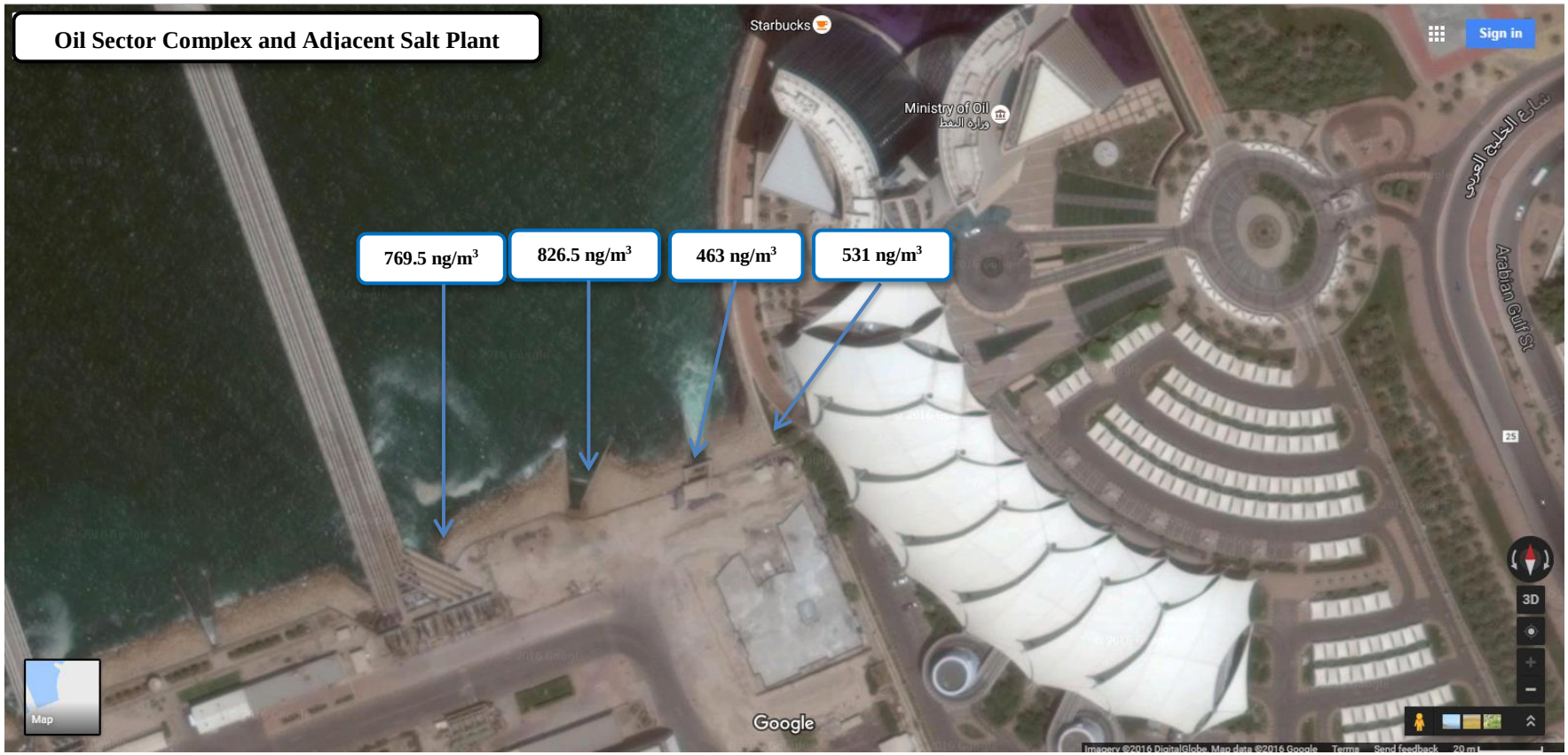
Measurement of Elemental Mercury (Hg^0) in Air around the Oil Sector Complex and KISR Areas

The most probable source of mercury in ambient air, as identified by Khan et al. (2008), was confirmed in the present measurements. In summer months, energy demand reached new heights. To fulfill the ever increasing demand, the Ministry of Water and Electricity operated all of the power stations at full load using all available fuels, including the crude oil. In July and August, the pollutant concentrations increased reflecting the quality and quantity of fuel consumed. The Doha Power Plant is located in the northwest of the Oil Sector Complex (OSC), and the predominant wind blew most of the times from this direction transporting these pollutants to the OSC. In April 2016, the Oil Sector Workers' Union announced an industrial action, which had compelled power stations to be operated on crude oil emitting high concentrations of the pollutants associated with crude oil. Mercury levels were measured around the OSC and are displayed in Figs. 77 to 79. To ascertain the source, mercury levels around KISR were measured during this period when the oil sector workers took an industrial action (Fig. 80). These values were instantaneous, displayed every 10 s, and correspondingly, one minute average values were registered. Mercury levels around the OSC were measured using Zeeman RA 915+ at different locations to identify any probable local source other than the distant source, i.e., the Doha Power Plant. Mercury levels were also measured around the OSC in July and September 2016, using Zeeman RA 915+, and the values are shown in Figs. 81 and 82.



OSC: Oil sector complex

Fig. 77. Mercury levels around the OSC on 17 April 2016.



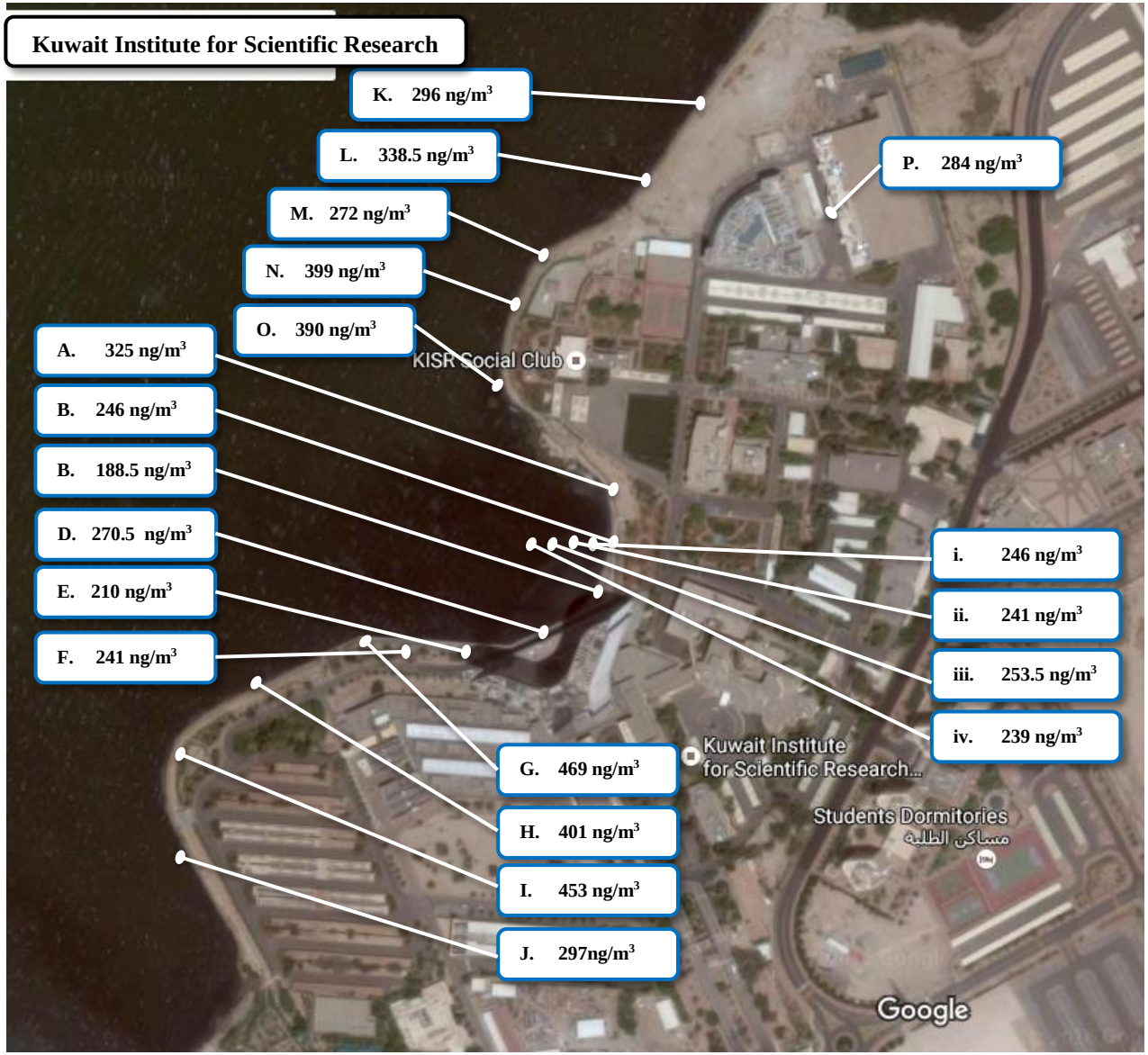
OSC: Oil sector complex

Fig. 78. Mercury levels around the OSC near the Shuwaikh Power and Desalination Plant on 18 April 2016.



OSC: Oil sector complex

Fig. 79. Mercury levels around the OSC, adjacent to the recreational area, on 19 April 2016.



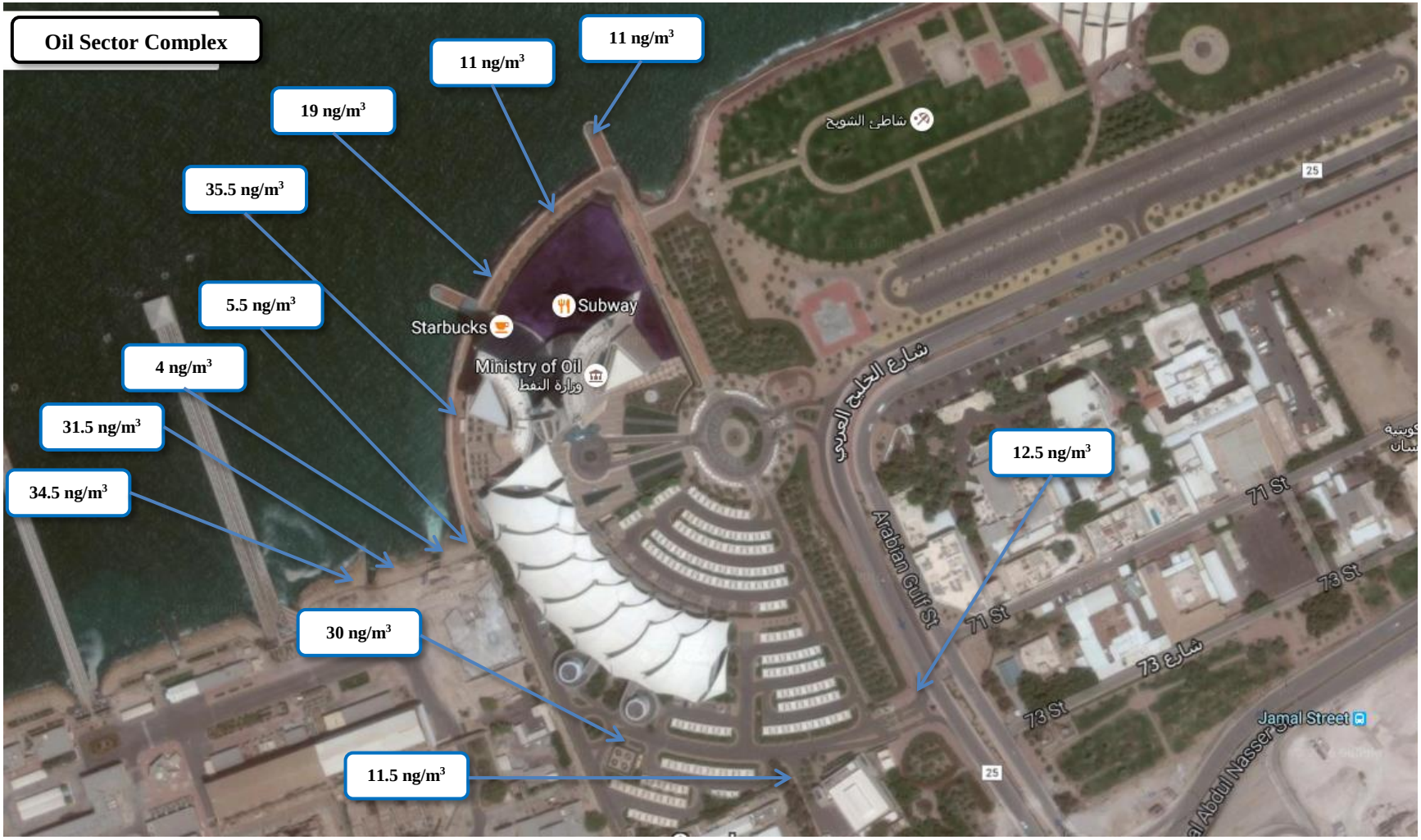
KISR: Kuwait Institute for Scientific Research

Fig. 80. Mercury levels around KISR on 27 April 2016.



OSC: Oil sector complex

Fig. 81. Mercury levels around the OSC in July 2016.

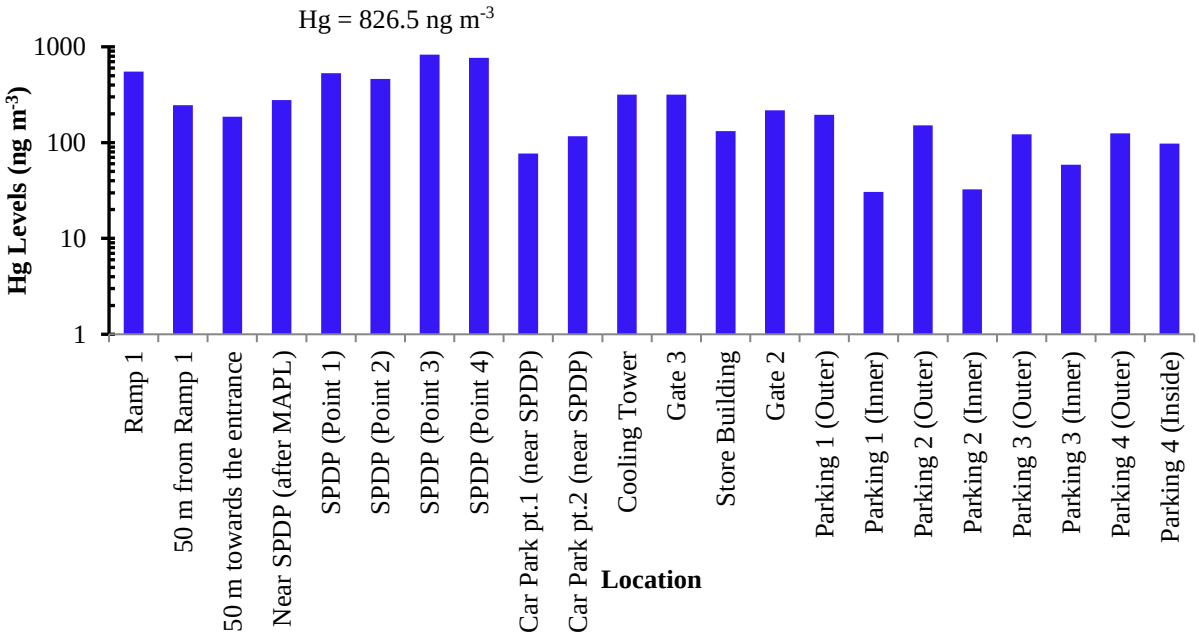


OSC: Oil sector complex

Fig. 82. Mercury levels around the OSC on 22 September 2016.

The highest concentration of mercury in April 2016 was measured in the ambient air (826.5 ng m^{-3}) near the Shuwaikh Power and Desalination Plant (SPDP), which must be near the touchdown position of the Doha Power Station plume located about 200 m to the left side of the OSC. The variations in the instantaneous mercury levels (minute average) at different locations were due to difference in the amount of crude oil used as fuel, physical obstruction and air circulation, wind speed, and wind direction. Fig. 83 shows the variation of mercury levels in April at the left side of the OSC, and all measured values are tabulated in Table 71.

On the right side of the OSC, the highest concentration of mercury in April 2016 was measured in the ambient air (589.5 ng m^{-3}) at Position I, in the middle of the recreation park. The variations in mercury levels were due to the reason previously discussed and are presented in Fig. 84 and Table 72.



SPDP: Shuwaikh Power and Desalination Plant; MAPL: Mobile air pollution laboratory

Fig. 83. Mercury levels around the OSC in April 2016.

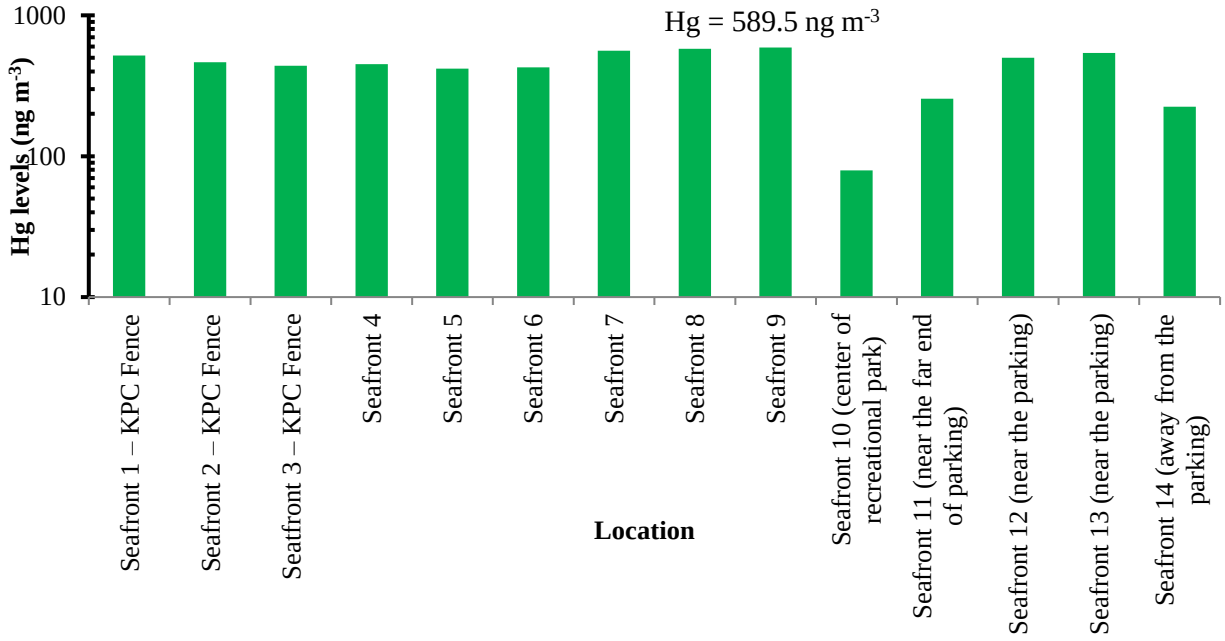
Table 71. Mercury Levels at Random Locations around the OSC

No.	Location	Hg Levels (ng m^{-3})		
		April 2016	July 2016	September 2016
1.	Ramp 1	549.3	-	11.0
2.	50 m from Ramp 1	245.5	-	11.0
3.	Ramp 2 (at the sea end)	-	238.0	-
4.	Ramp 2 (middle of the ramp)	-	100.0	-
5.	Seaside entrance (near SPDP)	-	70.0	-
6.	Seaside entrance (glass door)	-	36.6	-
7.	50 m towards the entrance	186.5	-	19.0
8.	Mobile laboratory (50 m away) - 1	-	167.0	-
9.	Mobile laboratory (50 m away) - 2	-	147.0	-
10.	Mobile laboratory (25 m away)	-	94.0	-
11.	Mobile laboratory (5 m away)	-	40.0	-
12.	Mobile laboratory (door)	-	10.0	-
13.	Near SPDP (after MAPL)	278.0	-	35.5
14.	SPDP (point 1)	531.0	-	5.5
15.	SPDP (point 2)	463.0	-	4.0
16.	SPDP (point 3)	826.5	-	31.5
17.	SPDP (point 4)	769.5	-	34.5
18.	Car park pt. 1 (near SPDP)	77.0	16.0	9.5
19	Car park pt. 2 (near SPDP)	116.5	-	
20.	Cooling tower	318.0	-	30.0
21.	Gate 3	316.5	-	11.5
22.	Store building	131.5	-	
23.	Gate 2	217.0	-	12.5
24.	Pool window (reception glass 1)	-	33.0	-
25.	Pool window (reception glass 2)	-	21.0	-

Table 71. (Cont'd.)

No.	Location	Hg Levels (ng m^{-3})		
		April 2016	July 2016	Sept 2016
26.	VIP entrance (in front of the fountain)	-	119.0	-
27.	VIP entrance (fountain stairs)	-	114.0	-
28.	Cafeteria (side road door)	-	42.0	-
29.	Parking 1 (outer)	194.5	-	-
30.	Parking 1 (inner)	30.5	-	-
31.	Parking 2 (outer)	151.0	-	-
32.	Parking 2 (inner)	32.5	-	-
33.	Parking 3 (outer)	122.0	-	-
34.	Parking 3 (inner)	59.0	-	-
35.	Parking 4 (outer)	124.5	-	-
36.	Parking 4 (inside)	97.5	-	-
		-	-	-

SPDP: Shuwaikh Power and Desalination Plant; MAPL: Mobile air pollution laboratory; OSC: Oil sector complex
Level : high Hg levels



OSC: Oil sector complex; KPC: Kuwait Petroleum Corporation

Fig. 84. Mercury levels at the right side of the OSC in April 2016.

Table 72. Mercury Measurements Taken at Random Locations at the Recreational Area Outside the Oil Sector Complex using Zeeman (19 April 2016) (Fig. 79)

No.	Location	Hg Levels ($ng\ m^{-3}$)
A.	Seafront 1 – KPC Fence	519.0
B.	Seafront 2 – KPC Fence	465.5
C.	Seafront 3 – KPC Fence	439.5
D.	Seafront 4	449.5
E.	Seafront 5	419.0
F.	Seafront 6	427.5
G.	Seafront 7	559.5
H.	Seafront 8	577.5
I.	Seafront 9	589.5
J.	Seafront 10 (center of the recreational park)	79.5
K.	Seafront 11 (near the far end of the parking)	256.0
L.	Seafront 12 (near the parking)	499.0
M.	Seafront 13 (near the parking)	539.5
N.	Seafront 14 (away from the parking)	225.0

KPC: Kuwait Petroleum Corporation
Level : High Hg levels

Mercury levels in the ambient air were measured near KISR to make sure that the only distant source was the Doha Power Plant. The highest concentration of mercury in April 2016 was measured near KISR, which was about 469 ng m^{-3}, at Location J, near KISR's meteorological station at the shore. The measured values near KISR are presented in Fig. 85 and listed in Table 73.

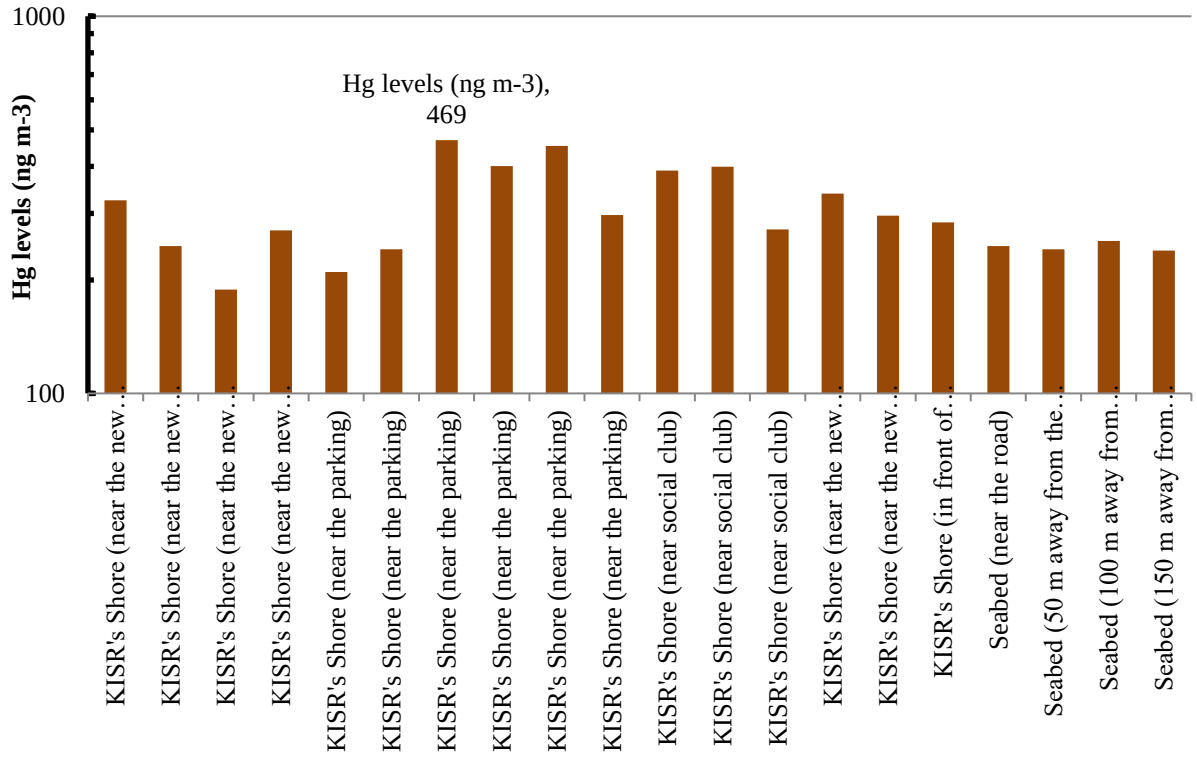


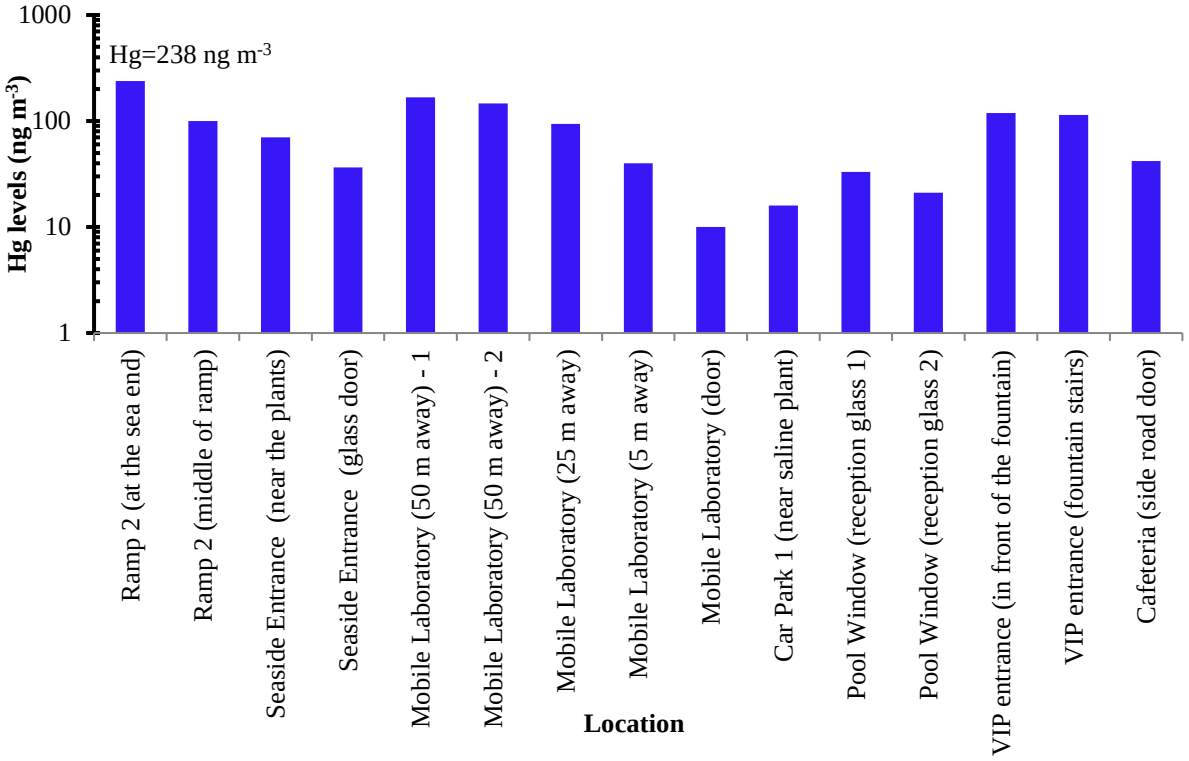
Fig. 85. Mercury levels outside KISR in April 2016.

Table 73. Mercury Levels at Random Points along the Shoreline of KISR on 27 April 2016

No.	Location	Hg Levels ($ng\ m^{-3}$)
A.	KISR's shore (near the new building)	325.0
B.	KISR's shore (near the new building)	246.0
C.	KISR's shore (near the new building)	188.5
D.	KISR's shore (near the new building)	270.5
E.	KISR's shore (near the parking)	210.0
F.	KISR's shore (near the parking)	241.0
G.	KISR's shore (near the parking)	469.0
H.	KISR's shore (near the parking)	401.0
I.	KISR's shore (near the parking)	453.0
J.	KISR's shore (near the parking)	297.0
K.	KISR's shore (near the social club)	296.0
L.	KISR's shore (near the social club)	338.5
M.	KISR's shore (near the social club)	272.0
N.	KISR's shore (near the new water resources building)	399.0
O.	KISR's shore (near the new water resources building)	390.0
P.	KISR's shore (in front of building 45)	284.0
i..	Seabed (near the road)	246.0
ii.	Seabed (50 m away from the road)	241.0
iii.	Seabed (100 m away from the road)	253.5
iv.	Seabed (150 m away from the road)	239.0

KISR: Kuwait Institute for Scientific Research
Level : High Hg levels

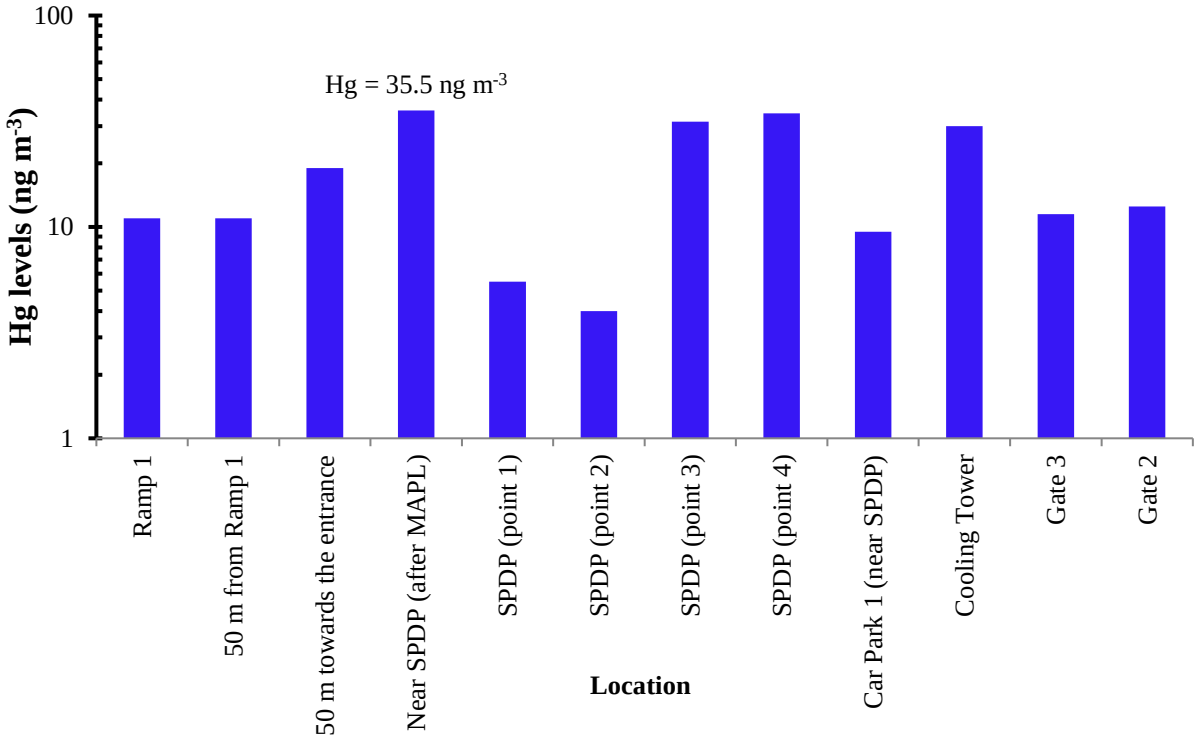
The highest concentration of mercury was measured in July 2016 in the ambient air (238 ng m^{-3}) at the Ramp II, near the back glass door entrance of the OSC. The variations in mercury levels were due to the amount of crude oil used in the power station, wind speed and wind direction, and motion of air in the wake of the building, and they are presented in Fig. 86 and tabulated in Table 71.



OSC: Oil sector complex

Fig. 86. Mercury levels around the OSC in July 2016.

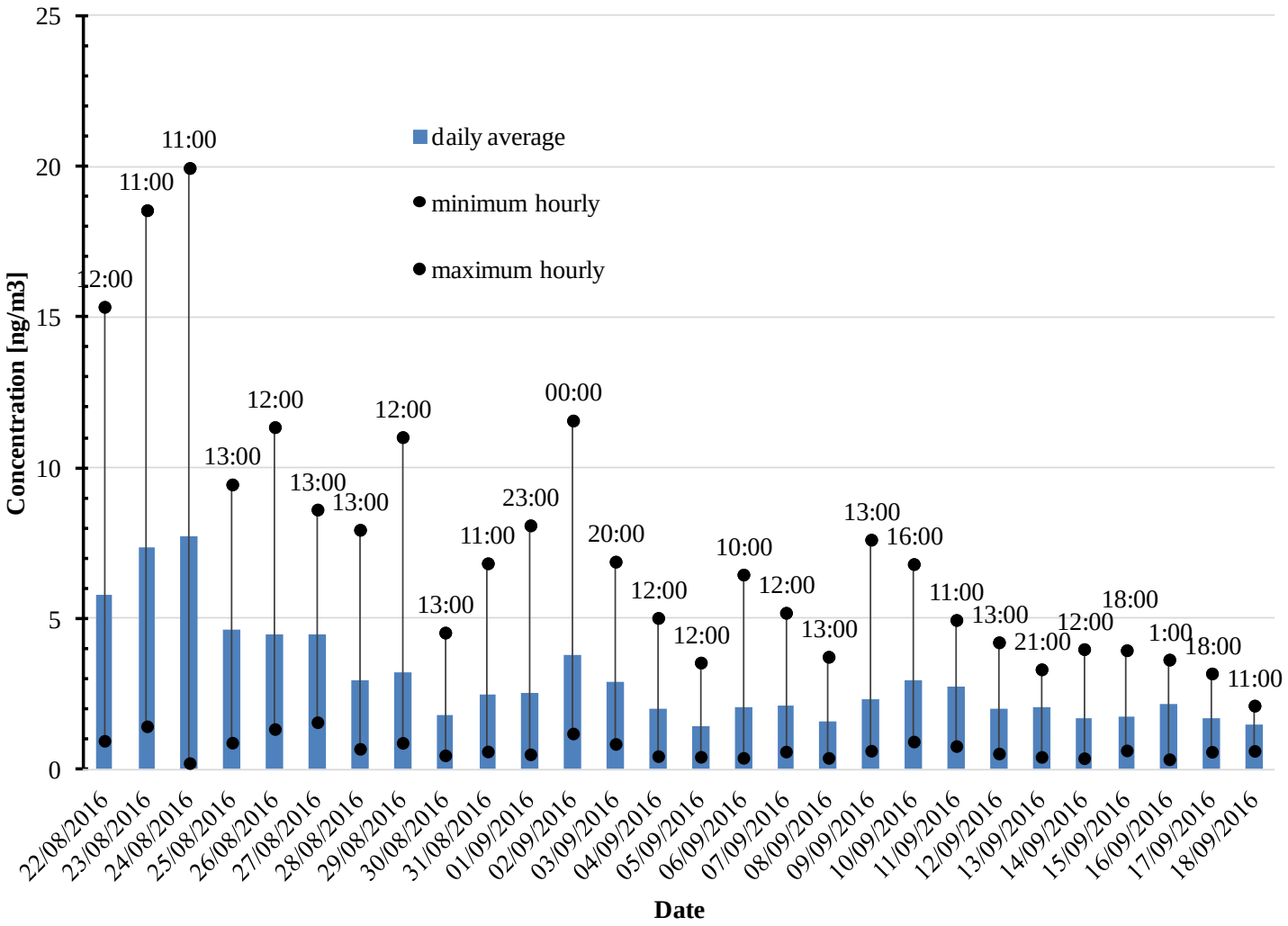
The measurement exercise was repeated in September 2016 to observe the influence of weather change and, indirectly, the power load. Natural gas was commonly used as the fuel of choice. The highest concentration of mercury was measured in September 2016 in the ambient air, which was 35.5 ng m^{-3}, near the SPDP toward the left side of the OSC. The variation in mercury levels was minimal and is presented in Fig. 87 and Table 71. For the continuous monitoring of mercury levels in the ambient air, Zeeman RA 915+ was operated via the computer mode.



SPDP: Shuwaikh Power and Desalination Plant; MAPL: Mobile air pollution laboratory; OSC: Oil sector complex

Fig. 87. Mercury levels around the OSC in September 2016.

The original software had a problem of recording mercury levels using the built-in default value of one second interval. This option provided the continuous operation of Zeeman for eight hours only. The parent company was contacted, and a new software was secured to monitor every 15-min interval covering a period of at least one week. This operation was completed by the end of August and at the beginning of September. The continuously monitored mercury data from Zeeman placed in the Air Pollution Laboratory (APL) was recorded. Fig. 88 presents the daily mean concentration and hourly maximum reaching the specified time.



APL: Air pollution laboratory; OSC: Oil sector complex

Fig. 88. Continuous mercury measurements from the APL outside the OSC.

The results of the mercury concentrations measured from April to September 2016 are obvious and significantly relative to the surroundings and seasons.

In April 2016, as a consequence of the Oil Sector Workers Union's industrial action, power stations operated on crude oil emitting high concentrations of the pollutants associated with crude oil. This resulted in the high levels of mercury near the SPDP, which must be near the touchdown position of the Doha Power Station plume. During the summer, it was significantly high due to the amount of crude oil used in the power station, wind speed, and wind direction. The mercury levels dropped in September due to weather change, and indirectly the power load and clean fuel (NG) also decreased.

Elemental Mercury (Hg^0) in Air over the Arabian Gulf Participating in AQABA Mission

AQABA Mission. The Middle East is a populous region with a hot, arid climate. Heat extremes, scarcity of precipitation, atmospheric dust, and photochemical air pollution combine into a major public health hazard. Environmental research in the region is needed to address these issues, but observational data, especially of atmospheric composition, are scarce. AQABA is aimed at performing pioneering field measurements across the Arabian Basin in summer, using a comprehensively instrumented research vessel to simultaneously characterize atmospheric chemistry and aerosol processes. The project, with international participation, was coordinated by the Max Planck Institute for Chemistry in Germany (www.mpic.de).

Sailing from Malta to Kuwait around the Arabian Peninsula (Plate 77), AQABA encountered a unique environmental "spectrum", ranging from pristine conditions over the Arabian Sea, unpolluted but dusty air from Africa over the Red Sea, via moderately polluted conditions over the Mediterranean, downwind urban areas (e.g., Cairo) and the Middle East, ship exhausts in the Suez Canal, to petrochemical emissions in the Arabian Gulf area. The annual maximum of atmospheric desert dust in this region occurred in summer, when photochemistry was intense. Taken together, this created a "natural laboratory" to study multiphase interactions of gaseous and particulate pollutants with crustal and sea salt aerosols.

The measurements, complemented by model calculations, helped to determine

the intricate effects of natural and anthropogenic emissions on the atmosphere in the Middle East. AQABA investigated the processes that determine the life cycle of natural and anthropogenic aerosols and oxidants, and investigated their role in air quality and public health, as well as impacts on clouds, climate, and biogeochemical cycles.



Plate 77. Vessel Kommandor Iona (AQABA mission) that was used to perform mercury (Hg) measurements over the Arabian Gulf.

KISR's Goal. The main objective of the mission was to measure mercury concentrations in the air across the Arabian Gulf. The second objective of the mission was to learn about all of the different air pollution monitoring equipment used in the ship and their methods of operation. KISR's delegate visited the ship and was told about the operation of all the aerosol and hazardous pollutants' instruments on board. KISR's employee was allowed to board the ship to complete mercury measurement over a section of the Arabian Gulf neighboring Kuwait and to learn about the operation of all air pollution monitoring equipment on the ship. The mission began on 2 August, in Kuwait, and ended on 6 August at Fujairah, UAE.

System Design. The instrument used by KISR is the Zeeman RA 915+ mercury analyzer from Lumex Instruments (Plate 78). This instrument is an atomic absorption spectrometer, which uses the effect of the resonance radiation absorption by the mercury atoms to detect mercury concentrations. The instrument employs the Zeeman effect for non-selective absorption by correcting for inaccuracies from interfering factors such as dust, aerosols, absorbing gases, and vapors.



Plate 78. Zeeman RA-915+ mercury portable atomic absorption spectrometer used for mercury measurements in dust and ambient air.

The Zeeman instrument has an ultralow detection limit because of the multipath cell with an effective optical length of 10 m. This provides the highest measurement sensitivity. The instrument uses a pump with a flow rate of 20 l/min when used to directly measure mercury concentrations in ambient air. The instrument connects through an RS232 port to a laptop to receive operational commands and to display the current data readings, graphically.

On the AQABA ship, the instrument was fitted on the top of a rack in an air conditioned container and was fully strapped down to ensure the stability (no movement) of the instrument (Plate 79).

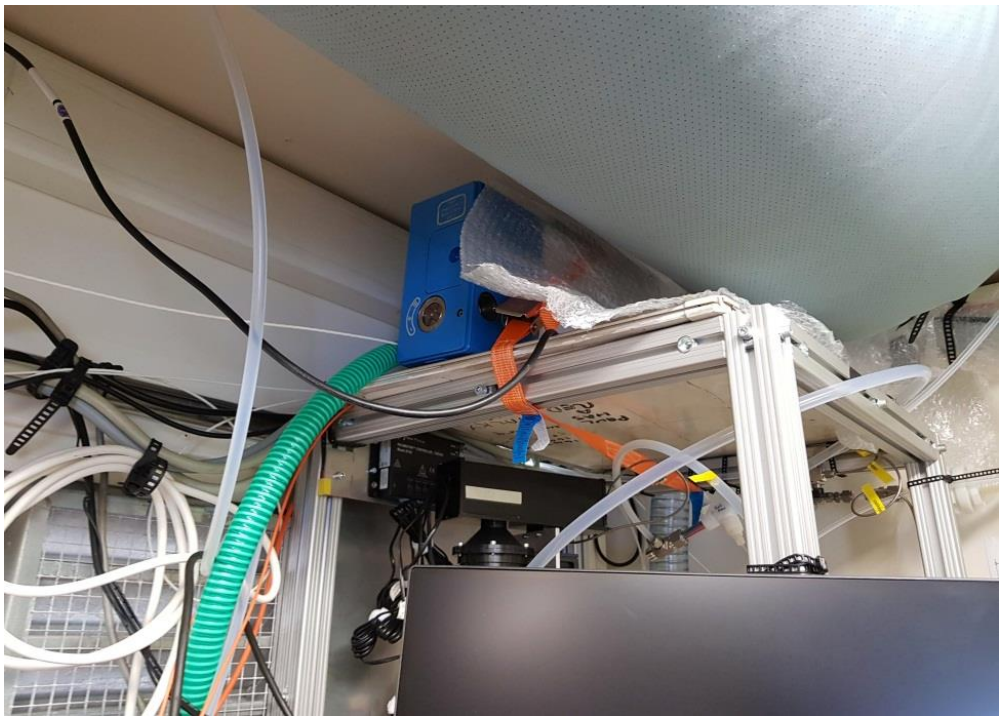


Plate 79. Zeeman instrument mounted on container rack.

The humidity over the Arabian Gulf was extremely high during that time of year, and because the temperature inside the container was lower than that outside the container, a water catcher/humidity trap had to be used to trap water from condensation in order not to damage the instrument. The water trap (Plate 80) was connected in between the original hose of the instrument and the inlet pipeline, which accesses the outside air from all directions.

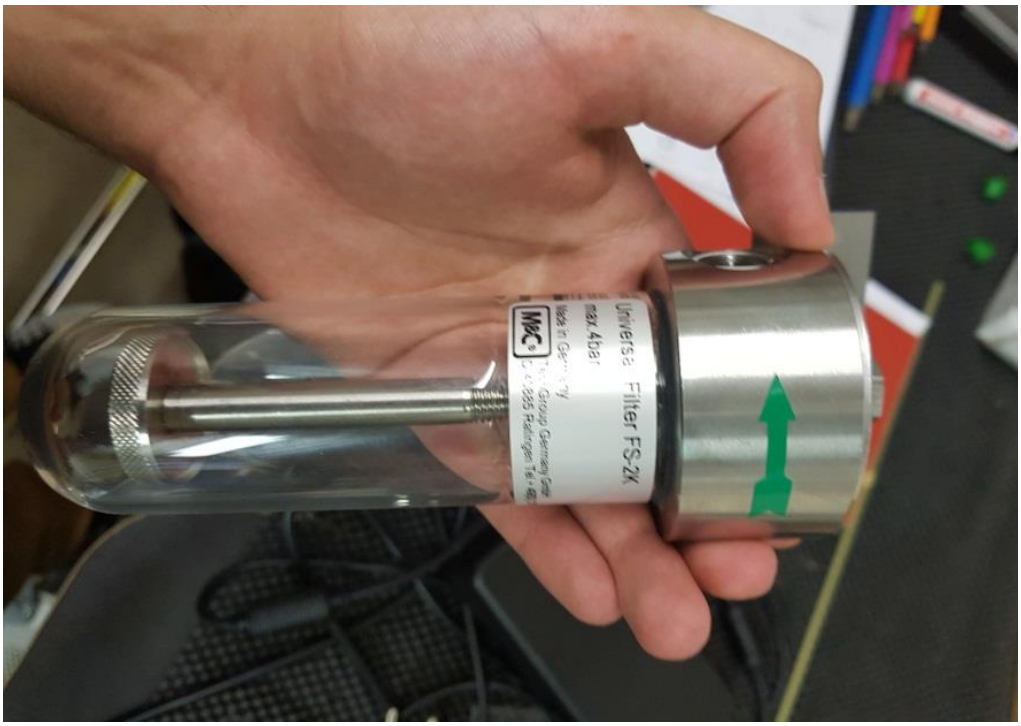


Plate 80. Water trap used to trap condensation formed due to humidity over the Arabian Gulf.

A custom-made fitting was erected to match the size of the original hose opening of the instrument's pump and to allow it to securely fit the trap's opening (Plates 81 and 82).



Plate 81. Custom fitting attached to the water filter.

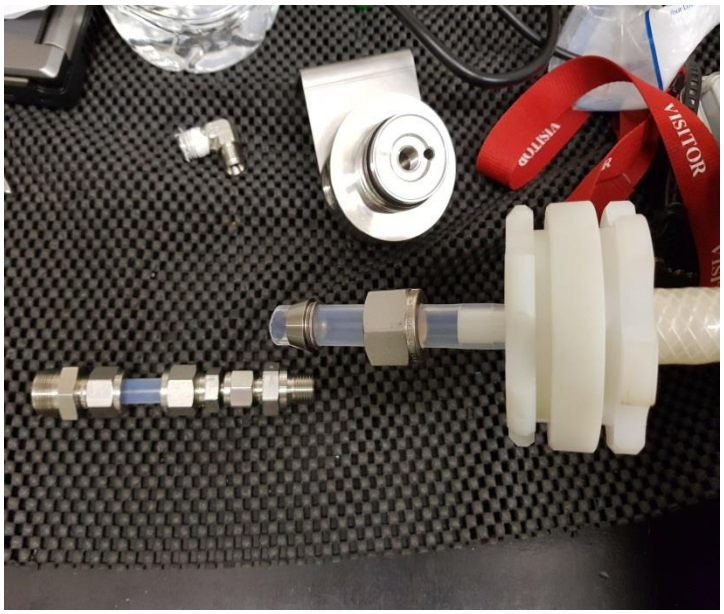


Plate 82. Custom fitting used to attach the water filter to the instrument hose.

After the water trap was connected in between the instrument's pump and the container's outlet, the instrument was operational. The instrument accessed air from the inlet outside and on the top of the container from all directions (Plate 83).



Plate 83. Inlet opening on top of the container.

The Zeeman RA 915+ was operated by a laptop using the Lumex RAPID software from the other corner of the container. As the original RS232 to USB cable was short in

length to reach the laptop, an extended RS232 to USB cable was prepared and used (Plate 84). Also, the laptop's time and date settings were synchronized to the ship's GPS system, in order to record the data readings accurately representing the current time and location of the readings.

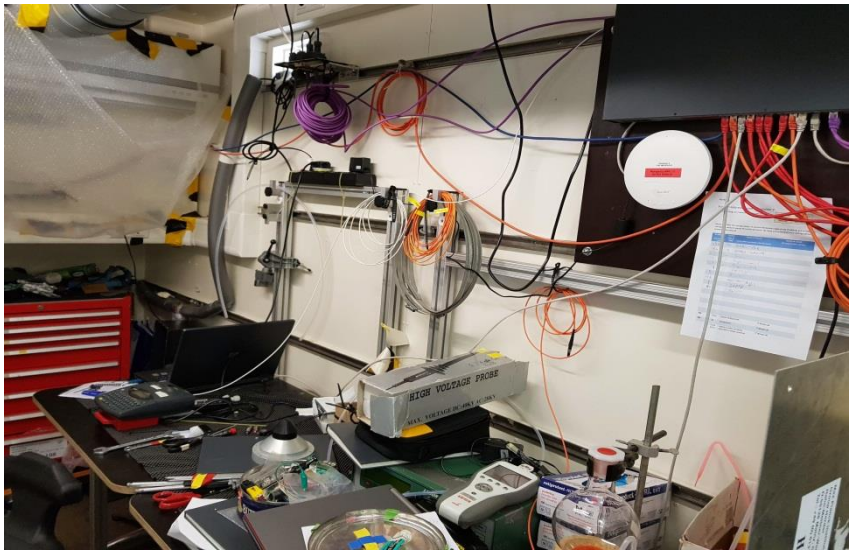


Plate 84. Laptop used to configure, control, and store data from the instrument.

Upon continuous operation of the instrument that displayed the mercury concentrations, water droplets were formed and got collected in the water trap (Plate 85). The glass of the trap had to be unscrewed, emptied, and then screwed back on, once a day.



Plate 85. Water collected from water trap.

Findings of the Mission. Measurements began at 9:27 AM on 4 August and ended at 12:30 PM on 6 August. Measurements were taken in twelve-hour increments. Measurements included vessel speed, relative humidity, temperature, true wind speed, true

wind direction, and mercury concentrations in ambient air samples. The concentrations were measured in the form of monograms per cubic meter. Readings were taken in ten-second increments, with a one-minute long baseline correction adjustment every five minutes. After the raw data were recorded, they were then processed to filter out negative values that correlated to mercury traces lower than the detection limit. The data were presented in two forms, raw data and hourly averages.

The track of the ship's movement can be seen in Plate 86. The red line indicates the start of the measurement. The beginning of the black line correlates to 5:30 pm on 2 August. The beginning of the red line correlates to 9:27 am on 4 August. The mercury concentrations along with meteorological data can be seen from Figs. 89 to 107.



Plate 86. Track of the vessel plotted.

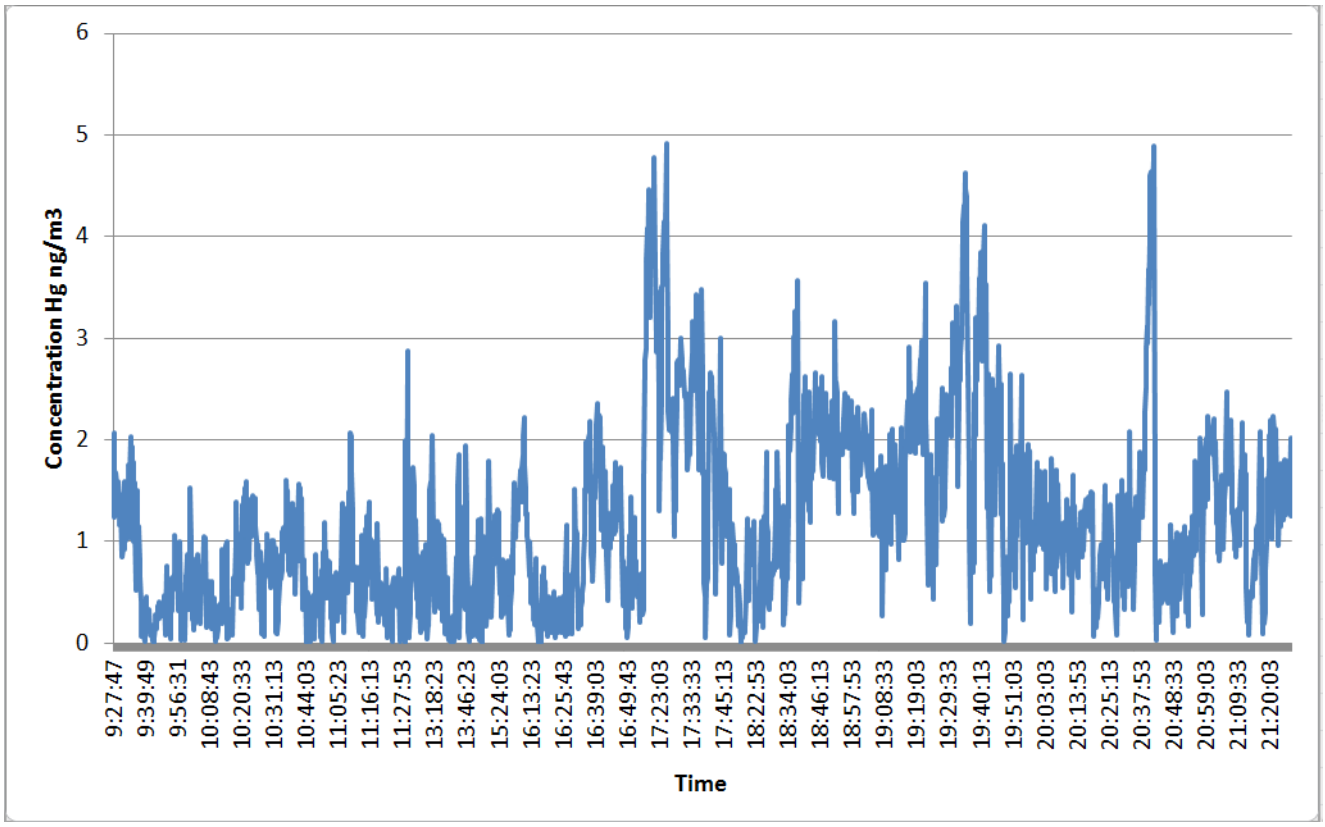


Fig. 89. Mercury concentrations for the first 12 h (9:27 am – 9:20 pm) on 4 August 2017.

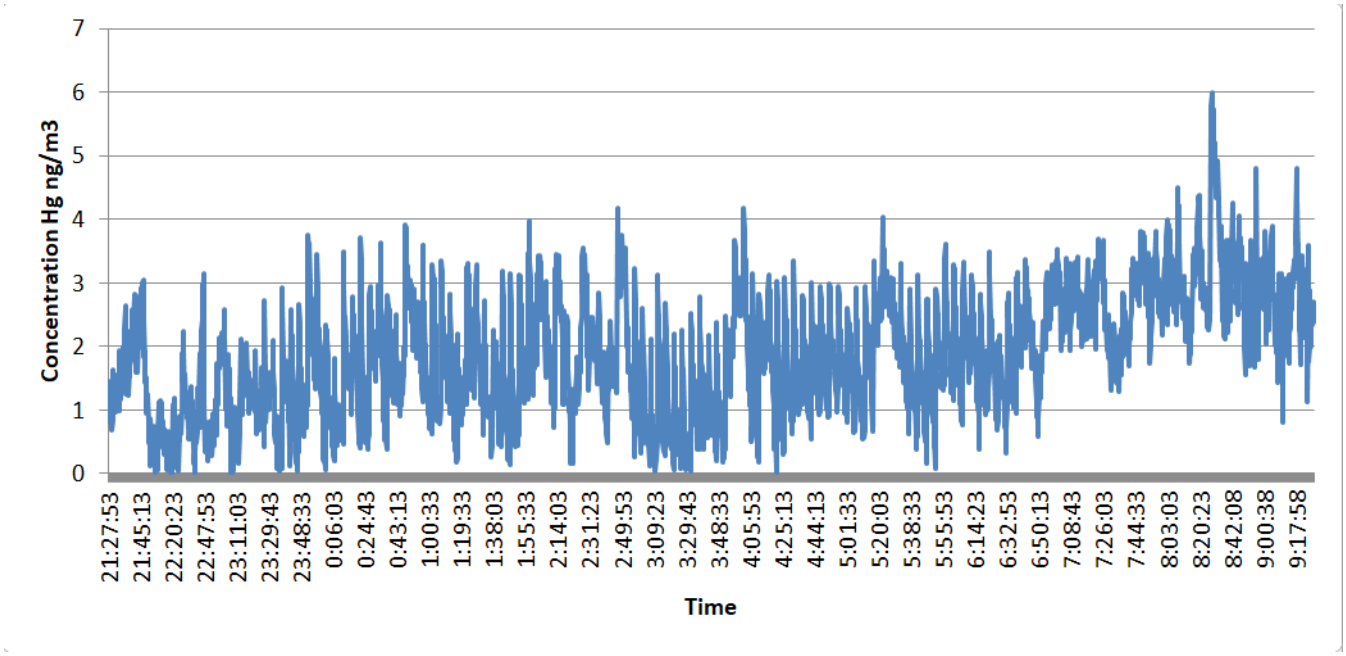


Fig. 90. Mercury concentrations for the second 12 h (9:27 pm – 9:17 am) on 4 and 5 August 2017.

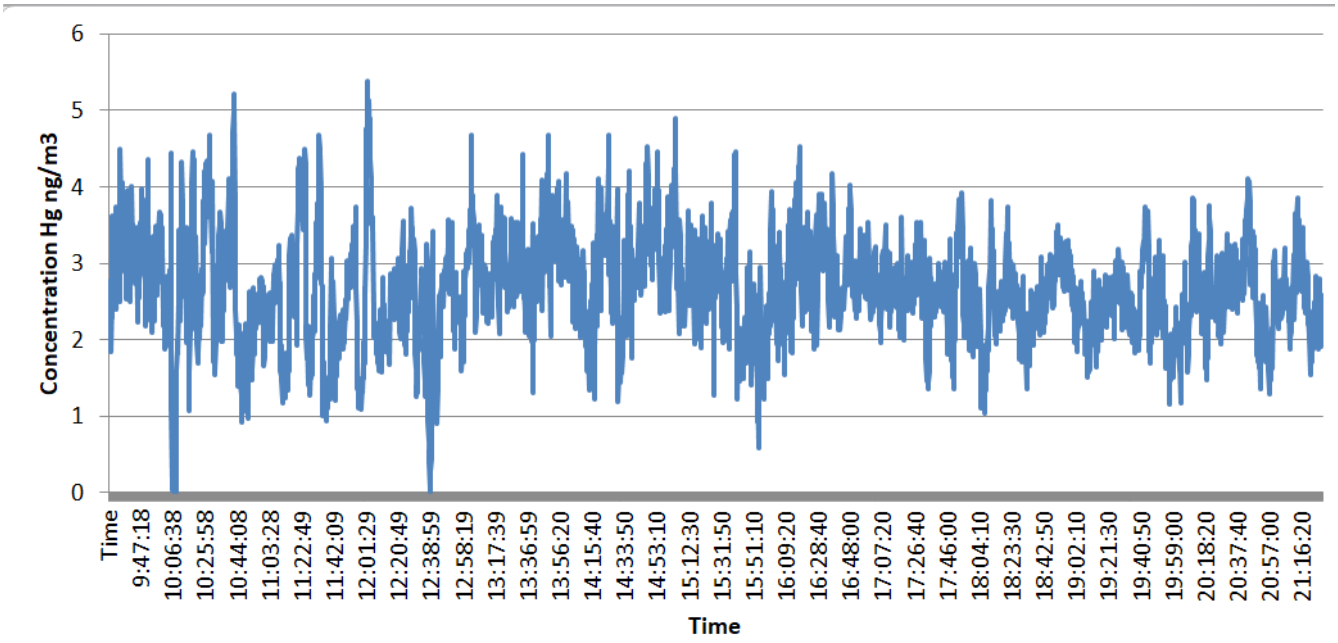


Fig. 91. Mercury concentrations for the third 12 h (9:47 am – 9:16 pm) on 5 August 2017.

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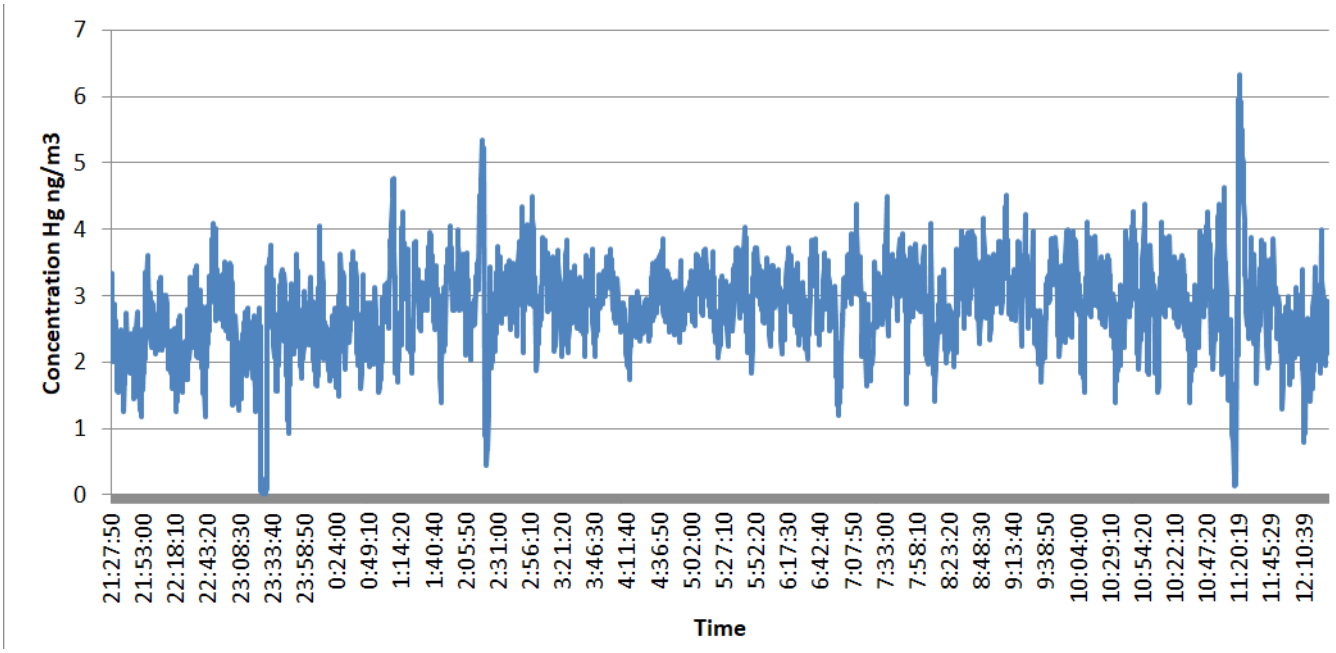


Fig. 92. Mercury concentrations for the fourth 12 h (9:27 pm – 12:10 am) on 5 and 6 August 2017.

The following data contain the hourly average of the mercury concentrations along with the hourly average of the meteorological data for 4 August 2017.

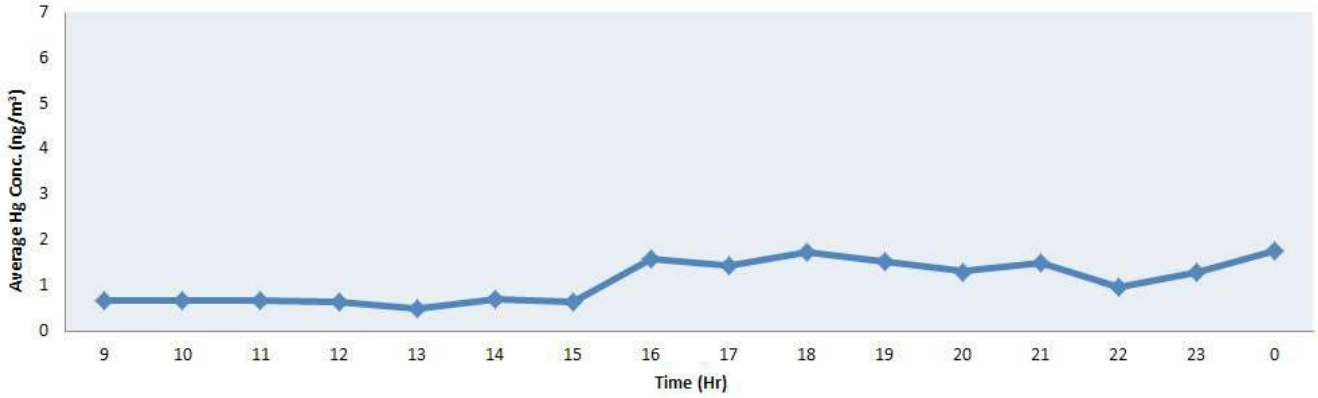


Fig. 93. Hourly average mercury concentration for 4 August 2017.

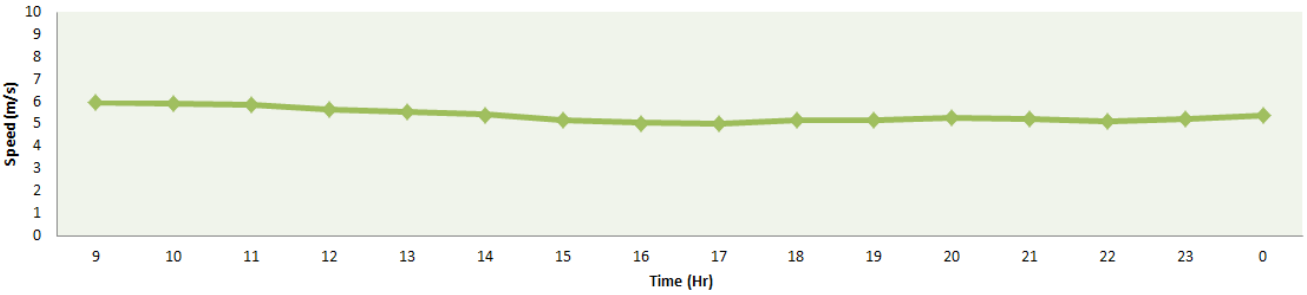


Fig. 94. Hourly average vessel (Kommandor Iona) speed for 4 August 2017.

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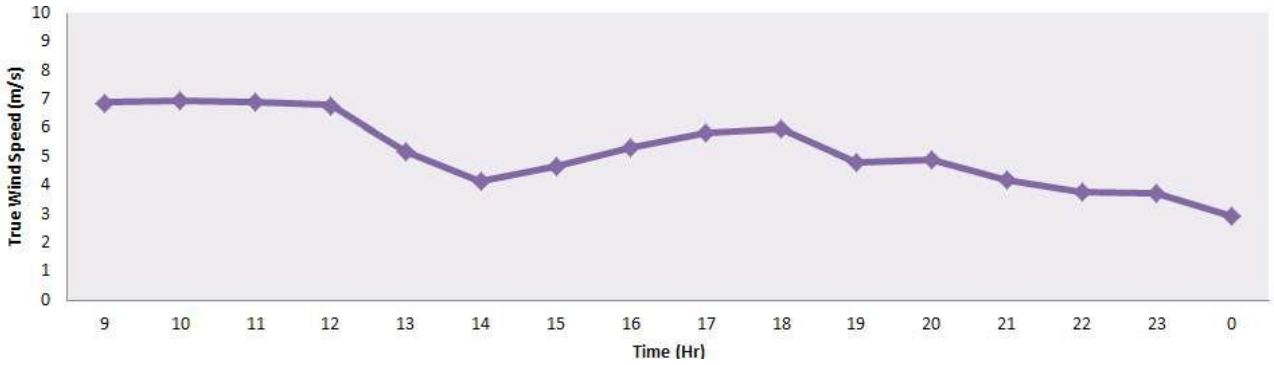


Fig. 95. Hourly average wind speed on 4 August 2017.

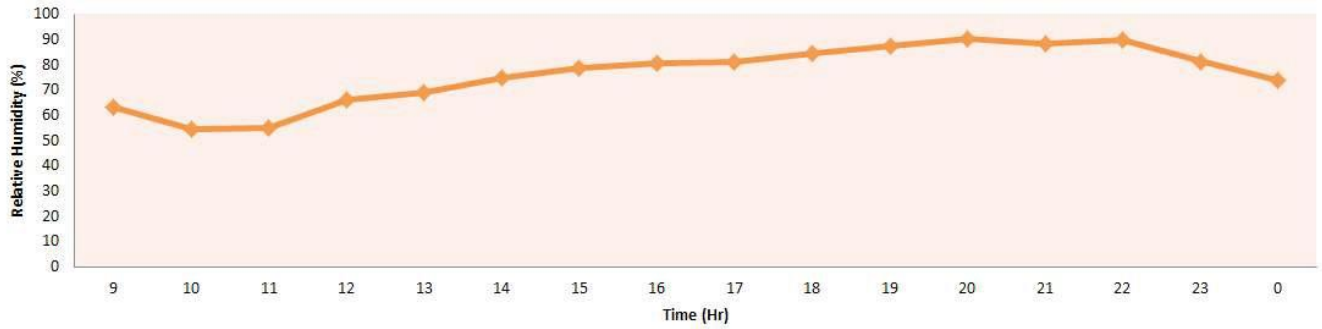


Fig. 96. Hourly average relative humidity on 4 August 2017.

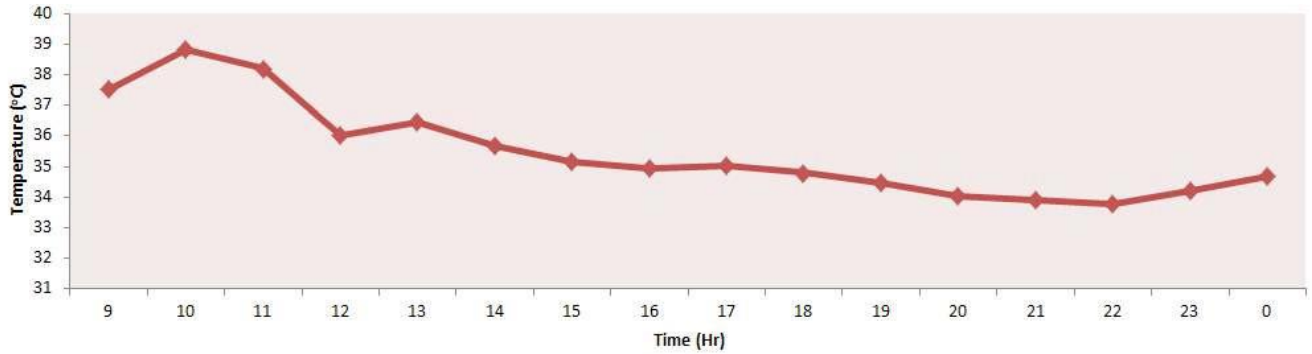


Fig. 97. Hourly average ambient temperature on 4 August 2017.

The following data contain the hourly average of the mercury concentrations along with the hourly average of the meteorological data for 5 August 2017.

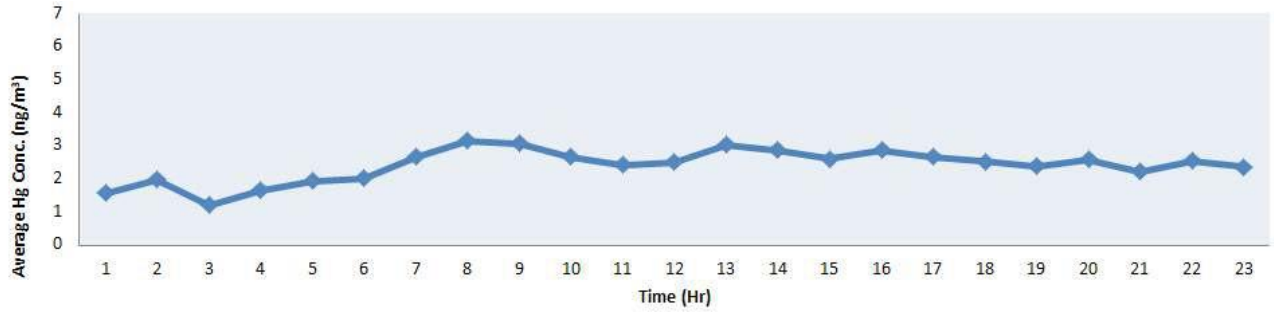


Fig. 98. Hourly average mercury concentrations on 5 August 2017.

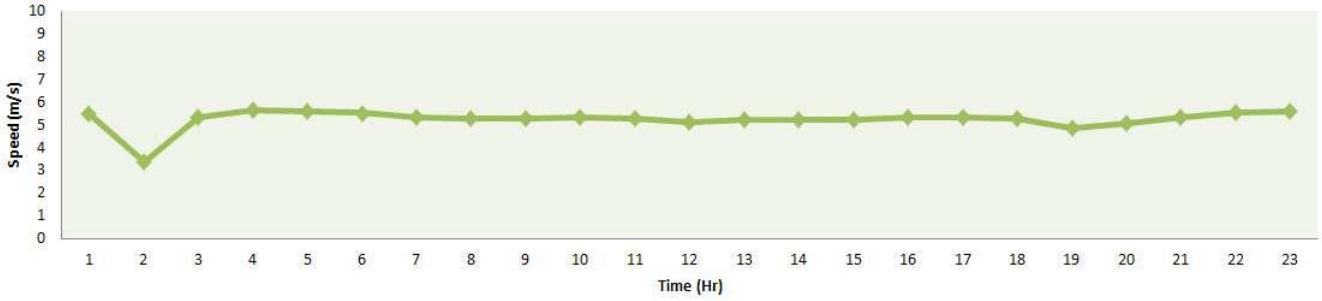


Fig. 99. Hourly average vessel speed on 5 August 2017.

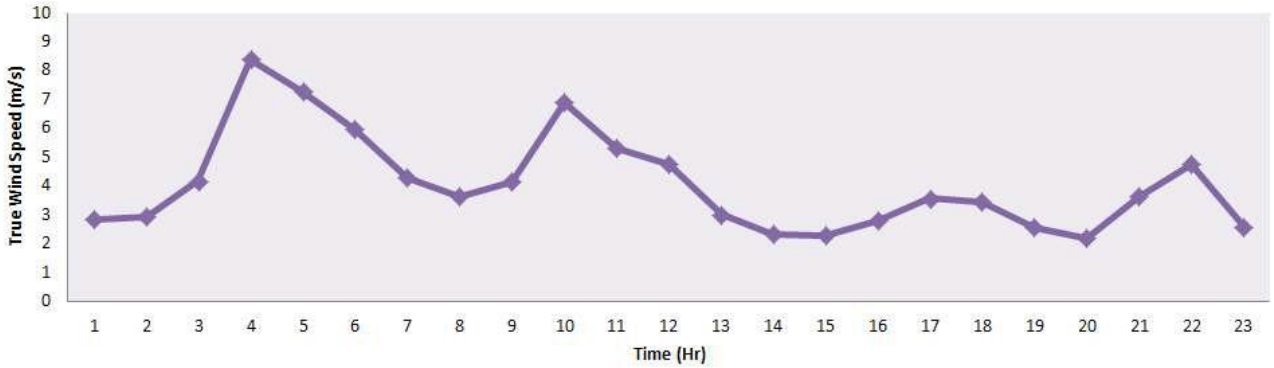


Fig. 100. Hourly average vessel speed on 5 August 2017.

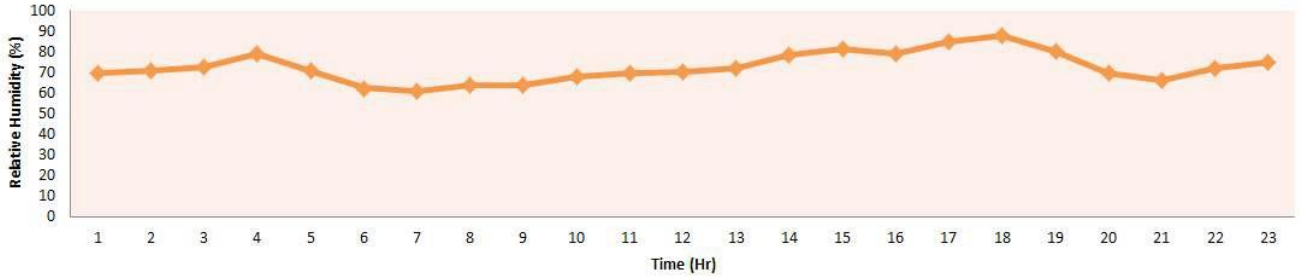


Fig. 101. Hourly average relative humidity on 5 August 2017.

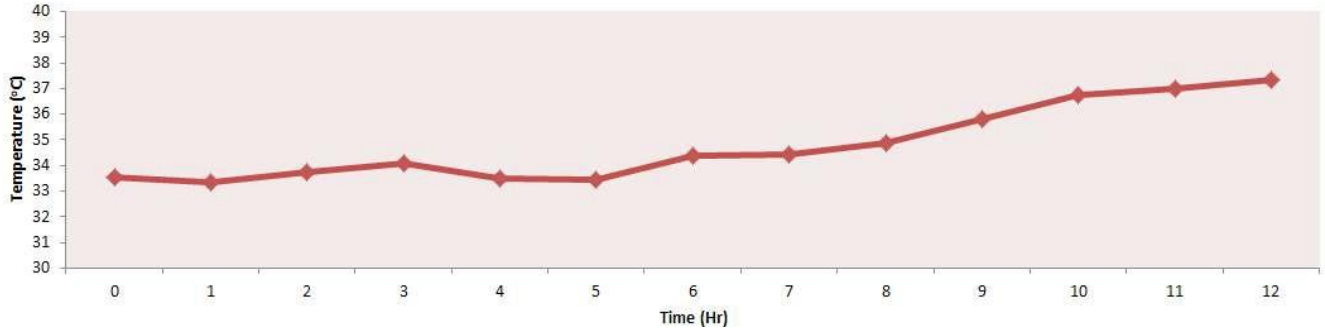


Fig. 102. Hourly average ambient temperature on 5 August 2017.

The following data contain the hourly average of the mercury concentrations along with the hourly average of the meteorological data for the last day of measuring (6 August 2017).

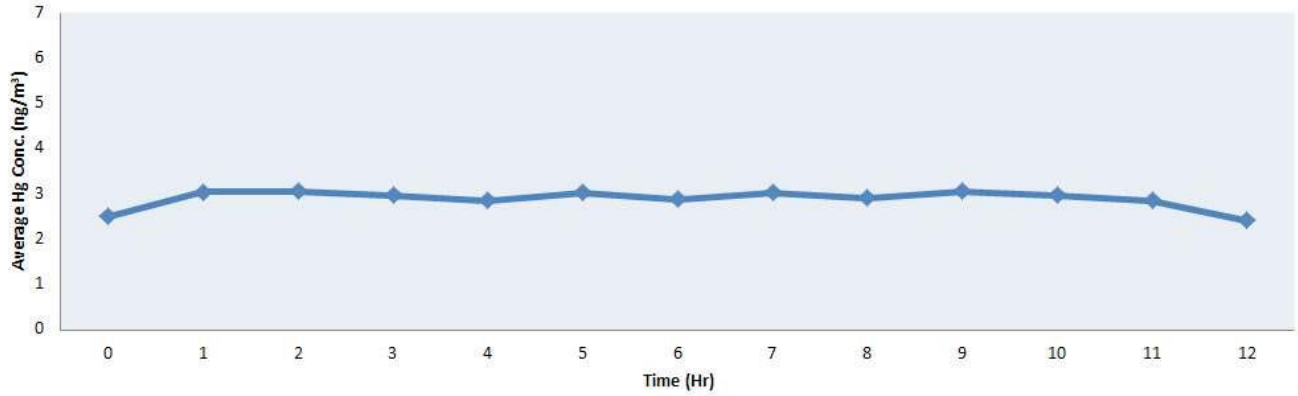


Fig. 103. Hourly average mercury concentration on 6 August 2017.

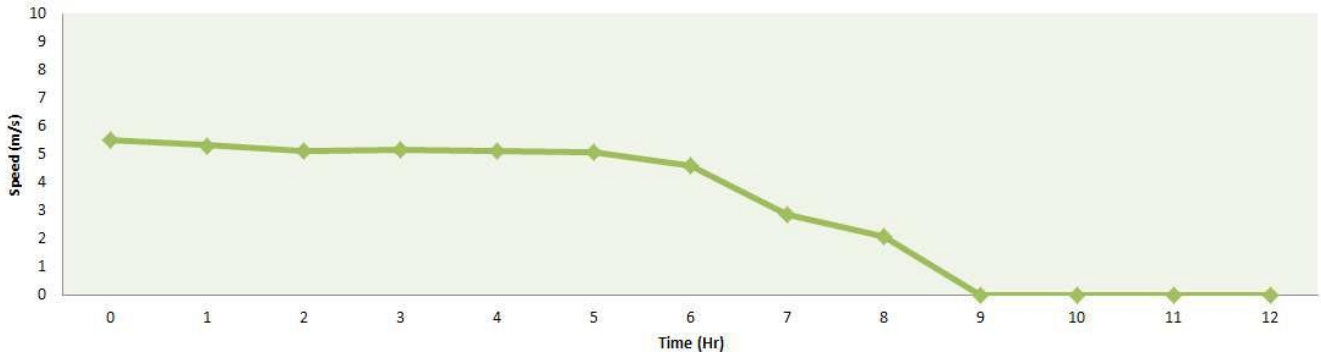


Fig. 104. Hourly average vessel speed on 6 August 2017.

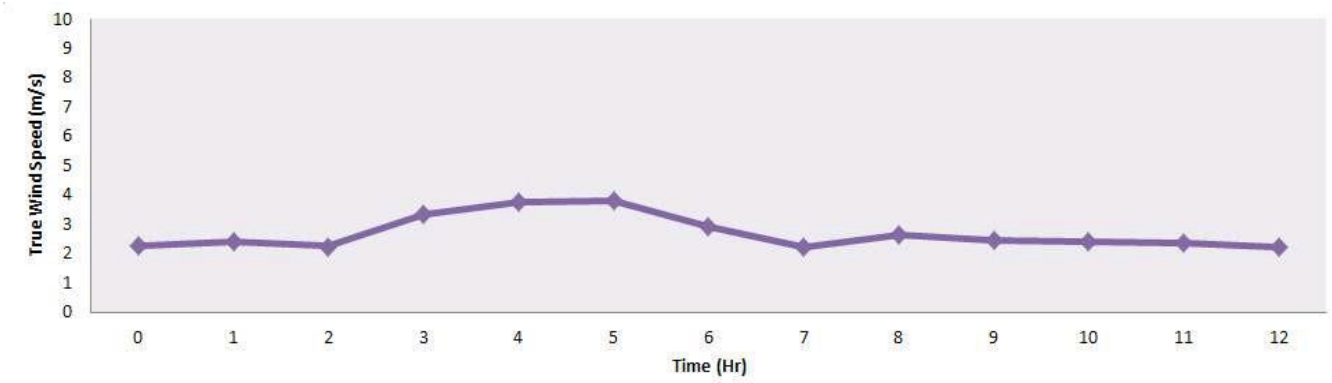


Fig. 105. Hourly average wind speed on 6 August 2017.

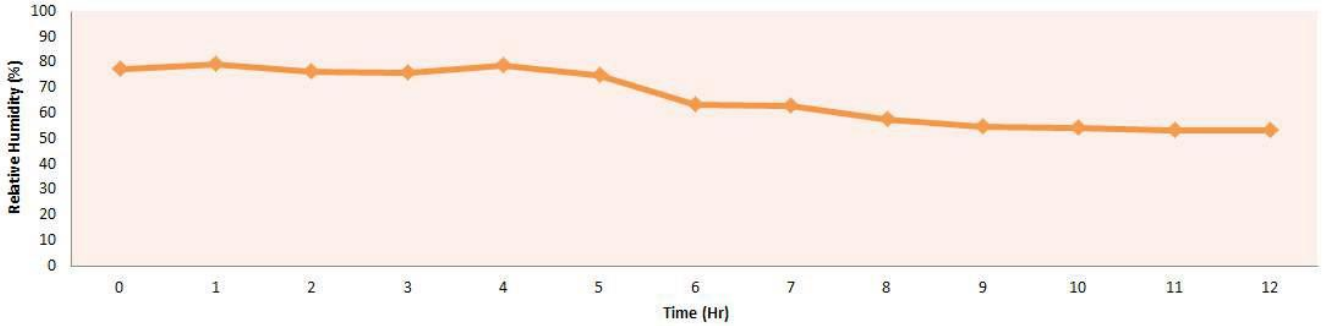


Fig. 106. Hourly average relative humidity on 6 August 2017.

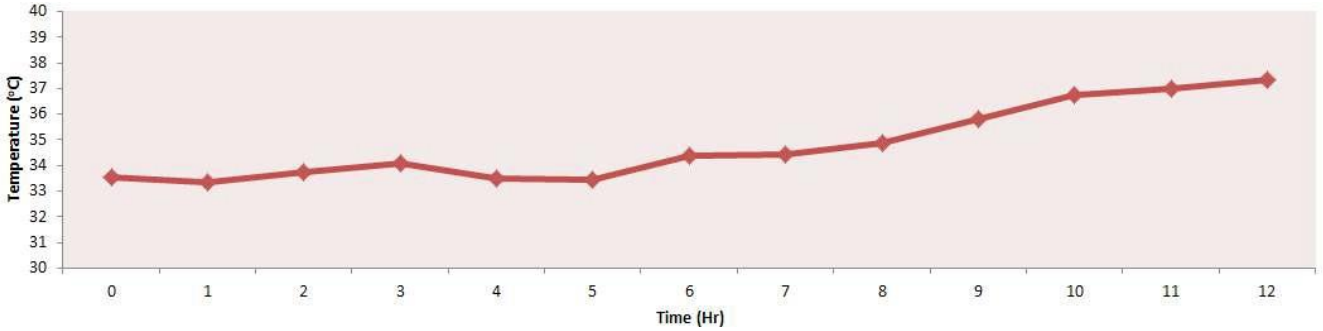


Fig. 107. Hourly average ambient temperature on 6 August 2017.

There were no violations of international and local standards. The average reading was found to be between 2 and 3 ng/m^3. Some areas showed Hg levels at around 6.3 ng/m^3 detecting the presence of a source; while some areas had near zero concentration values. A handful of negative values were recorded as a result of having mercury concentrations below the detection limit. The negative values were filtered out and

replaced with zeroes. Higher than average mercury concentrations occurred, when the vessel passed near an oil rig and near a ship. This indicated that crude oil from the oil rigs and burning diesel fuel for the ships might be a source of mercury emission. The data also indicated that the air in the Gulf is much cleaner in terms of mercury concentrations than the air on land, suggesting anthropogenic activities. Mashyanof et al. (2019) reported the mercury concentration in air over Baikal, which was about an average value of 1.09 ng m^{-3} and was less than 1.6 ng m^{-3}, obtained at onshore Listvyanka GMOS station during the same days of cruise due to Baikal being a significant sink of atmospheric mercury.

Plate 87 shows the route taken with color intensity correlating to mercury concentrations. Each point represents the average mercury concentration reading for one hour. A trend can be noticed, i.e., the mercury readings were higher near land.

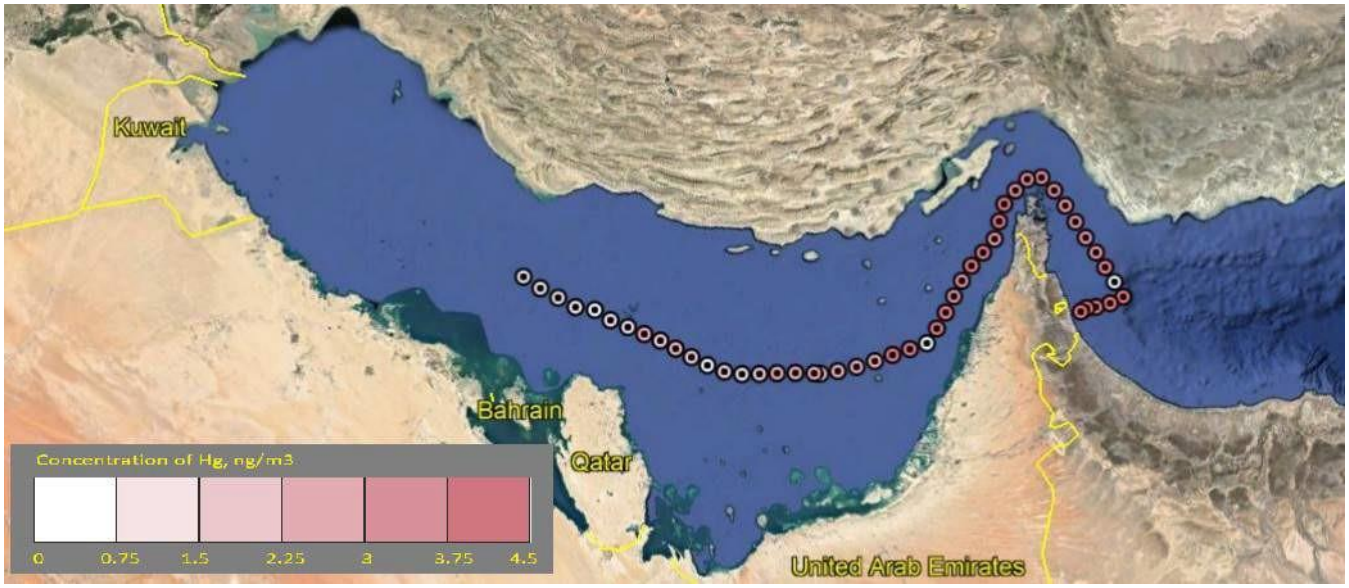


Plate 87. Plotted track with correlating mercury readings.

Conclusion of the Mission. In conclusion, the Zeeman RA 915+ mercury monitoring instrument was installed in the AQABA ship and was used to measure mercury concentrations across the Gulf. The concentrations were found to be very low across the ship's path to Fujairah, UAE, of the Gulf, with high levels occurring near oil rigs or nearby passing ships.

Table 74 shows the hourly average meteorological data and hourly average mercury concentrations in ambient air from 4 to 6 August 2017.

Table 74. Hourly Meteorological Data and Hourly Mercury Concentrations in Ambient Air from 4 to 6 August 2017

Hourly Vessel Speed (m/s)	Hourly Air Temp. (ºC)	Hourly Relative Humidity (%)	Hourly Wind Speed (m/s)	Hourly Wind Direction	Hour (hh:mm)	Date (dd mm yyyy)	Hg Hourly Min (ng/m^3)	Hg Hourly Max (ng/m^3)	Hg Hourly Mean (ng/m^3)	Hg Hourly Median (ng/m^3)
5.96	37.54	63.53	6.89	301.00	9.00	04 08 2017	0.00	2.08	0.69	0.60
5.90	38.82	54.83	6.94	300.50	10.00	04 08 2017	0.01	2.08	0.67	0.64
5.85	38.21	55.08	6.89	310.00	11.00	04 08 2017	0.01	2.88	0.67	0.21
5.68	36.03	66.03	6.80	309.30	12.00	04 08 2017	0.00	2.05	0.65	0.61
5.55	36.46	69.16	5.19	324.80	13.00	04 08 2017	0.00	1.95	0.51	0.40
5.42	35.68	74.85	4.14	315.00	14.00	04 08 2017	0.17	1.79	0.71	0.74
5.20	35.16	78.74	4.69	302.40	15.00	04 08 2017	0.00	2.22	0.64	0.44
5.05	34.94	80.85	5.32	282.10	16.00	04 08 2017	0.06	4.92	1.61	1.28
5.03	35.02	81.34	5.83	286.50	17.00	04 08 2017	0.01	3.48	1.45	1.25
5.21	34.79	84.60	5.96	294.90	18.00	04 08 2017	0.18	3.57	1.76	1.86
5.20	34.45	87.67	4.81	335.60	19.00	04 08 2017	0.02	4.63	1.55	1.28
5.29	34.04	90.47	4.92	336.60	20.00	04 08 2017	0.03	4.89	1.32	1.22
5.22	33.92	88.50	4.20	341.40	21.00	04 08 2017	0.02	3.04	1.50	1.44
5.11	33.77	89.74	3.78	323.80	22.00	04 08 2017	0.00	3.15	0.98	0.82
5.24	34.22	81.40	3.73	293.70	23.00	04 08 2017	0.01	3.76	1.29	1.22
5.42	34.68	74.10	2.93	276.90	0.00	04 08 2017	0.20	3.92	1.77	1.70

Table 74. (Cont'd.)

Hourly Vessel Speed (m/s)	Hourly Air Temp. (ºC)	Hourly Relative Humidity (%)	Hourly Wind Speed (m/s)	Hourly Wind Direction	Hour (hh:mm)	Date (dd mm yyyy)	Hg Hourly Min (ng/m^3)	Hg Hourly Max (ng/m^3)	Hg Hourly Mean (ng/m^3)	Hg Hourly Median (ng/m^3)
5.50	34.84	69.59	2.82	279.40	1.00	05 08 2017	0.14	3.98	1.58	1.40
3.40	34.74	70.96	2.91	238.30	2.00	05 08 2017	0.16	4.17	1.98	1.87
5.34	34.88	72.47	4.16	225.80	3.00	05 08 2017	0.03	3.67	1.19	0.93
5.69	34.43	79.26	8.39	203.90	4.00	05 08 2017	0.02	3.35	1.66	1.64
5.60	34.78	71.10	7.25	232.60	5.00	05 08 2017	0.08	4.04	1.93	2.00
5.53	35.73	62.35	5.96	248.40	6.00	05 08 2017	0.33	3.49	2.01	2.02
5.35	36.26	61.12	4.29	256.70	7.00	05 08 2017	1.29	3.82	2.66	2.71
5.31	35.78	63.80	3.64	281.90	8.00	05 08 2017	1.56	6.00	3.15	3.01
5.31	35.19	63.84	4.14	278.10	9.00	05 08 2017	1.85	4.50	3.07	3.05
5.37	35.18	67.86	6.87	254.60	10.00	05 08 2017	0.48	5.22	2.67	2.61
5.30	35.08	69.86	5.31	278.60	11.00	05 08 2017	0.94	4.68	2.41	2.30
5.12	35.01	70.36	4.75	355.70	12.00	05 08 2017	0.12	5.39	2.49	2.46
5.26	34.85	71.89	3.00	356.10	13.00	05 08 2017	1.30	4.69	3.01	2.98
5.25	33.92	78.51	2.31	354.70	14.00	05 08 2017	1.19	4.68	2.87	2.94
5.24	33.47	81.27	2.26	307.70	15.00	05 08 2017	0.58	4.90	2.60	2.63
5.35	33.63	79.21	2.78	263.40	16.00	05 08 2017	1.53	4.53	2.88	2.85
5.34	33.32	84.84	3.55	238.20	17.00	05 08 2017	1.35	3.92	2.65	2.64
5.30	32.93	87.74	3.45	212.90	18.00	05 08 2017	1.03	3.82	2.52	2.52
4.86	32.72	80.06	2.55	171.80	19.00	05 08 2017	1.16	3.73	2.39	2.39
5.08	34.06	69.67	2.19	138.50	20.00	05 08 2017	1.17	4.11	2.58	2.62
5.35	34.34	65.97	3.61	298.10	21.00	05 08 2017	1.17	3.61	2.22	2.17
5.55	34.02	71.89	4.73	314.70	22.00	05 08 2017	1.18	4.09	2.54	2.54
5.60	33.80	75.08	2.58	306.20	23.00	05 08 2017	0.05	3.77	2.36	2.32

Table 74. (Cont'd.)

Hourly Vessel Speed (m/s)	Hourly Air Temp. (°C)	Hourly Relative Humidity (%)	Hourly Wind Speed (m/s)	Hourly Wind Direction	Hour (hh:mm)	Date (dd mm yyyy)	Hg Hourly Min (ng/m^3)	Hg Hourly Max (ng/m^3)	Hg Hourly Mean (ng/m^3)	Hg Hourly Median
5.52	33.54	77.31	2.28	309.50	0.00	06 08 2017	1.48	4.05	2.49	2.44
5.33	33.33	79.49	2.43	350.00	1.00	06 08 2017	1.38	4.77	3.04	3.07
5.14	33.77	76.42	2.25	7.70	2.00	06 08 2017	0.45	5.34	3.05	3.09
5.16	34.11	75.85	3.36	114.10	3.00	06 08 2017	1.87	3.89	2.98	3.01
5.15	33.49	78.95	3.78	131.40	4.00	06 08 2017	1.74	3.87	2.84	2.83
5.10	33.47	75.08	3.81	130.00	5.00	06 08 2017	1.83	4.03	3.02	3.06
4.61	34.41	63.42	2.92	141.50	6.00	06 08 2017	1.19	3.86	2.88	2.93
2.87	34.42	62.98	2.24	173.20	7.00	06 08 2017	1.36	4.49	3.03	3.10
2.09	34.87	57.81	2.66	137.30	8.00	06 08 2017	1.40	4.16	2.90	2.89
0.00	35.82	54.86	2.48	155.80	9.00	06 08 2017	1.70	4.51	3.07	3.07
0.00	36.77	54.46	2.40	142.00	10.00	06 08 2017	1.39	4.39	2.97	2.99
0.00	36.99	53.56	2.39	153.50	11.00	06 08 2017	0.12	6.34	2.85	2.70
0.00	37.32	53.18	2.23	156.80	12.00	06 08 2017	0.78	3.99	2.41	2.42

The data acquired during the ship's expedition were statistically analyzed and hourly data were used for data visualization for meaningful and proper interpretation.

Data Visualization. This task was aimed to design a data visualization of the hourly averaged ambient concentration of mercury along with all meteorological parameters, ambient temperature, humidity, and wind speed, in order to have an obvious dependency of mercury levels on these four parameters, along with their spatial (location in the Arabian/Persian Gulf) and their temporal (4 – 6 August 2017) attributes, all in a visual display. This pictorial plot helped in understanding patterns and interpretations between these parameters.

Data Acquisition. The main focus of these data visualization was the hourly averaged ambient mercury concentrations, ambient temperatures, humidity, and wind speed values.

Data Analysis. Prior to analysis, the data acquired from the survey vessel were at a frequency of a hertz. Main statistical analysis was conducted to obtain the hourly mean, median, minimum, and maximum of the ambient recorded data consisting of mercury concentrations, as well as the average temperature, humidity, and wind speed values. The data were analyzed and then plotted as figures using Microsoft Office 2007 (Excel).

Plotting Coordinates on the Map. The data also came with a longitude and latitude and was plotted on the map using Google Earth.

The layout of the data visualization was chosen to be circular; to allow the layout to expand as more "Circular belts" of data were added. The circular layout with 5 "belts" depicted the date of the measurement, hour, location, and four parameters (mercury concentration, temperature, humidity, wind speed). Each parameter was then associated with a unique hue (color) and the saturation of the hue was changed according to the value of the parameter (e. g., high saturation of green is associated with high concentration of mercury, and low saturation of green is associated with low concentration of mercury).

After the first sketch of the visualization was drawn as Fig. 108, it was presented to the team members and project leader to obtain comments and feedback. The data visualization was designed using Adobe Creative Suit: Photoshop CS6.

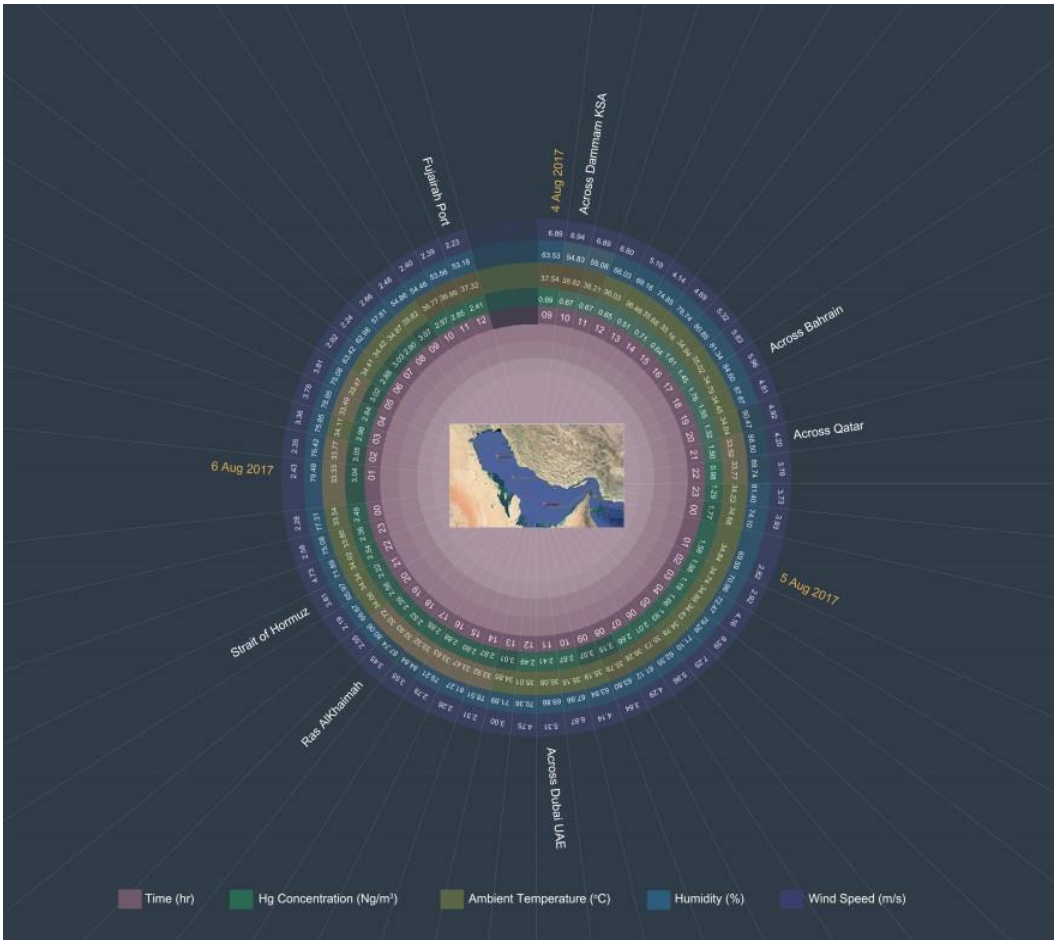


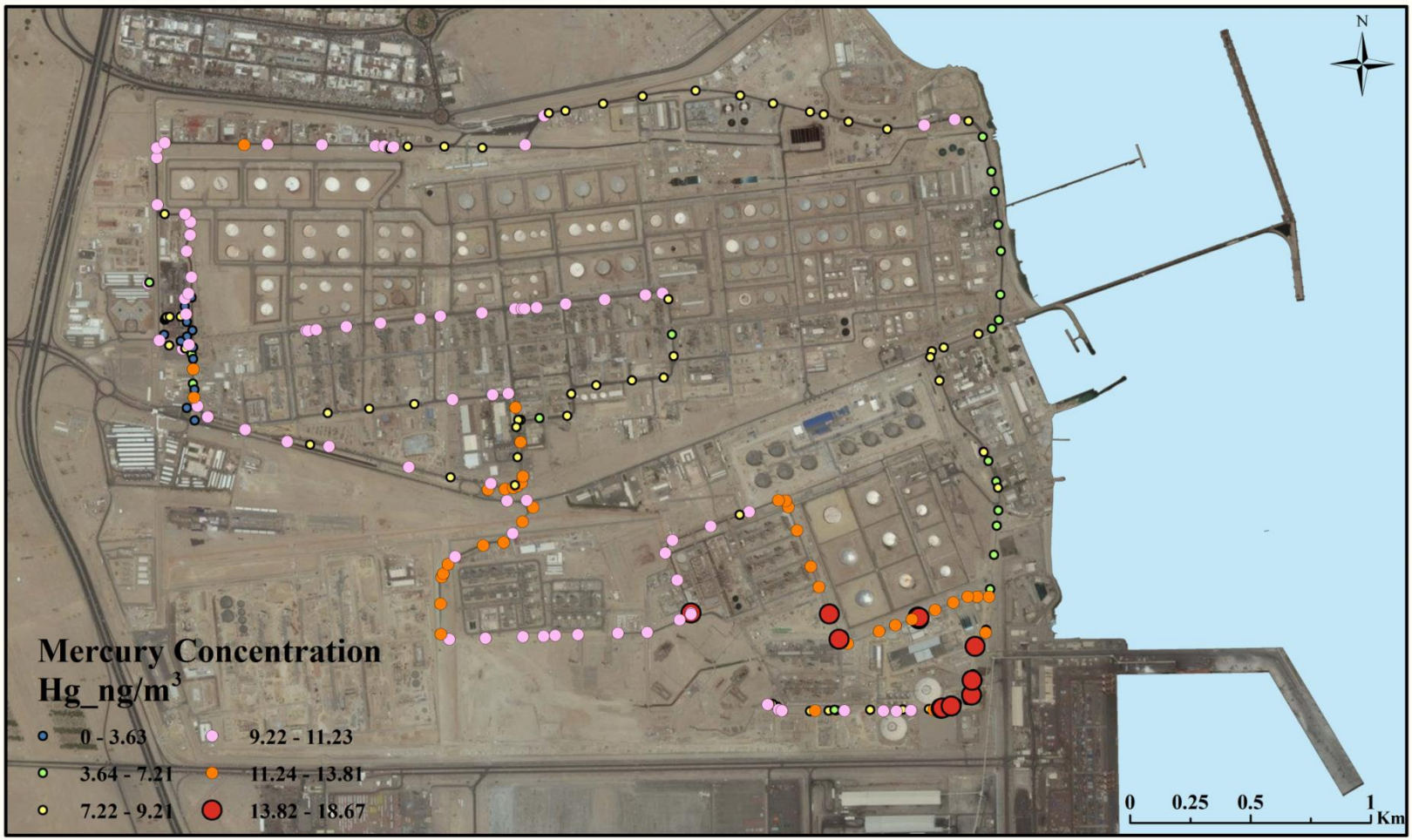
Fig. 108. Visualization of mercury with meteorological parameters.

Measurement of Elemental Mercury (Hg^0) in Air in Petroleum and Petrochemical Industries (KNPC)

Direct reading mercury analyzer (i.e., Zeeman RA-915+ mercury portable atomic absorption spectrometer) was used to measure the mercury levels instantaneously at KNPC's industrial area (Plate 78). The RA-915+ analyzer (base unit) is intended for measuring mercury vapor concentration in ambient air. The analyzer can be used for the onstream measuring of the total mercury concentration in the air, both in a stationary mode and in continuous mode from vehicles (car, helicopter, boat, etc).

Mercury was emitted from fossil fuels (crude oil and gas) and has been reported in the literature (Doll et al. [2012]; Lang et al. [2012]; Hoffman and Paulsen [2009]; Hollebone and Yaung [2007]). Zeeman RA 915+ instrument was used to monitor mercury levels in the petroleum refining industries in KNPC premises on 28 August 2017 and 5 October 2017. In the southeastern corner of KNPC petroleum refineries, elevated levels of mercury were recorded on 28 August. Zeeman RA 915+ was used to continuously monitor mercury levels in the ambient air on the way back to KISR and inside KISR. Very low mercury levels were noticed. The lowest levels of mercury were noticed at the eastern shore of petroleum industries. On 5 October, the second visit was arranged, and elevated levels were measured on the northern side of KNPC petroleum refineries, and all other places showed low concentrations during this visit. Mercury was not detected all over KISR and neighboring medical facilities. Figures 109 and 110 display the local ambient mercury levels at the KNPC premises on different dates; while Tables 75 and 76 show the local ambient mercury values logged at every 10 s.

Passive samplers were installed at ten locations in KNPC refineries for mercury monitoring. The exposure time was kept for about one month in the summer season and also surface dust was collected from the passive samplers' sites to be analyzed to know the mercury deposition rate.



KNPC: Kuwait National Petroleum Company

Fig. 109. Local mercury levels in air at the KNPC premises on 28 August 2017.

Table 75. Local Mercury Levels in Air at KNPC Premises on 28 August 2017 Logged at every 10 s

GPS Coordinates		Hg	Time
Latitude (N)	Longitude (E)	(ng/m^3)	(hh:mm:ss)
29.06154198	48.11510498	10.402818	8:31:49
29.06155799	48.11521302	7.806251	8:31:59
29.06134802	48.11549004	5.977799	8:32:09
29.06024203	48.11553698	4.549829	8:32:19
29.05933502	48.11528301	2.476269	8:32:29
29.05886102	48.115612	2.338268	8:32:39
29.05937299	48.11573203	3.340922	8:32:50
29.06002502	48.11560798	3.50257	8:33:00
29.06002502	48.11560798	3.582166	8:33:10
29.06116697	48.11555601	3.628752	8:33:20
29.06159696	48.11555098	2.592171	8:33:30
29.06223801	48.11552198	2.502389	8:33:40
29.06347199	48.11549398	1.525594	8:33:50
29.06361599	48.11530799	0.783774	8:34:00
29.06313797	48.11520103	0	8:34:10
29.06255501	48.11528603	0	8:34:20
29.06200499	48.11529298	0	8:34:30
29.06183903	48.11501898	0	8:34:41
29.06207599	48.11431197	0.233208	8:34:51
29.06207599	48.11431197	0.283454	8:35:01
29.06263498	48.11434901	0.505989	8:35:11
29.062696	48.11437097	0.748192	8:35:21
29.062696	48.11437097	2.41301	8:35:31
29.062696	48.11437097	4.533414	8:35:41
29.062726	48.11442303	5.78325	8:35:51
29.062726	48.11442303	6.295267	8:36:01
29.062726	48.11442303	6.522273	8:36:11
29.06272701	48.11442504	6.879751	8:36:21
29.06272701	48.11442504	7.031253	8:36:32
29.06272701	48.11442504	7.41594	8:36:42
29.06272701	48.11442504	7.444982	8:36:52
29.06272701	48.11442504	8.039369	8:37:02
29.06272802	48.11442303	8.751578	8:37:12
29.06272802	48.11442303	8.514578	8:37:22
29.06272802	48.11442303	8.976894	8:37:32
29.06273296	48.11442898	8.20995	8:37:42
29.06273296	48.11442898	8.688398	8:37:52

KNPC: Kuwait National Petroleum Company

Table 75. (Cont'd.)

GPS Coordinates		Hg (ng/m^3)	Time (hh:mm:ss)
Latitude (N)	**Longitude (E)**		
29.06274696	48.11455596	8.506553	8:38:02
29.06275299	48.11501697	8.725416	8:38:12
29.06284997	48.115252	9.754106	8:38:22
29.06343101	48.11519098	9.6953	8:38:32
29.06361801	48.11534696	9.520945	8:38:42
29.064235	48.11548099	9.601148	8:38:53
29.06520302	48.11527404	10.236662	8:39:03
29.06580602	48.11542399	10.927909	8:39:13
29.06629301	48.11544201	10.677349	8:39:23
29.06660104	48.11521403	9.659561	8:39:33
29.06659601	48.11434197	9.121076	8:39:43
29.06694302	48.11402103	10.670586	8:39:53
29.06694302	48.11402103	10.956441	8:40:03
29.06870699	48.11400896	11.152107	8:40:13
29.06907102	48.11401097	11.220569	8:40:23
29.06926297	48.11434499	10.20863	8:40:33
29.06918099	48.11773698	12.314144	8:41:54
29.06920203	48.11873501	10.870395	8:42:04
29.06920203	48.11873501	10.697675	8:42:14
29.06917898	48.12104699	10.772925	8:42:24
29.06914604	48.12333701	10.523844	8:42:34
29.06913497	48.12371504	10.128478	8:42:44
29.06903498	48.12396498	10.245603	8:42:54
29.06903498	48.12396498	10.0115	8:43:05
29.06903598	48.12397102	10.138276	8:43:15
29.06903598	48.12397102	9.854113	8:43:25
29.06903104	48.123968	9.818007	8:43:35
29.06903104	48.123968	9.824241	8:43:45
29.06903104	48.123968	9.847737	8:43:55
29.06903104	48.123968	9.488371	8:44:05
29.06903196	48.12396398	9.189539	8:44:15
29.06910597	48.12410496	9.974572	8:44:25
29.06911603	48.12471299	9.104105	8:44:35
29.06911201	48.12628199	9.089557	8:44:46
29.06906096	48.127893	8.30589	8:44:56

GPS: Global Positioning System

Table 75. (Cont'd.)

GPS Coordinates		Hg (ng/m^3)	Time (hh:mm:ss)
Latitude (N)	**Longitude (E)**		
29.06906096	48.127893	9.012295	8:45:06
29.06917202	48.12972	9.843841	8:45:16
29.07025798	48.13054101	9.703345	8:45:26
29.070361	48.13073404	8.997206	8:45:36
29.07044297	48.13144097	8.233828	8:45:46
29.07070801	48.13305499	8.71166	8:45:56
29.07098402	48.13473296	8.681977	8:46:06
29.07098402	48.13473296	8.707326	8:46:16
29.07118997	48.13699801	7.941499	8:46:26
29.07100799	48.13889399	7.292061	8:46:37
29.07071304	48.140305	7.006896	8:46:47
29.07071304	48.140305	7.577404	8:46:57
29.07039402	48.14187996	7.960296	8:47:07
29.07030098	48.142462	7.421769	8:47:17
29.07002002	48.14351602	7.935099	8:47:27
29.06974099	48.14516801	8.351305	8:47:37
29.06988901	48.14674096	9.418376	8:47:47
29.07010401	48.14804996	9.407942	8:47:57
29.07004299	48.148632	7.708608	8:48:07
29.06944896	48.14924397	6.680174	8:48:17
29.06944896	48.14924397	6.209557	8:48:27
29.06815404	48.14961604	5.915943	8:48:37
29.06741099	48.14975501	6.30694	8:48:48
29.06615898	48.14990404	5.770022	8:48:58
29.06517	48.15000999	5.847059	8:49:08
29.06517	48.15000999	6.625879	8:49:18
29.06353997	48.14998099	6.626716	8:49:28
29.06258997	48.14991804	6.494676	8:49:38
29.06227003	48.149623	5.713804	8:49:48
29.06207004	48.149048	7.416554	8:49:58
29.06156796	48.14756599	7.874258	8:50:08
29.06142304	48.14705797	7.982287	8:50:18
29.06120402	48.146992	7.842648	8:50:28
29.06031998	48.14738603	7.827751	8:50:39
29.05766401	48.14926199	9.891396	8:51:59

GPS: Global Positioning System

Table 75. (Cont'd.)

GPS Coordinates		Hg (ng/m^3)	Time (hh:mm:ss)
Latitude (N)	**Longitude (E)**		
29.05766401	48.14926199	8.492801	8:52:09
29.05766501	48.14926299	7.978063	8:52:19
29.05766501	48.14926299	8.088787	8:52:29
29.05765001	48.14927297	7.535043	8:52:40
29.05731699	48.14946399	7.18126	8:52:50
29.05655298	48.14980103	7.066379	8:53:00
29.05631301	48.149883	7.491242	8:53:10
29.05545697	48.14988401	6.619717	8:53:20
29.05488297	48.14981997	5.977511	8:53:30
29.05379903	48.14970204	5.777599	8:53:40
29.05250704	48.14953599	5.974993	8:53:50
29.05250704	48.14953599	6.093766	8:54:00
29.05099302	48.14935997	5.769202	8:54:10
29.05043503	48.14909502	5.938936	8:54:20
29.05019497	48.14892101	6.844446	8:54:30
29.049336	48.14880601	7.027274	8:54:41
29.049336	48.14880601	7.21448	8:54:51
29.04888798	48.14870099	6.680998	8:55:01
29.04846403	48.14866796	6.763497	8:55:11
29.04835599	48.14856998	7.516234	8:55:21
29.048244	48.14810403	7.993241	8:55:31
29.048244	48.14810403	7.688325	8:55:41
29.048027	48.14692402	7.739887	8:55:51
29.04801099	48.14580697	8.296465	8:56:01
29.04801099	48.14580697	8.155402	8:56:11
29.04799498	48.14440602	8.689074	8:56:21
29.04799498	48.14440602	8.269939	8:56:32
29.04798601	48.14295502	8.404451	8:56:42
29.047955	48.14184601	9.145048	8:56:52
29.047955	48.14184601	9.068747	8:57:02
29.04813001	48.14043199	9.1945	8:57:12
29.04822598	48.14024398	9.095305	8:57:22
29.04822598	48.14024398	8.981024	8:57:32
29.04822498	48.14011599	7.999347	8:57:42
29.04820897	48.140075	7.547983	8:57:52

GPS: Global Positioning System

Table 75. (Cont'd.)

GPS Coordinates		Hg (ng/m^3)	Time (hh:mm:ss)
Latitude (N)	**Longitude (E)**		
29.04820897	48.140075	7.470294	8:58:02
29.04820897	48.140046	9.275245	8:58:12
29.04800897	48.14051203	9.290592	8:58:22
29.04797402	48.14063801	11.168667	8:58:33
29.04797796	48.142059	11.510992	8:58:43
29.04796799	48.14264196	9.208075	8:58:53
29.04800101	48.14288897	6.850264	8:59:03
29.04797503	48.14331	9.698026	8:59:13
29.04796204	48.144979	10.820838	8:59:23
29.04794997	48.14553204	10.355079	8:59:33
29.04794997	48.14553204	10.734408	8:59:43
29.04798198	48.14615197	10.908871	8:59:53
29.04798198	48.14615197	10.220318	9:00:03
29.04799699	48.14711999	11.567558	9:00:13
29.04803798	48.147424	11.927794	9:00:23
29.04803798	48.147424	12.148379	9:00:33
29.04803798	48.147424	12.393477	9:00:44
29.04805399	48.14744102	13.986769	9:02:04
29.04805399	48.14744102	10.740583	9:02:14
29.04805399	48.14744102	11.574929	9:02:24
29.04805298	48.14745099	11.348086	9:02:34
29.04805298	48.14745099	17.118789	9:02:44
29.04805298	48.14745099	18.672967	9:02:59
29.04805298	48.14745099	16.996683	9:03:09
29.04806002	48.147481	17.802581	9:03:19
29.048143	48.14786799	18.302781	9:03:29
29.048546	48.14873502	16.786854	9:03:42
29.04909996	48.14876402	15.880014	9:03:52
29.04909996	48.14876402	16.626563	9:04:02
29.05037099	48.14888799	15.801905	9:04:12
29.05089201	48.14933298	13.706116	9:04:22
29.05089201	48.14933298	11.45606	9:04:32
29.05223496	48.14948302	11.536718	9:04:42
29.05223597	48.148977	12.814122	9:04:53

GPS: Global Positioning System

Table 75. (Cont'd.)

GPS Coordinates		Hg (ng/m^3)	Time (hh:mm:ss)
Latitude (N)	**Longitude (E)**		
29.05223203	48.14858397	13.805358	9:05:03
29.05201502	48.147955	13.667416	9:05:13
29.05173498	48.14718797	13.709182	9:05:23
29.05173498	48.14718797	13.708004	9:05:33
29.05147699	48.14645598	14.027895	9:05:43
29.051407	48.14649303	14.51179	9:05:53
29.051407	48.14649303	14.657494	9:06:03
29.051407	48.14649303	14.714079	9:06:13
29.051407	48.14649303	14.544855	9:06:23
29.051407	48.14649303	14.308101	9:06:33
29.051407	48.14649303	14.289639	9:06:43
29.05140901	48.14649101	15.676032	9:06:54
29.05145796	48.14650501	14.250736	9:07:04
29.05138697	48.146201	12.624532	9:07:14
29.05117004	48.14548703	12.252379	9:07:24
29.05117004	48.14548703	11.899339	9:07:34
29.05093996	48.14479896	12.062753	9:07:44
29.05093996	48.14479896	13.076864	9:07:54
29.05048599	48.14345601	13.153764	9:08:04
29.05064701	48.14309299	14.923798	9:08:14
29.05158796	48.14268001	14.82964	9:08:24
29.05158796	48.14268001	14.125977	9:08:35
29.05259999	48.142232	12.96752	9:08:45
29.05337096	48.14189103	12.889313	9:08:55
29.05472799	48.141297	12.562303	9:09:05
29.05558999	48.14093297	12.76445	9:09:16
29.05582904	48.140823	12.3612	9:09:26
29.05585703	48.14050399	11.970278	9:09:36
29.05585703	48.14050399	12.380251	9:09:46
29.05542101	48.139255	11.229264	9:09:56
29.05530701	48.138852	9.17902	9:10:06
29.05488599	48.13761801	9.766236	9:10:17
29.05488599	48.13761801	9.47083	9:10:27
29.05435399	48.13598103	9.8796	9:10:37
29.05387798	48.13568599	10.733897	9:10:47
29.05286998	48.136191	11.161295	9:10:57

GPS: Global Positioning System

Table 75. (Cont'd.)

GPS Coordinates		Hg (ng/m^3)	Time (hh:mm:ss)
Latitude (N)	**Longitude (E)**		
29.05163901	48.13677303	16.063737	9:12:18
29.05163901	48.13677303	14.465169	9:12:28
29.05163901	48.13677303	11.358669	9:12:38
29.05164002	48.13677203	10.495279	9:12:48
29.05158704	48.13677597	10.26211	9:12:58
29.051379	48.13628596	10.191262	9:13:08
29.051379	48.13628596	10.71152	9:13:18
29.05091599	48.13490697	9.909621	9:13:28
29.05091599	48.13490697	9.545366	9:13:38
29.05088103	48.13366	10.065453	9:13:49
29.05088103	48.13366	10.42095	9:13:59
29.05082697	48.13195403	9.509961	9:14:09
29.05080099	48.13098701	9.517606	9:14:19
29.05077601	48.130482	9.431349	9:14:29
29.05075204	48.12959997	10.05473	9:14:39
29.05075204	48.12959997	10.670461	9:14:49
29.05069697	48.12800297	10.31288	9:14:59
29.05069697	48.12800297	10.528156	9:15:09
29.05066201	48.12645701	10.40007	9:15:19
29.05085396	48.12610203	12.160642	9:15:29
29.05085396	48.12610203	12.935616	9:15:39
29.05199298	48.12609801	13.090918	9:15:49
29.05299101	48.12613699	12.813955	9:16:00
29.05311498	48.12620002	12.38433	9:16:10
29.05311498	48.12620002	11.925207	9:16:20
29.05311498	48.12620002	12.209925	9:16:30
29.05347297	48.126413	11.427628	9:16:40
29.053752	48.12671601	10.972466	9:16:50
29.05417202	48.12790699	12.383111	9:17:00
29.05428501	48.12878097	12.141897	9:17:10
29.05461903	48.129173	10.780113	9:17:20
29.05506402	48.129591	11.991231	9:17:30
29.05559502	48.13003801	12.558814	9:17:40
29.05586299	48.12976803	10.120845	9:17:50

GPS: Global Positioning System

Table 75. (Cont'd.)

GPS Coordinates		Hg (ng/m^3)	Time (hh:mm:ss)
Latitude (N)	**Longitude (E)**		
29.05584304	48.12893897	10.235277	9:18:00
29.05626297	48.12812299	11.567714	9:18:10
29.05628904	48.12883403	12.136966	9:18:21
29.05633598	48.12919303	12.420416	9:18:31
29.05640001	48.12938397	12.103063	9:18:41
29.05640001	48.12938397	11.977308	9:18:51
29.05651703	48.12954498	12.570695	9:19:01
29.05676002	48.12960701	12.255476	9:19:11
29.05676002	48.12960701	12.163536	9:19:21
29.058037	48.12950903	11.41196	9:19:31
29.05933896	48.12929504	11.863105	9:19:41
29.05986903	48.12899396	11.079331	9:19:51
29.05981396	48.128325	9.243506	9:20:01
29.05981396	48.128325	9.265827	9:20:11
29.05964197	48.12661098	9.471041	9:20:21
29.05946704	48.12498598	8.252972	9:20:31
29.05946704	48.12498598	8.301538	9:20:42
29.059302	48.12305898	7.955197	9:20:52
29.05914098	48.12128596	8.014369	9:21:02
29.06222401	48.12036898	9.927842	9:22:22
29.06222904	48.12050301	9.015414	9:22:32
29.06222904	48.12050301	9.708367	9:22:42
29.06221798	48.120458	9.963476	9:22:52
29.06221798	48.120458	9.434041	9:23:02
29.06226399	48.12080802	9.191113	9:23:12
29.06226399	48.12080802	10.322018	9:23:23
29.06237396	48.12208702	9.88589	9:23:33
29.06250103	48.12353801	9.812027	9:23:43
29.06266599	48.12522202	9.67699	9:23:53
29.06275702	48.126096	10.282548	9:24:03
29.06275702	48.126096	9.522242	9:24:13
29.062884	48.12786399	10.783667	9:24:23
29.06303404	48.12927903	10.693347	9:24:33
29.06303697	48.129577	10.656605	9:24:43
29.06303697	48.129577	11.016076	9:24:53

GPS: Global Positioning System

Table 75. (Cont'd.)

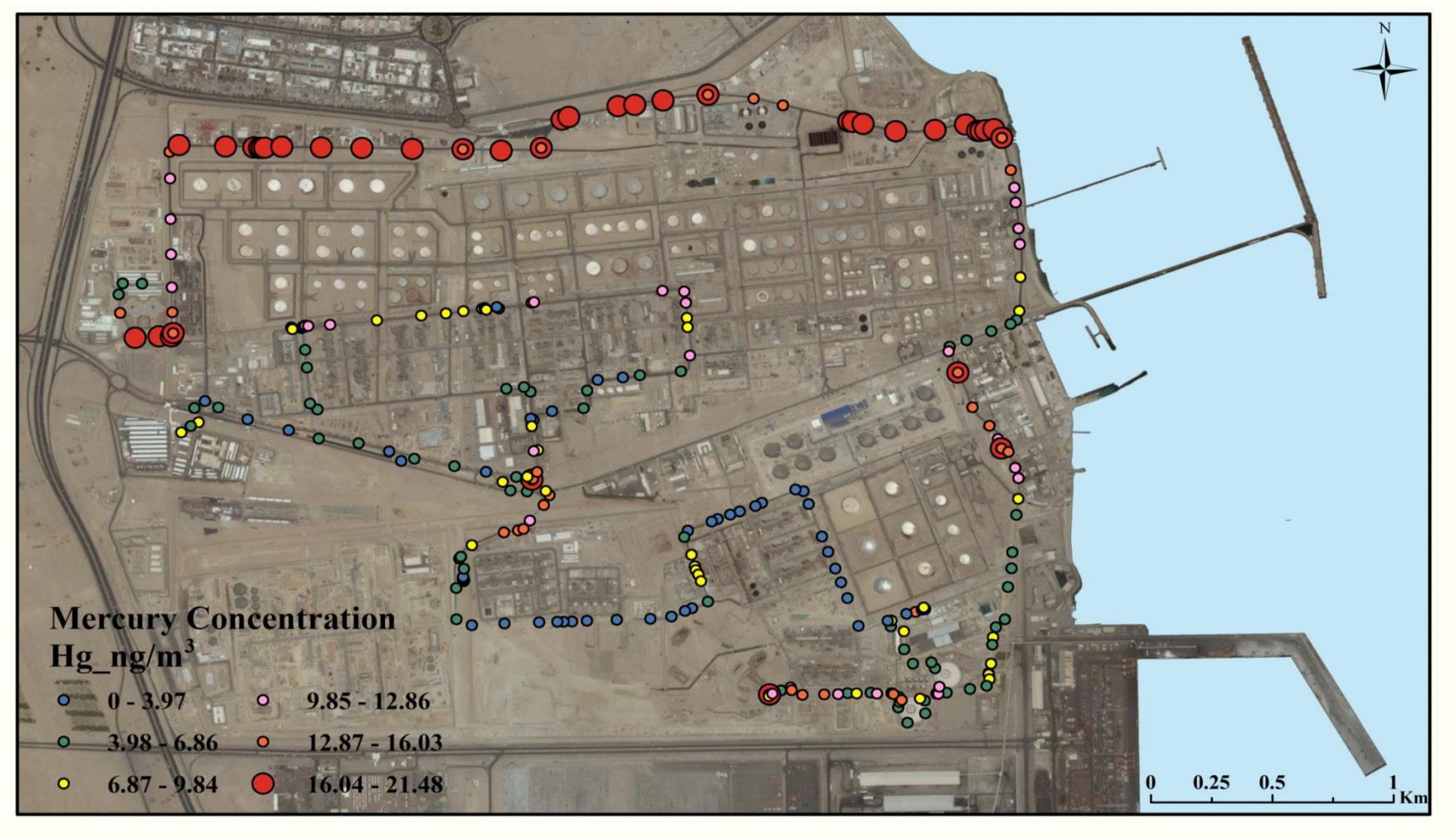
GPS Coordinates		Hg (ng/m^3)	Time (hh:mm:ss)
Latitude (N)	**Longitude (E)**		
29.06303697	48.129577	10.927457	9:25:03
29.06303496	48.12969502	11.04548	9:25:13
29.06308299	48.13020003	11.117929	9:25:23
29.06321903	48.13144499	9.974769	9:25:33
29.06337703	48.13311098	10.717435	9:25:44
29.06354198	48.13485098	10.501553	9:25:54
29.06361398	48.13557702	10.185846	9:26:04
29.06338298	48.13582898	8.239153	9:26:14
29.06205998	48.13596996	6.695676	9:26:24
29.06125599	48.13604599	7.360605	9:26:34
29.06045401	48.13562103	7.716687	9:26:44
29.06034504	48.13426802	7.858212	9:26:54
29.06034504	48.13426802	8.378766	9:27:04
29.06016701	48.132741	8.133542	9:27:14
29.05984003	48.13167499	8.277182	9:27:24
29.05902497	48.13150803	7.344229	9:27:35
29.05893403	48.13031604	7.072813	9:27:45
29.05887301	48.12951498	7.354711	9:27:55
29.05886899	48.129419	8.258597	9:28:05
29.05860001	48.12933401	7.561645	9:28:15
29.05748103	48.12938497	8.502641	9:28:26
29.05643103	48.129275	8.58784	9:28:36
29.05649196	48.12824403	9.244597	9:28:46
29.05673001	48.12652498	9.188061	9:28:56
29.05711298	48.12473897	9.660517	9:29:06
29.05711298	48.12473897	9.681166	9:29:16
29.05788696	48.12133701	9.808926	9:29:26
29.05795704	48.12053301	8.973492	9:29:36
29.05807002	48.11955702	9.268126	9:29:47
29.05852198	48.11776598	9.794286	9:29:57
29.05899497	48.11616504	10.779151	9:30:07
29.059404	48.11573496	11.137707	9:30:17
29.05972503	48.11558099	11.646562	9:30:27
29.06078601	48.11555601	11.843505	9:30:37
29.06169998	48.11536599	9.579092	9:30:47
29.061675	48.11452604	8.328961	9:30:57
29.06186099	48.114103	9.349104	9:31:07

GPS: Global Positioning System

Table 75. (Cont'd.)

GPS Coordinates		Hg (ng/m^3)	Time (hh:mm:ss)
Latitude (N)	**Longitude (E)**		
29.06400399	48.11363596	10.306963	9:32:27
29.06403299	48.11368701	5.864934	9:32:38
29.06403299	48.11368701	5.715603	9:32:48
29.06403299	48.11368701	5.384514	9:32:58
29.06403299	48.11368701	5.436671	9:33:08
29.06403098	48.113685	5.253653	9:33:18

GPS: Global Positioning System



KNPC: Kuwait National Petroleum Company

Fig. 110. Local mercury levels in air at the KNPC premises on 5 October 2017.

Table 76. Local Mercury Levels in Air at the KNPC Premises on 5 October 2017

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.06390802	48.11284203	10:46:59	14.361991
29.06390802	48.11284203	10:47:09	6.411145
29.06391598	48.11202304	10:47:19	4.909674
29.063487	48.11184601	10:47:30	6.638253
29.06277797	48.11190996	10:47:40	8.297351
29.06277797	48.11190996	10:47:50	14.845055
29.06181003	48.11253701	10:48:00	16.486073
29.06186904	48.11355298	10:48:10	19.018043
29.06186803	48.11408004	10:48:20	19.237689
29.06198597	48.11414902	10:48:30	16.391353
29.06198597	48.11414902	10:48:40	13.808786
29.06279901	48.11411801	10:48:50	13.165592
29.06279901	48.11411801	10:49:00	13.081037
29.063761	48.11409697	10:49:10	12.743915
29.063761	48.11409697	10:49:20	12.464734
29.06504603	48.11406604	10:49:30	12.262569
29.06504603	48.11406604	10:49:40	11.657397
29.06641102	48.114044	10:49:50	11.923779
29.06641102	48.114044	10:50:00	12.403583
29.06798297	48.11402597	10:50:10	12.453632
29.06901302	48.11400896	10:50:20	13.1782
29.06928501	48.11440802	10:50:30	17.527993
29.06928501	48.11440802	10:50:40	17.65447
29.06922298	48.116374	10:50:50	17.539564
29.06918501	48.11757403	10:51:00	17.762977
29.06916398	48.117813	10:51:10	17.045936
29.06916599	48.11792297	10:51:20	16.359484
29.06916599	48.11792297	10:51:30	16.313429
29.06917504	48.11802599	10:51:40	16.347807
29.069212	48.11875999	10:51:50	16.46133
29.069212	48.11875999	10:52:00	16.379891
29.069212	48.11875999	10:52:10	16.181206
29.069182	48.12043402	10:52:20	16.218013
29.06915903	48.12214301	10:52:30	16.39307
29.06915903	48.12214301	10:52:40	16.386538
29.06912198	48.12427696	10:52:50	16.432916
29.06912198	48.12427696	10:53:00	16.343483
29.06911	48.12641904	10:53:10	16.66459
29.06911	48.12641904	10:53:20	16.008243
29.06905401	48.12803599	10:53:30	16.351555
29.06915702	48.12973198	10:53:40	16.798138
29.06915702	48.12973198	10:53:50	15.106461

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.07025203	48.13061301	10:54:00	16.465052
29.07035798	48.13089497	10:54:10	17.101428
29.07035798	48.13089497	10:54:20	17.25558
29.07077196	48.13298701	10:54:31	17.866656
29.07082301	48.13369302	10:54:41	17.258166
29.07099701	48.13488401	10:54:51	17.40883
29.07099701	48.13488401	10:55:01	17.589115
29.07120799	48.136795	10:55:11	17.154419
29.07120799	48.136795	10:55:21	16.02817
29.07105502	48.13872099	10:55:31	15.524489
29.07079803	48.13996696	10:55:41	15.36234
29.07016997	48.14275101	10:57:01	19.477836
29.07016997	48.14275201	10:57:11	16.886685
29.07015396	48.14291798	10:57:21	17.278863
29.070074	48.14335601	10:57:31	17.367543
29.06979304	48.144734	10:57:41	17.770447
29.06979304	48.144734	10:57:51	18.235641
29.06983503	48.14639797	10:58:01	18.995348
29.07004701	48.14768703	10:58:11	18.760314
29.06979497	48.14819799	10:58:21	17.145199
29.06979497	48.14834501	10:58:31	17.638844
29.06979497	48.14834501	10:58:41	17.758961
29.06979497	48.14834501	10:58:51	17.753468
29.06979497	48.14834501	10:59:01	18.015781
29.06979497	48.14834501	10:59:11	16.226393
29.06979497	48.14834501	10:59:21	16.687542
29.06979597	48.148344	10:59:31	17.096563
29.06979597	48.148344	10:59:41	18.937726
29.06979597	48.148344	10:59:51	18.739054
29.06979597	48.148344	11:00:01	18.92943
29.06979497	48.14834199	11:00:11	18.750303
29.06979497	48.14834199	11:00:21	18.717002
29.06979497	48.14834199	11:00:31	19.895243
29.06979597	48.148344	11:00:41	20.076686
29.06979597	48.148344	11:00:51	19.770272
29.06979597	48.148344	11:01:01	18.901854
29.06979597	48.148344	11:01:11	18.669833
29.06979597	48.148344	11:01:21	18.332187
29.06979698	48.14833998	11:01:31	18.307497
29.06979698	48.14833998	11:01:41	18.001583
29.06982204	48.14853603	11:01:51	18.255146

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.06986596	48.14889	11:02:02	18.249584
29.06952498	48.14922502	11:02:12	16.903562
29.06952498	48.14922502	11:02:22	15.015477
29.06828002	48.14959902	11:02:32	14.215365
29.06759597	48.14974898	11:02:42	12.660041
29.06701603	48.14980396	11:02:52	12.277555
29.06601196	48.14992801	11:03:02	10.866302
29.065401	48.14997797	11:03:12	9.988519
29.06411899	48.14999901	11:03:22	8.821228
29.06411899	48.14999901	11:03:32	8.142994
29.06281603	48.14995098	11:03:42	7.616608
29.06245803	48.14984403	11:03:52	6.493136
29.06230297	48.14957899	11:04:02	5.501319
29.06203601	48.14876502	11:04:12	6.045598
29.06168103	48.14772801	11:04:22	6.576419
29.06142798	48.14700298	11:04:32	6.67877
29.06125196	48.14696099	11:04:42	10.778114
29.06042903	48.147351	11:04:52	16.080551
29.06042903	48.147351	11:05:02	15.64526
29.05907803	48.14796698	11:05:12	14.422427
29.05836599	48.14868699	11:05:22	14.688067
29.05785101	48.14904498	11:05:32	12.404101
29.05769099	48.149091	11:05:42	12.150415
29.05748497	48.14918504	11:07:03	16.880596
29.05748497	48.14918303	11:07:13	14.069452
29.05748497	48.14918303	11:07:23	14.365003
29.05748497	48.14918303	11:07:33	14.379289
29.05748497	48.14918303	11:07:43	14.159744
29.05748497	48.14918303	11:07:53	14.321107
29.05748396	48.14918999	11:08:03	13.907551
29.05748396	48.14918999	11:08:13	11.718912
29.05748396	48.14918999	11:08:23	11.628518
29.05748396	48.14918999	11:08:33	12.756821
29.05748203	48.14918999	11:08:43	13.027978
29.05734901	48.14948302	11:08:53	13.882005
29.05673102	48.149767	11:09:03	12.186975
29.05633103	48.14991402	11:09:13	12.743007
29.05553198	48.14990203	11:09:23	7.462531
29.05490996	48.14981704	11:09:33	6.511383
29.05490996	48.14981704	11:09:43	5.955768
29.05345797	48.14964898	11:09:53	5.434622

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.05283804	48.14960699	11:10:03	6.34095
29.052112	48.14945502	11:10:13	6.303957
29.050861	48.14933097	11:10:23	6.860438
29.05055498	48.14894901	11:10:33	4.985469
29.05016396	48.14882898	11:10:43	7.10879
29.04987596	48.14879201	11:10:53	6.161316
29.04914497	48.14874197	11:11:03	7.036586
29.04876502	48.14863896	11:11:13	6.0197
29.04876502	48.14863896	11:11:23	8.75439
29.04872797	48.14864399	11:11:33	9.801111
29.04872797	48.14864399	11:11:43	9.278428
29.04872797	48.14864399	11:11:53	8.51621
29.04872797	48.14864399	11:12:03	8.229597
29.04872797	48.14864399	11:12:13	7.910044
29.04872797	48.14864399	11:12:23	8.460874
29.04872697	48.14863896	11:12:33	8.704358
29.04872697	48.14863896	11:12:43	8.762868
29.04872697	48.14863896	11:12:53	8.790776
29.04872303	48.14863401	11:13:03	8.195991
29.04872303	48.14863401	11:13:13	9.082385
29.04853997	48.14867601	11:13:23	7.346431
29.048286	48.14855103	11:13:33	5.373735
29.04816102	48.14784704	11:13:43	5.072908
29.048013	48.14685697	11:13:53	4.568256
29.04797704	48.14642798	11:14:03	4.629696
29.04771301	48.14593202	11:14:13	4.926103
29.04721403	48.14595801	11:14:23	6.540997
29.04685001	48.14520397	11:14:34	4.140024
29.04744797	48.14481698	11:14:44	4.278075
29.047653	48.14487297	11:14:54	8.666279
29.04784402	48.14484699	11:15:04	5.817932
29.04800202	48.144533	11:15:14	5.337573
29.04801602	48.14365399	11:15:24	5.153122
29.04800403	48.14267297	11:15:34	5.165021
29.04800403	48.14267297	11:15:44	5.394666
29.04815197	48.14025496	11:17:04	13.944944
29.04814803	48.140262	11:17:14	11.764007
29.04814803	48.140262	11:17:24	11.837909
29.04814803	48.140262	11:17:34	11.49598
29.04814803	48.140262	11:17:44	11.474713
29.04814803	48.140262	11:17:54	11.458653

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.04814803	48.140262	11:18:04	11.709436
29.04814904	48.14026502	11:18:14	11.626038
29.04814904	48.14026502	11:18:24	11.696553
29.04814904	48.14026502	11:18:34	11.503387
29.04814803	48.14026996	11:18:44	11.899559
29.04822003	48.14025898	11:18:54	10.003475
29.04810796	48.13984601	11:19:04	6.36835
29.04797	48.13940998	11:19:14	4.92648
29.04795097	48.13936698	11:19:24	4.608093
29.04795097	48.13936698	11:19:34	4.680733
29.04795097	48.13936698	11:19:44	3.501192
29.04795097	48.13936698	11:19:54	3.370751
29.04795097	48.13936698	11:20:04	4.569489
29.04795097	48.13937101	11:20:14	15.435693
29.04795097	48.13937101	11:20:24	19.351192
29.04795097	48.13937101	11:20:34	20.751802
29.04795298	48.13937302	11:20:44	21.100005
29.04795298	48.13937302	11:20:54	21.482449
29.04795298	48.13937302	11:21:04	19.51361
29.04795298	48.13937302	11:21:14	10.138831
29.04796002	48.13937704	11:21:24	7.947632
29.04795198	48.13934603	11:21:34	6.752703
29.04789104	48.13934896	11:21:44	8.814715
29.04798701	48.13949296	11:21:54	11.76813
29.04812003	48.140305	11:22:04	15.638294
29.04793496	48.14075402	11:22:14	13.306377
29.04795097	48.14168299	11:22:25	13.262108
29.04795097	48.14168299	11:22:35	13.348632
29.04796103	48.14227399	11:22:45	12.514042
29.04798903	48.14305401	11:22:55	8.350003
29.04798098	48.14390603	11:23:05	12.619908
29.04796103	48.14460601	11:23:15	13.556039
29.04773103	48.14495704	11:23:25	12.937776
29.04779096	48.14573304	11:23:35	8.760823
29.04796497	48.14651197	11:23:45	11.238759
29.04824601	48.14655597	11:23:55	9.948492
29.04895898	48.14637098	11:24:05	4.922294
29.04919501	48.14621097	11:24:15	6.08898
29.04914397	48.14543196	11:24:25	4.08328
29.04969499	48.14506399	11:24:35	5.221342
29.05039103	48.14505	11:24:45	7.444518
29.050588	48.14449696	11:24:55	5.399602

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.05081498	48.144518	11:25:05	8.304313
29.05115001	48.14554101	11:25:15	13.922741
29.051235	48.14581996	11:25:25	13.28564
29.05124699	48.14586103	11:25:35	13.819863
29.05124699	48.14586103	11:25:45	14.248816
29.051249	48.14585902	11:27:05	15.086474
29.05125696	48.14594401	11:27:15	11.643294
29.05132502	48.14589003	11:27:25	8.414633
29.051077	48.14515997	11:27:36	3.556347
29.051077	48.14515997	11:27:46	2.436783
29.050804	48.14436796	11:27:56	2.083807
29.05060703	48.14313699	11:28:06	2.360988
29.05060703	48.14313699	11:28:16	3.3971
29.05168503	48.14266199	11:28:28	3.46831
29.05230202	48.14239101	11:28:38	3.73138
29.052831	48.14215698	11:28:48	3.361358
29.05348303	48.14185599	11:28:58	3.176178
29.05348303	48.14185599	11:29:08	2.694104
29.05407404	48.14159104	11:29:18	2.481382
29.055334	48.14103196	11:29:28	2.486892
29.05583801	48.14081001	11:29:38	2.285863
29.05590397	48.14047499	11:29:48	2.420189
29.05538597	48.139053	11:29:58	1.919141
29.05526301	48.13878201	11:30:08	1.494958
29.05505204	48.13811196	11:30:18	0.544676
29.05492899	48.137716	11:30:28	0.514853
29.05465901	48.13693296	11:30:48	0.079492
29.05430697	48.13592403	11:30:58	0.427706
29.05406599	48.13577198	11:31:08	4.9955
29.05337004	48.13606703	11:31:18	8.317711
29.05292303	48.13621698	11:31:28	7.842496
29.05278398	48.13625897	11:31:38	8.428006
29.05278398	48.13625897	11:31:48	7.987363
29.05278398	48.13625897	11:31:58	7.481106
29.05278398	48.13625897	11:32:08	7.801427
29.05261198	48.13636098	11:32:18	7.777517
29.05235499	48.13647204	11:32:28	8.164092

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.05156299	48.13676398	11:32:38	7.945618
29.05156299	48.13676398	11:32:48	4.207008
29.051306	48.13608597	11:32:58	2.915649
29.05119603	48.13579696	11:33:08	3.015953
29.05098304	48.13522599	11:33:18	3.365392
29.05089302	48.13432502	11:33:28	2.99129
29.05089302	48.13432502	11:33:38	3.084414
29.05085396	48.13290797	11:33:48	2.842493
29.050818	48.13164599	11:33:58	2.564936
29.05079604	48.13102003	11:34:08	2.700313
29.05078196	48.130655	11:34:18	2.796267
29.05078104	48.13039097	11:34:28	2.512504
29.05076201	48.12962	11:34:38	2.722913
29.05072102	48.12816096	11:34:48	3.029029
29.05072102	48.12816096	11:34:58	3.500625
29.05065296	48.12677904	11:35:08	3.643698
29.05088598	48.12613003	11:35:18	4.475599
29.05088598	48.12613003	11:35:28	6.554672
29.052097	48.12611796	11:35:38	5.947913
29.05323903	48.12624704	11:35:48	9.152002
29.05239397	48.12644703	11:37:08	12.978144
29.05239799	48.12644896	11:37:18	10.425443
29.05239799	48.12644896	11:37:28	10.33883
29.05239799	48.12644896	11:37:39	10.188022
29.05239799	48.12644896	11:37:49	10.232161
29.05240604	48.12644804	11:37:59	9.949083
29.05240604	48.12644804	11:38:09	9.706498
29.05236597	48.12642901	11:38:19	8.50269
29.05237896	48.12643304	11:38:29	3.956727
29.05243102	48.12640102	11:38:39	3.461633
29.05243102	48.12640102	11:38:49	3.796515
29.05249497	48.12639599	11:38:59	3.553935
29.05249497	48.12639599	11:39:09	3.512226
29.05249497	48.12639599	11:39:19	3.483324
29.05249598	48.12639699	11:39:29	3.550817
29.05249598	48.12639699	11:39:39	3.566426
29.05249598	48.12639699	11:39:49	3.207994
29.05252498	48.12640596	11:39:59	3.671251
29.05283603	48.12644703	11:40:09	4.811915
29.05330801	48.12631301	11:40:19	5.162532

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.053752	48.12678298	11:40:29	9.703776
29.05425098	48.128138	11:40:39	14.654608
29.05432801	48.12873504	11:40:49	15.434871
29.054385	48.12896102	11:40:59	15.889181
29.05470997	48.12923896	11:41:09	12.165074
29.05530601	48.12982896	11:41:19	13.887608
29.05530601	48.12982896	11:41:29	14.707066
29.05568998	48.13006902	11:41:39	13.88715
29.05585201	48.12991697	11:41:49	9.174752
29.05583298	48.12912396	11:41:59	6.308833
29.05587899	48.12841401	11:42:09	5.753776
29.05620698	48.12808502	11:42:19	7.863621
29.05627999	48.12906504	11:42:29	13.114715
29.05624897	48.12910904	11:42:39	13.555638
29.05628703	48.12932697	11:42:49	13.950493
29.05628703	48.12932697	11:42:59	14.764292
29.05628703	48.12932697	11:43:09	14.54826
29.05628703	48.12932697	11:43:19	14.889075
29.05628703	48.12932697	11:43:29	14.793422
29.05628703	48.12932697	11:43:39	14.559049
29.05629097	48.12932303	11:43:49	15.13471
29.05629097	48.12932303	11:43:59	15.857823
29.05629097	48.12932303	11:44:09	16.351071
29.05629097	48.12932303	11:44:19	15.801219
29.05629197	48.12932203	11:44:29	14.599697
29.05629197	48.12932203	11:44:39	13.936967
29.056326	48.12937198	11:44:49	15.901913
29.05658701	48.12954901	11:44:59	14.530501
29.05744096	48.12957499	11:45:10	9.283545
29.05861703	48.12939	11:45:20	6.083796
29.05970299	48.12926796	11:45:30	6.288754
29.05988001	48.12899203	11:45:40	4.993481
29.05981597	48.12824696	11:45:50	5.05126
29.05902799	48.12025599	11:47:10	6.015695
29.05925296	48.11993597	11:47:20	3.466628
29.05925296	48.11993597	11:47:30	5.277652
29.06064503	48.11980697	11:47:40	5.413299
29.06133704	48.11973698	11:47:50	4.728941
29.062178	48.11958997	11:48:00	3.782298
29.06220398	48.11915402	11:48:10	4.28188

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.06214103	48.11919602	11:48:20	7.309271
29.062237	48.11963699	11:48:30	10.569034
29.06227497	48.11973204	11:48:40	10.359801
29.06227497	48.11973204	11:48:50	10.296726
29.06227497	48.11973204	11:49:00	12.173432
29.06227497	48.11973204	11:49:10	11.18415
29.06227497	48.11973204	11:49:20	12.175648
29.06227598	48.119739	11:49:30	12.382839
29.06227598	48.119739	11:49:40	12.664457
29.06227598	48.119739	11:49:50	12.918924
29.06227204	48.11974	11:50:00	13.394482
29.06227204	48.11974	11:50:10	12.57118
29.06227204	48.11974	11:50:20	12.5343
29.06227204	48.11974	11:50:30	11.16711
29.06226098	48.11986598	11:50:40	11.023453
29.06230699	48.12079201	11:50:50	10.034846
29.06230699	48.12079201	11:51:00	9.967593
29.06247597	48.12276503	11:51:10	9.83872
29.06247597	48.12276503	11:51:20	9.675726
29.06266096	48.12465599	11:51:30	9.229552
29.06274403	48.125694	11:51:40	9.5095
29.06282499	48.12642801	11:51:50	9.328056
29.062926	48.12722504	11:52:00	8.294942
29.06295299	48.12733401	11:52:10	8.383922
29.06295299	48.12733401	11:52:20	9.12945
29.06295299	48.12733401	11:52:31	8.84492
29.06292801	48.12793801	11:52:41	6.249246
29.06298903	48.127851	11:52:51	1.732283
29.06294301	48.12734499	11:53:01	0.273177
29.062883	48.12740601	11:53:41	3.435119
29.062883	48.12740601	11:53:51	8.146056
29.06314602	48.12932898	11:54:02	10.761158
29.06317502	48.129418	11:54:12	11.041393
29.06317502	48.129418	11:54:22	10.438682
29.06317502	48.129418	11:54:32	10.509245

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.06317502	48.129418	11:54:42	10.706743
29.06317502	48.129418	11:54:52	10.495948
29.06317502	48.129418	11:55:02	10.68305
29.06317502	48.129419	11:55:12	11.020143
29.06317502	48.129419	11:55:22	10.744695
29.06317502	48.129419	11:55:32	10.844829
29.06317603	48.12942202	11:55:42	11.082148
29.06317603	48.12942202	11:55:52	12.113765
29.06361097	48.13485199	11:57:12	12.815695
29.06357802	48.13578196	11:57:22	10.720871
29.06314602	48.13584398	11:57:32	10.407221
29.06314602	48.13584398	11:57:42	10.010338
29.06255702	48.13588799	11:57:52	8.245573
29.06219501	48.13592202	11:58:02	9.391591
29.061101	48.136019	11:58:12	10.259061
29.06049298	48.13563603	11:58:22	8.592804
29.06049298	48.13563603	11:58:32	4.845989
29.06049298	48.13563603	11:58:42	4.404882
29.06033699	48.13389997	11:58:52	4.160338
29.06024999	48.13317703	11:59:02	3.776637
29.06015402	48.13210901	11:59:12	3.96573
29.05975202	48.13166401	11:59:22	4.517486
29.05906504	48.13152001	11:59:32	7.498896
29.05906504	48.13152001	11:59:42	4.28762
29.058943	48.13017304	11:59:52	2.517309
29.05865701	48.12927903	12:00:02	3.197626
29.05836297	48.129318	12:00:12	8.393853
29.05739998	48.12940903	12:00:23	10.28308
29.05640697	48.12913301	12:00:33	7.779646
29.05639599	48.12866899	12:00:43	4.773931
29.05660302	48.12738497	12:00:53	4.038229
29.05660302	48.12738497	12:01:03	3.932257
29.05682196	48.12604998	12:01:13	4.081041
29.05710602	48.12434804	12:01:23	4.246918
29.05702103	48.12379701	12:01:33	3.83047
29.05740199	48.12328898	12:01:43	3.650817
29.05771597	48.121997	12:01:53	4.342987
29.05789702	48.12031098	12:02:03	5.116676
29.05789702	48.12031098	12:02:13	4.175905

GPS: Global Positioning System

Table 76. (Cont'd.)

GPS Coordinates		Time	Hg Concentrations (ng/m^3)
Latitude (N)	Longitude (E)		
29.05821797	48.11903601	12:02:23	3.71968
29.05864603	48.11730397	12:02:33	3.737442
29.059101	48.11605901	12:02:43	4.200662
29.05935497	48.11549499	12:02:53	3.859624
29.05908298	48.11504597	12:03:03	6.662782
29.05853597	48.11522802	12:03:13	8.866522
29.05838904	48.11489602	12:03:23	6.205352
29.05814496	48.11449	12:03:33	7.092979

GPS: Global Positioning System

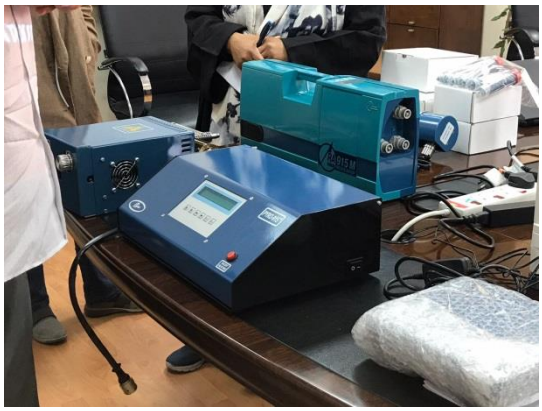
Conclusion

Real-time monitoring at OSC and KISR sites revealed the presence of an upwind distant mercury emission source, namely, Al-Doha Power Desalination Plant, which uses crude oil during the peak load, i.e., July-August 2016, and the consequence of the Oil Sector Workers Union's industrial action in Apirl 2016, which compelled power stations to be operated on crude oil emitting high concentrations of the pollutants associated with crude oil. Mercury measurements over the Arabian Gulf were very low, at less than 10 ng/m^3. There was a slight increase near the offshore oil rigs and near the passing ships confirming the source of mercury combustion of fuel. Ambient mercury levels in oil industries were measured in two expeditions conducted on 28 August 2017 and 5 October 2017. The results showed elevated levels of mercury in the southeastern corner of petroleum refineries on 28 August, which were in the range of 13.82–18.67 ng m^{-3}, compared to other locations. On 5 October 2017, elevated levels were measured on the northern side of petroleum refineries ranging between 16.04 and 21.48 ng m^{-3}, confirming a local source (combustion of fuel in open pit fire). Mercury emissions were substantial from coal power stations and in the ash fallout, and elevated gaseous mercury levels were detected in the downwind direction of coal powered power plants in Russia and Poland (Zasina and Zawadzki, 2017; Sloss, 2012).

Limitations

Another mercury analyzer (latest model) was supposed to be purchased for K-EPA according to the agreement and contract between the two organizations (KISR and K-EPA), along with the provision of conducting planned operational training for their staff for continuous monitoring and using pyrolitic accessory for the determination of mercury levels in dust samples. The budget for the purchase of Zeeman was not allocated due to administrative complications in KISR. Now, the budget has been arranged and the requisition has been obtained to purchase this analyzer. There were unforeseen complications, mainly from the Kuwait Audit Bureau, obstructing the purchase several times claiming that it was an open violation of the regulations governing the purchase of such an equipment. In spite of the unexpected delays related to the approval of the budget, the purchase process was started and the analyzer arrived KISR, unfortunately, very late, which could not be used for this project. Kuwait EPA's staff were trained to use it for the analysis of mercury in air, water, and soil. Two letters were issued (Appendix O), one was for nominating the employees for the training and the other was for the determined date of the training, which was held in KISR.

The training course was conducted for five working days for Kuwait EPA's staff to enable them handle this analyzer on their own and to measure the mercury content in the air, soil, sludge, suspended dust, water, etc. The certificate of training was issued to the trained staff. Plates 88 – 89 show EPA staff being trained on the measurements of Hg. Samples of dust from residential homes, sediments, and food samples were measured during this training sessions.










EPA: Environment Public Authority

Plate 88. Kuwait EPA's staff along with KISR's staff being trained on using the Zeeman RA915+ analyzer in a laboratory in KISR.








EPA: Environment Public Authority

Plate 89. Field measurements being taken by Kuwait EPA's staff.

Section 11 - Mercury Regulation for the Protection of Human Health

Kuwait EPA has indoor air mercury guidelines for daily and annual exposure, of 0.002 and 0.001 mg m^{-3} or (2 and 1 μg m^{-3}), respectively. WHO (2007) estimated 1 μg m^{-3} in air (annual average) as a guideline and 1 mg m^{-3} in water for total mercury as guideline, and a tolerable concentration of 0.2 μg m^{-3} for long-term inhalation exposure to elemental mercury vapour, and a tolerable intake of total mercury of 2 ng g^{-1} of body weight per day. Mercury intake in the food has been regulated by Joint FAO/WHO Expert Committee of Food Additives (JECFA) to a tolerable intake of 1.6 ng g^{-1} bodyweight per week for methylmercury, to protect the developing fetus from neurotoxic effects. Later, JECFA clarified that life-stages other than the embryo and fetus were not that sensitive to the adverse effects of methylmercury. Therefore, adult population could not show any adverse effect or risk of neurotoxicity for 3.2 ng g^{-1} bodyweight per week consumption of seafood containing that much methylmercury. The available data had not confirmed these results for children (up to about 17 y), as they were more sensitive than adults.

Soil guideline values for mercury in soil reported that elemental mercury being volatile could be absorbed through inhalation, whereas absorption due to oral ingestion was extremely limited (Hannah et al., 2009). The repeated inhalation exposure to elemental mercury influenced the central nervous system (CNS). Long-term occupational exposure to mercury concentrations of 20 μg m^{-3} showed mild effects on the CNS and thus provided basis for the tolerable concentration in air of 0.2 μg m^{-3}, which is recommended for the derivation of the inhalation of tolerable daily intake (TDI). Although the paucity of oral and dermal toxicity data precludes the derivation of an oral TDI for elemental mercury, a high degree of toxicity is unlikely.

Shodor Education Foundation, 1994, reported threshold concentrations of the chemical mercury for air, water, soil and food in Massachusetts, which are tabulated in Table 77.

Table 77. Recommended Limit for Metallic Mercury Concentrations in Various Environmental Media

Massachusetts Ambient Air Levels: micrograms/cubic meter	
Allowable ambient limit (annual avg.)	0.07 µg/cu.m
Threshold effects' exposure limit (24-hour avg.)	0.14 µg/cu.m
USEPA reference concentration for ambient air	0.3 µg/cu.m
US NIOSH air threshold limit value (Occupational limit for long-term exposure)	50 µg/cu.m
ATSDR (draft) Air Concentration Limit	
Chronic duration exposure	0.014 µg/cu.m
Acute duration exposure	0.02 µg/cu.m
Massachusetts residential soil standard (assuming ingestion by a pre-school child playing at home)	10 mg/kg or µg/g total Hg
Massachusetts Type I sludge standard	10 mg/kg or µg/g total Hg
USEPA sludge standard	17 mg/kg or µg/g total Hg
Massachusetts drinking water standard (MCL)	0.002 mg/l total Hg
USEPA ambient water quality standard for human health, assuming ingestion of contaminated fish/shellfish	0.146 µg/l (0.000146 mg/l)
Massachusetts limit for fish used as food by pregnant women	0.5 mg/kg (total mercury: almost all of which will be in methylated form)
US FDA limit for fish used as food	1 mg/kg

Conclusion

Mercury monitoring and mapping for the entire State of Kuwait was accomplished using many accurate measuring techniques, such as diffusive passive sampling technique, and distribution of questionnaires to Customs and Import Division, Ministry of Health, dental clinics, gold workshops, etc. The information was scarce and the project leader faced a lot of difficulties and requested Kuwait EPA to assist in this matter. Different organizations and their employees were not cooperative and completely ignored the request. Therefore, it was hard to gather the required information. The Central Statistical Bureau dispatched a CD that contained data on imported mercury and mercury salts and other accessories that contained mercury, but the composition or amount of mercury in each accessory, such as shampoos, hair spray, etc., was not disclosed. The imported amount was mentioned in kilogram and in very large quantity for 2011, 2013, and 2014, which led to doubts about the authenticity of the reported values.

Cement industries all over the world were the second biggest source of mercury other than power production using fossil fuels. The Assistant Executive Director of Cement industries informed that 20 μg Nm^{-3} of mercury were measured by NPESCO, which if calculated for the entire year based on those fixed operating conditions resulted in 146.3 kg of mercury per year. Samples of raw material and cement were analyzed in KISR's laboratory using Zeeman RA 915+ and applying material balance over raw materials indicated the annual emissions of mercury of about 100.2 kg $year^{-1}$. If based on products, the emission from grey cement would be 38.1 kg y^{-1}. The net emission from the stack was 62.1 kg y^{-1}, which was less than mercury emissions from the incinerator (3.2 kg per day or one ton per year), as specified by Law (1991), Steverson (1991), and Singh and Parkash (2007).

Ambient air, water, soil, sludge, and crude oil samples were collected from KOC premises (booster, gathering center, sludge treatment, and oil pits). The passive samples' results for one-month exposure showed the highest mercury level, that is, 5.8 ng m^{-3}, and the concentration of mercury in other samples was similar to that reported at other places in Kuwait. Contaminated water samples showed 10 ng m^{-3} concentration of mercury within a range of 13 ng m^{-3} soil, and sludge samples indicated 184.1 and 200.5 ng m^{-3}, within a range equivalent to 117 and 163 ng m^{-3} reflecting non-homogeneity of the sludge samples.

Recovered crude oil had 1.6 ng m^{-3} mercury levels, within a range of 1.3 ng m^{-3}. The KOC mercury data from 13 sites were collected using OPSIS device from 2013 to 2019.

First three years' data were monthly mean and did not show any significant trend. The following four years' data had a gradual increase, while the concentration at six sites doubled due to the presence of live sources in the vicinity of the respective locations.

EC (2001) tabulated a concentration of TGM in different locations in Europe from 1977 to 1999. The median values ranged between 1.35 and 8.6 ng m^{-3}, and the average of TGM background concentration in the air throughout the world was about 1.5 ng m^{-3} and the mean concentrations of TGM at heavily impacted European locations ranged from 1.96 to 85 ng m^{-3}. Pirrone et al. (2001) reported TGM concentrations that averaged from 1.7–1.9 ng m^{-3} in the open sea atmosphere to 3 ng m^{-3} in the coastal urban environment, as a result of the completion of MED-OCEANOR project. Wängberg et al. (2016) discussed different mercury species in the air, where mercury occurred as an atomic gas at normal temperatures, similar to noble gases. Airborne mercury largely consisted of atomic mercury, which was denoted as GEM. Mercury in the atmosphere constituted more than 98% of GEM and negligible amounts of Gaseous Oxidized Mercury (GOM). Mercury atoms are relatively stable in the atmosphere and have a residence time of about one year. This is long enough to allow transport on hemispherical scales before being oxidized and leaving the atmosphere via wet or dry deposition.

The annual mean elemental mercury concentrations from KOC sites measured by OPSIS showed the highest values in 2019. For the last four years' period, the annual mercury levels were in the range of 0.1 to 6.4 ng m^{-3} with the only exception of Al-Ardiya location, where the value was lower than that of heavily impacted sites in Europe, and the annual mean values of elemental mercury were higher than the average of TGM background concentration in the air throughout the world (EC, 2001).

Eight waves of passive sampling were repeated all over Kuwait covering desert, borders, landfills, coastal, dental clinics, gold workshops, KNPC refineries, and KOC's oil installations. The PL faced many obstacles in placing the samplers in the right place but was able to install them at a compromised place where measurements might not be accurate. The measurement of mercury in ambient air was TGM, which mainly represented elemental mercury. The results showed elevated values in some places confirming the presence of a source in the vicinity of the sampling site. Landfill sites at Yarmouk and Mina Abdullah had showed slightly higher values due to the disposal of 300- cm top layer

soil polluted with mercury from old salt-chlor plant near Mina Al-Shuwaikh. Northern and northeastern coastal samples also indicated elevated levels due to oil production and associated flaring resulting in mercury emissions either from southern Iraqi oil fields or northern Kuwait oil fields.

The average concentration of all data measured for the entire study period using diffusive passive sampling technique was 2.31 ng m^{-3}, similar to that reported elsewhere (Khan et al., 2008). The elevated values of mercury reflected the presence of a nearby source, either a power station or landfill/dumping site or upstream oil facilities, and prevailing meteorological conditions, which dispersed the emissions. Fakour et al. (2010) measured mercury levels in the scalp hairs of Iranian women having dental fillings, which showed high levels, i.e., 1.28±1.38μg g^{-1} or ppm. The highest mercury level (8.7 ng m^{-3}) was measured at Yarmouk landfill site during the spring season, while all other measurements were near to the average value. All measured data for the entire study period ranged from 0.8 to 8.7, from 278 samples, with an average value of 2.31, median value of 2.1, and mode value of 1.7 ng m^{-3}. Standard deviation and standard error for the total measured values were 0.95 and 0.061, respectively, reflecting the scatter in the data. The distribution of the data showed a kurtosis value of 18.17 and a skewness value of 3.69.

Passive sampling provided data on the temporal and spatial distribution of mercury levels over the entire State of Kuwait. EC (2001) tabulated the concentration of TGM in different locations in Europe from 1977 to 1999. The median values ranged between 1.35 and 8.6 ng m^{-3} and the average of TGM background concentration in the air throughout the world was about 1.5 ng m^{-3}, and TGM mean concentrations at heavily impacted European locations ranged from 1.96 to 85 ng m^{-3}. Pirrone et al. (2001) reported TGM concentrations averaging from 1.7–1.9 ng m^{-3} in the open sea atmosphere to 3 ng m^{-3} in the coastal urban environment, as a result of the completion of MED-OCEANOR project. The current average concentrations of TGM were comparable to those reported elsewhere (EC, 2001).

The daily dust data measured using a sequential sampler placed in Ali Sabah Al-Salem residential area, for seven years, were analyzed for mercury contamination mainly from combustion processes in upwind private and governmental industries. The highest annual TPM mean concentration was 106.3 pg m^{-3} in 2013, with an exclusive monthly average range from 0.4 to 556.9 pg m^{-3} and the corresponding median value was 90 pg m^{-3}. The lowest annual mean concentration was 23.4 pg m^{-3} in 2017, with an exclusive range

from 0.4 to 268.9 pg m^{-3} and the corresponding median value was 17.9 pg m^{-3}. Seasonal variation in TPM was similar to that reported in the literature (EC, 2001; Wan et al., 2009; Xu et al., 2013), and high levels were noticed in winter and spring due to low average temperatures resulting in the least dispersion and lower planetary boundary layer substantiating mercury concentrations. In summer, TPM concentrations were low due to the prevalence of frequent dust storms and elevated temperatures facilitating high dispersion with the exception of 2014 and 2018, where the maximum TPM concentrations were found in June and August, respectively, depicting excessive fuel combustion activities resulting in significant mercury emissions. The general trend of annual mean TPM concentrations showed a gradual decline due to the emission control strategies applied by KNPC cutting down flares and reducing particulate matter by integrating the latest technologies. The production of the oldest Al-Shuaiba refinery was stopped, which was later decommissioned and scraped.

The other set of daily dust data from sequential samplers placed in Al-Ardiya residential area, for three years, was analyzed for mercury contamination from power and desalination industries in upwind location (Al-Doha). The highest annual concentration was 31.3 pg m^{-3} in 2018, with an exclusive monthly average ranging from 0.6 to 182.6 pg m^{-3}, and the corresponding median value was 23.2 pg m^{-3}. The lowest annual concentration was 18.9 pg m^{-3} in 2019, with an exclusive range from 0.2 to 78.3 pg m^{-3}, and the corresponding median value was 16.8 pg m^{-3}. The average TPM concentration measured in the present research is similar to the background concentration of TPM reported at four sites on the Mediterranean coast, given in the range of 3 to 23 pg m^{-3} (Wangberg et al., 2008), due to identical meteorological conditions prevalent in these areas and the presence of similar power and petroleum industries. Similar seasonal effects were observed from this set of data as reported earlier, that is, high levels in winter and spring depicting fuel combustion activities and low values in summer, due to the presence of strong and dusty wind dispersing and diluting TPM concentrations. It was not possible to depict any specific trend from very limited data, for six months in 2017, ten months in 2018, and four months in 2019. A long-term study with accurate measurements of emissions could provide a real trend for the abatement of mercury emissions.

The analysis of the historical data showed monthly maximum mercury deposition flux (MDF) of 3242 ng m^{-2} mo^{-1} in June 2011, at Liyah, and the second high flux was 3030 ng m^{-2} mo^{-1}, in May 2012 at Liyah, while at Al-Bahra and Boubiyan, MDF was lower

than Liyah. In 2012, complete data for 12 mo from Liyah location showed that the maximum MDF was observed in May, which was of almost the same order of magnitude as that of the previous year.

The annual maximum MDF was calculated for 2011, as the data were incomplete for a few months, and was 10690 ng m^{-2} yr^{-1}, observed at Liyah, while MDF was the lowest at 570 ng m^{-2} yr^{-1}, observed at Al-Bahra location. For 2012, dust fallout data were complete at Liyah and showed a similar value of maximum MDF, i.e., 15717 ng m^{-2} y^{-1}, reflecting identical operations in the neighbouring southern Iraqi and northern Kuwaiti oil fields. There was random seasonal variation, mainly depicting the activities associated with mercury emissions. In China and Europe, winter season had elevated levels of mercury deposition due to high coal consumption in heating and high energy demand being fulfilled by fossil fuels (Wan et al., 2009; Xu et al., 2013; EC, 2001).

The comprehensive measurements of monthly natural dust fallout at different locations in the State of Kuwait were conducted from 2017 to 2019, to identify the most probable sources of mercury emissions. In 2017, nineteen locations were sampled for the period of seven months, from May to December 2017. The calculated annual average MDF was about 7673 ng m^{-2} y^{-1} and the median value was 5655.3 ng m^{-2} y^{-1}, measured from all of the selected locations, and the annual maximum MDF was almost 2.2 times the annual average MDF, which was observed at Al-Buhaith, assuring the predominant source from the flares of southern Iraqi and northern Kuwaiti Oil fields' activities. The monthly MDFs were high from October to November at Shagaya location and the highest MDF was observed in December at Al-Buhaith, strongly influenced by the prevailing meteorological conditions. There were significant values of MDF at Al-Shaheed Jerman in May and Al-Tahreer in June.

In 2018, forty-two locations, most of which were along the international border of Kuwait, were sampled for the entire year. The annual average MDF was about 19242 ng m^{-2} y^{-1} and the median value was 15280 ng m^{-2} y^{-1}, measured from all of the selected border locations, and the annual maximum MDF was almost 7.3 times the annual average MDF, which was observed at Shagaya, assuring the predominant source from Kra'Almru Oil fields' activities. The monthly MDFs were high from April to August at Shagaya, the the highest was observed in July, strongly influenced by the prevailing meteorological conditions.

In 2019, twenty-eight locations were sampled for the period of five months, from January to May 2019. The calculated annual average MDF was about 13944 ng m^{-2} y^{-1} and the median value was 9305 ng m^{-2} y^{-1}, measured from all of the selected locations, and the annual maximum MDF was almost 6.7 times the annual average MDF, which was observed at Shagaya assuring the predominant source from the flares of Kra'Amru oil-field activities. The monthly MDFs were high from January to May at Shagaya location, and the highest was observed in March, strongly influenced by the prevailing meteorological conditions.

The annual mercury deposition fluxes were calculated from the annual dust fallout values at different locations and had an increasing trend, based on three years' data (2017-2019), mainly due to the increased petroleum upstream activities.

Shagaya's remote site was chosen to produce power using renewable sources, which were present in abundance and were utilized to the maximum availability. This site has very strong and gusty wind. The average wind speed for the Shagaya Wind Farm for 2017 and 2018 was 8.11 m/s and 8.15 m/s, respectively, (Al Nassar et al., 2019; Al-Nassar and Neelamani, 2018) for most of the period making it suitable for harvesting excessive energy to convert to power to be utilized by the Kuwaiti population. Strong wind and gust transported large amounts of dust/sand from distant sources carrying different pollutants, originating from distant sources.

The cluster analysis of mercury levels in the ground contaminated soil/sand showed seven major probable sources: petroleum upstream activities in the north, south, and west contributing to the mercury pollution through the flaring of gas, oil, oil-water emulsion, and sludge containing oil, water, and sand; landfill sites; KOC; KNPC petroleum downstream sites; and urban societal emissions. The highest average mercury level was noticed in 2017, comprising western oil-field production followed by northern oil-field production and petroleum downstream at KNPC. In 2018, the average mercury levels decreased, consisting of the contribution from landfill sites and petroleum upstream from northern, southern, and western oil fields. In 2019, the average mercury levels increased from 2018 and reached almost the same levels of 2017, consisting of KOC where the site of sampling was limited, and only covered booster station and oil recovery facility from sludge followed by petroleum upstream from southern, western, and northern oil fields.

Real-time monitoring at OSC (KPC and Ministry of Oil Buildings) and KISR sites revealed the presence of an upwind distant mercury emission source, namely, Al-Doha

Power Desalination Plant, which uses crude oil during the peak load, i.e., July-August 2016, and and the consequence of the Oil Sector Workers Union's industrial action in Apirl 2016, which compelled power stations to be operated on crude oil emitting high concentrations of the pollutants associated with crude oil. Mercury measurements over the Arabian Gulf were very low, at less than 10 ng/m^3. There was a slight increase near the offshore oil rigs and near the passing ships confirming the source of mercury combustion of fuel. Ambient mercury levels in oil industries were measured in two expeditions conducted on 28 August 2017 and 5 October 2017. The results showed elevated levels of mercury in the southeastern corner of petroleum refineries on 28 August, which were in the range of 13.82–18.67 ng m^{-3}, compared to other locations. On 5 October 2017, elevated levels were measured on the northern side of petroleum refineries ranging between 16.04 and 21.48 ng m^{-3}, confirming the local source (combustion of fuel in open pit fire). Mercury emissions were substantial from coal power stations and in the ash fallout, and elevated gaseous mercury levels were detected in the downwind direction of coal-powered power plants in Russia and Poland (Zasina and Zawadzki, 2017; Sloss, 2012). (Response to the comments of EPA reviewers on the report is attached in Appendix P.)

Recommendations

1. Based on three years' monitoring and mapping data for the atmospheric behaviour of mercury levels, which are associated with health risk, a comprehensive monitoring plan should be suggested for the accurate assessment of all mercury species' levels (TGM, RGM, and TPM) in air, and dry and wet deposition should also be quantified using state-of-the art monitoring stations.
2. Mercury monitoring should be recommended to the GCC countries, to contribute positively to the health of their nationals and to curtail emissions from power sectors and petroleum upstream and downstream industries.
3. Mercury in soil and seafood must be measured for Kuwait and neighboring countries, to minimize the health risk to Kuwait's citizens and also to GCC population.

4. Standard measurement methods must be developed with quality assurance/quality control (QA/QC) procedures for the accurate assessment of mercury levels with clear common guidelines for all GCC countries.
5. Mercury levels have indicated some hotspots for future monitoring stations, such as Liyah, Shagaya, and other important locations, which have to be considered for continuously monitoring mercury levels for the planning of mitigation strategies.
6. Inter-comparative measurements between neighboring states certify the authenticity of the data and confirm the sources for mitigation applications.
7. Measurement data for Kuwait and neighboring countries must be compiled as a database for GCC, to be shared and used for model development and predictions.
8. Domestic waste has to be segregated by citizens to be recycled most effectively and each type has to be collected in different days or times. Batteries and other appliances using mercury must be separated and collected to recover and recycle mercury.
9. Large industries using fossil fuels must monitor the emission of hazardous pollutants from the stacks periodically to abate pollution.
10. The data provided by the KOC was limited and the project team requested the KOC authorities to share all raw data covering a broad spectrum, for a longer span, to identify probable sources of mercury for mitigation.
11. In Kuwait, the data on the mercury content in fossil fuel from different venders should be made available for the power generation sectors.

Appendix A

Mercury in Kuwait Questionnaire – English and Arabic

Mercury in Kuwait Questionnaire – Inventory and Release

This study is a joint project between Kuwait Institute for Scientific Research (KISR) and Kuwait Public Authority for Environment (KEPA) in response to the United Nations Environment Program in support of 'Minamata Convention on Mercury' to protect human health and the environment from human emissions and releases of mercury and its compounds. Information provided will help improve inventory control measures and uses of mercury in Kuwait and treated as confidential.

	Please mark √ in the circle for each of the following activities	Do you think these activities are found in Kuwait		
		Always	**Sometimes**	**No**
I	**Extraction and use of fuels/energy sources**			
1	The use of coal combustion in electricity production	o	o	o
2	The use of coal for heating in the industrial sector	o	o	o
3	Burning coal to produce coke	o	o	o
4	Petroleum extraction and refining	o	o	o
5	Production and manufacturing of chemicals, ex. diesel, oil, naphtha, gasoline, kerosene, propane, etc.	o	o	o
6	Petroleum coke manufacturing	o	o	o
7	Polymer production	o	o	o
8	The use of bitumen for asphalt in paving roads	o	o	o
9	Refining and natural gas extraction	o	o	o
10	The use of natural gas in electricity production	o	o	o
11	Extraction of oil shale fuel	o	o	o
12	Produce energy by burning biomass (agricultural waste, wood, and waste from poultry and animal waste)	o	o	o
13	Geothermal power production, geothermal energy in underground reservoirs	o	o	o
II	**Primary (virgin) metal production**			

	Please mark √ in the circle for each of the following activities	Do you think these activities are found in Kuwait		
		Always	**Sometimes**	**No**
1	Extract mercury from the mines	o	o	o
2	Gold and silver extraction with mercury-amalgamation process	o	o	o
3	Gold extraction and processing other than mercury amalgam	o	o	o
4	Copper extraction or production of copper-rich substrate metal and initial processing	o	o	o
5	Lead extraction or production of lead-rich substrate metal and initial processing	o	o	o
6	Zinc extraction or production of zinc-rich substrate metal and initial processing	o	o	o
7	Aluminum extraction or production of bauxite and initial processing	o	o	o
8	Extraction and processing of other non-ferrous metals (ex. nickel)	o	o	o
9	Iron and steel production, melting iron to make iron sheets, panels, slides, rods, and rails	o	o	o
III	**Production of other materials with mercury impurities**			
1	Cement production	o	o	o
2	Lime production and light weight aggregate kilns	o	o	o
3	Pulp and paper production	o	o	o
IV	**Use of mercury in industrial processes**			
1	Chlor-alkali production with mercury-technology	o	o	o
1	vinyl-chloride-monomer production with $HgCl_2$ as catalyst	o	o	o
3	Acetaldehyde production with $HgSO_4$ as catalyst	o	o	o
4	Production of polymers with mercury compounds as catalysts such as the production polyurethane to make foam/sponge	o	o	o
V	**Consumer products with intentional use of mercury**			
1	Thermometers to measure body temperature (in hospitals)	o	o	o
2	Thermometers to measure the ambient air temperature (environment)	o	o	o
3	Thermometers in chemical laboratories and testing of petroleum products	o	o	o
4	Thermometers in industrial processes; ex. for control of marine engines	o	o	o
5	Thermometers in control devices of some engines; ex. huge diesel engines	o	o	o
6	Electrical switches & contacts with thermostats used in HVAC	o	o	o
7	Electrical switches/contacts used as alarms in motor vehicles	o	o	o

	Please mark √ in the circle for each of the following activities	Do you think these activities are found in Kuwait		
		Always	**Sometimes**	**No**
8	Electrical switches used in washing machines & refrigerators	o	o	o
9	Electrical switches used in some sport shoes with light beams	o	o	o
10	Buoyancy switches & contacts used in drain and sink pumps	o	o	o
11	Florescent tubular lamps (long) and compact fluorescent bulbs	o	o	o
12	Mercury vapor lamps, sodium and neon lamps, street lightings	o	o	o
13	Special lamps used in photography	o	o	o
14	Chemical analysis lamps (atomic adsorption & spectrophoto)	o	o	o
15	Flat-panel computer monitors & TV taillights and halide lamps	o	o	o
16	Sterilization lamps, ultraviolet lamps used in tanning leather	o	o	o
17	Mercury oxide batteries (zinc-mercury batteries)	o	o	o
18	Batteries in the form of a button containing mercury	o	o	o
19	Alkaline cell batteries containing mercury	o	o	o
20	Biocides and pesticides (general)	o	o	o
21	Biocides and pesticides used as agricultural fertilizers	o	o	o
22	Paints and coating (general)	o	o	o
23	Paints used for coating the structure of ships and boats	o	o	o
24	Pharmaceuticals for human uses (ex. vaccine, eye drops)	o	o	o
25	Pharmaceuticals for veterinary uses	o	o	o
26	Cosmetics & related products (skin-whitening creams, soaps)	o	o	o
VI	**Other intentional products/process uses**			
1	Dental amalgam fillings (mix of mercury, silver, copper, tin)	o	o	o
2	Blood pressure manometers and gauges	o	o	o
3	Environmental manometers and pressure gauges used in meteorology	o	o	o
4	Manometers and pressure valves used in industry	o	o	o
5	Chemicals & solvents, ex.blood gas analysis, thermal balance	o	o	o
6	Laboratory devices and equipment	o	o	o
7	Mercury use in religious rituals	o	o	o
8	Mercury metal use in folklore medicine	o	o	o
9	Semiconductors use as infrared detectors	o	o	o
10	Gyroscope devices with mercury	o	o	o

	Please mark √ in the circle for each of the following activities	Do you think these activities are found in Kuwait		
		Always	**Sometimes**	**No**
11	Pump discharge with mercury	o	o	o
12	Refrigeration cooling systems	o	o	o
13	Sea lighthouses as navigation lights	o	o	o
14	Dyeing and coloring materials in leather tanning	o	o	o
VII	**Production of recycled metals**			
1	Production of recycled mercury from recycled eqip's and scrap	o	o	o
2	Production of recycled ferrous iron and steel from scrap	o	o	o
3	Production of other recycled metals (aluminum, copper, zinc)	o	o	o
VIII	**Waste incineration**			
1	Incineration of non-hazardous municipal, general, commercial, and industrial solid waste	o	o	o
2	Incineration of hazardous waste such as hydrocarbons, paints and dyes, chemicals, pesticides, batteries, fuels and oils	o	o	o
3	Incineration of medical and veterinary waste	o	o	o
4	Sewage sludge incineration: municipal, agricultural, industrial	o	o	o
5	Informal waste burning (fires in open land, drums)	o	o	o
IX	**Waste deposition / landfilling and waste water treatment**			
1	Controlled landfills and waste deposits	o	o	o
2	Diffuse deposal under some control: under roads, construction	o	o	o
3	Informal local deposal of industrial production waste	o	o	o
4	Informal dumping of general waste	o	o	o
5	Waste water system/treatmentor in aquatic environments	o	o	o
X	**Cemeteries**			
1	Cemeteries	o	o	o
XI	**Potential hot spots**			
1	Closed and abandoned chlor-alkali production sites	o	o	o

استبيان الزئبق في الكويت
هذه الدراسة هي جزء من مشروع مشترك بين معهد الكويت للأبحاث العلمية والهيئة العامة للبيئة دعما لبرنامج الأمم المتحدة للبيئة الخاص ب 'اتفاقية ميناماتا' بشأن الزئبق لحماية صحة الإنسان والبيئة من الانبعاثات والإطلاقات البشرية للزئبق ومركباته. المعلومات التي سوف تقدمها ستساهم في تحسين تدابير مراقبة مخزون واستخدامات الزئبق في الكويت ، ويتم التعامل بها بسرية تامة.

الرجاء وضع علامة √ امام الاختيارات في الدائرة o في العبارات التالية		هل باعتقادك توجد هذه الأنشطة في الكويت		
		دائما	احيانا	لا توجد
I	**استخراج الوقود و مصادر الطاقة المختلفة واستخدامها**			
1	استخدام الفحم في إنتاج الكهرباء	o	o	o
2	استخدام الفحم في التدفئة في القطاع الصناعي	o	o	o
3	حرق الفحم لإنتاج فحم الكوك (من الفحم)	o	o	o
4	استخراج البترول وتكريره	o	o	o
5	تصنيع الكيماويات كالزيوت والديزل والنافثا والجازولين والكيروسين والبروبان ، الخ	o	o	o
6	تصنيع فحم الكوك البترولي	o	o	o
7	إنتاج البوليمر	o	o	o
8	استخدام الأسفلت في رصف الطرق (بيتومين)	o	o	o
9	استخراج الغاز الطبيعي وتكريره	o	o	o
10	استخدام الغاز الطبيعي في إنتاج الكهرباء	o	o	o

11	استخراج وقود الزيت الحجري	o	o	o
12	انتاج الطاقة بحرق الكتلة البيولوجية (النفايات الزراعية والخشب ، ونفايات الدواجن، وروث البقر والجمال)	o	o	o
13	انتاج الطاقة الحرارية الأرضية في مستودعات في جوف الأرض	o	o	o
II	**إنتاج المعادن الأولية**			
1	استخراج الزئبق من المناجم	o	o	o
2	استخراج الذهب والفضة بعملية المزج السبكي بالزئبق (الملغمة)	o	o	o
3	استخراج الذهب بعمليات تختلف عن المزج السبكي بالزئبق	o	o	o
4	استخراج النحاس او إنتاج الركازة الغنية بالنحاس من الفلز ومعالجته الأولية	o	o	o
5	استخراج الرصاص او إنتاج الركازة الغنية بارصاص من الفلز ومعالجته الأولية	o	o	o
6	استخراج الزنك او إنتاج الركازة الغنية بالزنك من الفلز ومعالجته الأولية	o	o	o
7	استخراج الألومنيوم او إنتاج البوكسيت ومعالجته الأولية	o	o	o
8	استخراج المعادن غير الحديدية الأخرى ومعالجتها (نيكل ، ...)	o	o	o
9	انتاج الحديد والصلب وصهرهما وانتاج الحديد كالصفائح ، والألواح ، والشرائح ، والقضبان	o	o	o
III	**إنتاج المعادن والمواد الأخرى التي بها شوائب من الزئبق**			
1	إنتاج الأسمنت (بما في ذلك النفايات المستخدمة كوقود لإنتاج الأسمنت)	o	o	o
2	إنتاج الجير عن طريق تكليس الحجر الجيري	o	o	o
3	إنتاج اللب والورق	o	o	o
IV	**الاستخدام العمدي للزئبق في العمليات الصناعية**			
1	إنتاج الكلور-الصودا باستخدام تكنولوجيا خلايا الزئبق	o	o	o
2	إنتاج أحادي كلوريد الفينيل باستخدام ثنائي كلوريد الزئبق ($HgCl_2$) كعامل حفاز	o	o	o
3	إنتاج الأستالدهيد باستخدام كبريتات الزئبق ($HgSO_4$) كعامل حفاز	o	o	o
4	إنتاج البولميرات باستخدام مركبات الزئبق كعوامل حفازة كإنتاج البولي يوريثان المادة الأساس في تصنيع الأسفنج	o	o	o

V	المنتجات الاستهلاكية المستخدم فيها الزئبق بشكل عمدي			
1	الموازين الحرارية لقياس درجة حرارة الجسم في المستشفيات	o	o	o
2	الموازين الحرارية لقياس درجة حرارة الهواء المحيط	o	o	o
3	الموازين الحرارية في المختبرات الكيميائية و اختبار المنتجات البترولية	o	o	o
4	الموازين الحرارية في العمليات الصناعية كالتحكم في المحركات البحرية	o	o	o
5	الموازين الحرارية في أجهزة الضبط في بعض الماكينات كمحركات الديزل الكبرى	o	o	o
6	المفاتيح الإلكترونية للثرموستات المستخدمة في أجهزة التدفئة والتهوية والمكيفات	o	o	o
7	المفاتيح والتوصيلات الكهربائية في أجهزة الإنذار ضد السرقة في المراكب	o	o	o
8	المفاتيح والتوصيلات الكهربائية في غسالات الملابس والمبردات	o	o	o
9	المفاتيح والتوصيلات الكهربائية في بعض الأحذية الرياضية التي تصدر إضاءة	o	o	o
10	مفاتيح الطفو التي في العادة تستخدم في مضخات البالوعات	o	o	o
11	مصابيح الفلوروسينت الأنبوبية ذات الطرفين ومصابيح فلورسنت مضغوط طرف واحد	o	o	o
12	مصابيح بخار الزئبق والصوديوم ومصابيح النيون والمستخدمة في إنارة الشوارع	o	o	o
13	مصابيح خاصة تستخدم في التصوير الفوتوغرافي	o	o	o
14	مصابيح التحليل الكيميائي (مصابيح امتصاص المطياف الضوئي الذري)	o	o	o
15	المصابيح الخلفية في شاشات الكمبيوتر المسطحة والتليفزيونات ومصابيح الهاليد	o	o	o
16	مصابيح التعقيم فوق البنفسجي ، مصابيح تستخدم في الدباغة	o	o	o
17	بطاريات أكسيد الزئبق (التي يطلق عليها أحياناً بطاريات الزنك-الزئبق)	o	o	o
18	بطاريات على شكل زر تحتوي على الزئبق	o	o	o
19	بطاريات الخلايا القلوية تحتوي على الزئبق	o	o	o
20	المبيدات الحشرية العامة	o	o	o
21	مبيدات الآفات الزراعية ، ومبيدات تستخدم في الأسمدة الزراعية	o	o	o

22	الدهانات ومواد الطلاء العامة	o	o	o
23	دهانات ومواد الطلاء لهياكل المراكب البحرية	o	o	o
24	المواد الصيدلانية للاستخدامات البشرية كاللقاح، وقطرات العين، وبعض الأعشاب الطبية	o	o	o
25	المواد الصيدلانية للاستخدامات البيطرية	o	o	o
26	مستحضرات التجميل والمنتجات ذات الصلة (كريمات تفتيح البشرة، والصابون، ومواد حافظة في مستحضرات تجميل العين)	o	o	o
VI	**المنتجات/العمليات الأخرى التي يستخدم فيها الزئبق بشكل عمدي**			
1	حشوة الأسنان بالأملغمة (خلائط من الزئبق، والفضة، والنحاس، والقصدير)	o	o	o
2	مقاييس وعدادات ضغط الدم	o	o	o
3	المانومترات البيئية ومقاييس الضغط المستخدمة في والأرصاد الجوية	o	o	o
4	المانومترات وصمامات الضغط المستخدمة في الصناعة	o	o	o
5	استخدام المواد الكيميائية والمحاليل (كجهاز تحليل غاز الدم ، الموازين الحرارية)	o	o	o
6	أجهزة المختبرات	o	o	o
7	استخدام الزئبق في الطقوس الدينية	o	o	o
8	استخدام الزئبق الطب الشعبي	o	o	o
9	أشباه الموصلات للكشف بالأشعة تحت الحمراء	o	o	o
10	أجهزة الجيروسكوب المستخدم فيها الزئبق	o	o	o
11	مضخات التفريغ المستخدم فيها الزئبق	o	o	o
12	استخدام الزئبق كمادة مبردة في بعض نظم التبريد	o	o	o
13	المنارات (مصابيح الملاحة البحرية)	o	o	o
14	مواد الصباغة والتلوين وفي الدباغة	o	o	o
VII	**إنتاج المعادن المعاد تدويرها (إنتاج المعدن "الثانوي")**			
1	إنتاج الزئبق المعاد تدويره من الأجهزة والمواد التي تم تفكيكها ومنتجات الخردة	o	o	o

2	إنتاج المعادن الحديدية المعاد تدويرها كإنتاج الحديد والصلب من المعدن الخردة ، صهر الخردة في الأفران (التقطيع ، والتخزين ، والصهر)	o	o	o
3	إنتاج المعادن الأخرى المعاد تدويرها (كالألومنيوم والنحاس والزنك)	o	o	o
VIII	**حرق النفايات**			
1	حرق النفايات البلديات الصلبة و النفايات العامة والنفايات الصلبة الصناعية الأخرى والتجارية غير الخطرة	o	o	o
2	حرق النفايات الخطرة كالمذيبات وغيرها من الهيدروكربونات ومواد الطلاء والأصبغة والمواد الكيميائية والمبيدات والبطاريات وأنواع الوقود والزيوت	o	o	o
3	حرق النفايات الطبية والبيطرية بجميع انواعها	o	o	o
4	حرق حمأة المجاري و الصرف من النشاطات البلدية أو الزراعية أو الصناعية	o	o	o
5	حرق النفايات بشكل غير رسمي (الحرائق في ارض مكشوفة، البراميل)	o	o	o
IX	**المدافن الصحية للنفايات / توضع النفايات الخاضع للمراقبة**			
1	المدافن الصحية وردم المخلفات الخاضع للمراقبة	o	o	o
2	التوضعات المتناثرة تحت قدر من المراقبة (ردم بقايا الحرق وغير ذلك من البقايا الصلبة تحت الطرق وفي أعمال التشييد)	o	o	o
3	ردم نفايات الإنتاج الصناعي المحلية بشكل غير رسمي	o	o	o
4	إلقاء وردم النفايات العامة بشكل غير رسمي	o	o	o
5	نظم و معالجة مياه الصرف ، ومياه الصرف التي تلقى مباشرة في البيئات المائية	o	o	o
X	**مقابر الجثث**			
1	مدافن مقابر الجثث	o	o	o
XI	**تحديد الأماكن المحتمل أن تكون نقاطاً ساخنة**			
1	مواقع إنتاج الكلور- الصودا المغلقة/المهجورة	o	o	o

Appendix B

Kuwait Environment Public Authority's Letters Distributed Internally

وارد إدارة البيئة الصناعية ... / ... / ...					
رقم	لعمل اللازم	للإفادة	للعلم	مراجعتي	تجميع الرديد
قسم المواد الكيماوية					
قسم التحكم بالمخلفات					
قسم بيئة العمل					
قسم البيئة الداخلية					

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT

التاريخ : ٢٦ / ١ / ٢٠١٧
الرقم :

الهيئة العامة للبيئة
إدارة البيئة الصناعية
قسم المواد الكيماوية
وارد رقم/ ٥٥
تاريخ: ٥ / ٢ / ٢٠١٧

الدكتور / مدير ادارة البيئة الصناعية **المحترم**

تحية طيبة و بعد،

الموضوع: تعبئة استبيان معهد الكويت للأبحاث العلمية بخصوص الزئبق

بالاشاره الى الموضوع أعلاه، و بناءً على كتابكم رقم 179 بتاريخ 24 يناير 2017، نرفق لكم استبيان معهد الكويت للأبحاث العلمية بعد تعبئته من قبل مركز الشعيبة (مرفق طيه) ، نرجوالتكرم بالاطلاع و اتخاذ ماترونه مناسبا.

وتفضلوا بقبول فائق الاحترام و التقدير ،

رئيس مركز الشعيبة

دلال جاسم النجار
2017/1/26

وارد إدارة البيئة الصناعية ٢٦ / ١ / ٢٠١٧					
رقم ١١٦	لعمل اللازم	للإفادة	للعلم	مراجعتي	تجميع الرديد
قسم المواد الكيماوية			✓		
قسم التحكم بالمخلفات					
قسم بيئة العمل					
قسم البيئة الداخلية					

برقية: Opr.: 22208310 – 22208410
ص.ب: ٢٤٣٩٥ الصفاة – الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

الهيئة العامة للبيئة
إدارة البيئة الصناعية
التاريخ: ٢٤/ ١ /٢٠١٧
الصادر رقم: ا.ع.ب/ ٦٠٧

إدارة التخطيط وتقييم المردود البيئي
وارد
الرقم: ا ق م ب/ ٤١١
التاريخ: ٢٦/ ١/ ٢٠١٧ م

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT

التاريخ : ٢٢/ ١/ ٢٠١٧
الرقم : م ب د/ ١٠٠

السيدة / سميرة الكندري
مدير إدارة التخطيط والمردود البيئي
تحية طيبة وبعد ،

المحترمة

الموضوع : تعبئة استبيان معهد الكويت للأبحاث العلمية بخصوص الزئبق

بالإشارة إلى الموضوع أعلاه، ورد لنا من معهد الكويت للأبحاث العلمية الاستبيان المرفق بخصوص مادة الزئبق في الكويت.

يرجى التكرم بالإيعاز للمتخصصين في إدارتكم بتعبئة الاستبيان وإفادتنا بذلك حتى يتسنى لنا مخاطبة معهد الكويت للأبحاث العلمية بذلك.

وتفضلوا بقبول فائق الاحترام

مدير إدارة البيئة الصناعية
مدير إدارة البيئة الصناعية

رئيس قسم المواد الكيميائية

مرفق : نسخة من الاستبيان باللغة العربية والانجليزية

سلوى

بدالة: Opr.: 22208310 - 22208410
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
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الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT

الهيئة العامة للبيئة
إدارة البيئة الصناعية
التاريخ: ٢٠١٧/١/٢٤
الصادر رقم: ا.ب.ص/ ١٧٠٨

التاريخ : ٢٠١٧/١/٢٤
الرقم : م.ك/ ٩٩

السيد / مدير إدارة رصد تلوث الهواء المحترم

تحية طيبة وبعد ،

الموضوع : تعبئة استبيان معهد الكويت للأبحاث العلمية بخصوص الزئبق

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وتفضلوا بقبول فائق الاحترام

رئيس قسم المواد الكيميائية

مدير إدارة البيئة الصناعية
د. مشعل الإبراهيم
مدير إدارة البيئة الصناعية

مرفق نسخة من الاستبيان باللغة العربية والانجليزية

سلوى

بدالة: Opr.: 22208310 - 22208410
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
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الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT

الهيئة العامة للبيئة
إدارة البيئة الصناعية
قسم التحكم بالمخلفات الصناعية
وارد رقم / ٦٤/ ص ت
تاريخ ٢٠١٧/١/٢٥

التاريخ : ٢٠١٧/١/٢٤
الرقم : م.ب.ك/ ١٠١

٤/أصلح للرد على الاستفسار المتعلقة بالشاي فقط
المحترمة ٢٠١٧/١/٢٥

السيدة / رئيس قسم التحكم
تحية طيبة وبعد ،

الموضوع : : تعبئة استبيان معهد الكويت للأبحاث العلمية بخصوص الزئبق

بالإشارة إلى الموضوع أعلاه، ورد لنا من معهد الكويت للأبحاث العلمية الاستبيان المرفق بخصوص مادة الزئبق في الكويت.

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وتفضلوا بقبول فائق الاحترام

رئيس قسم المواد الكيميائية

مرفق نسخة من الاستبيان باللغة العربية والانجليزية
سلوى

بدالة: 22208410 - 22208310 :Opr.
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

Appendix C

Kuwait Environment Public Authority's Letters to Governmental Organizations and One Private Company

الهيئة العامة للبيئة
وارد مكتب المدير العام
التاريخ: ٩ / ٤ / ٢٠١٧
الرقم: م.ع/ ٥٨١

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT

صادر
نائب المدير العام للشئون الفنية
رقم: ٣١٤
تاريخ: ٩ / ٤ / ٢٠١٧

التاريخ : ٢٠١٧/٤/٩
الرقم : م.ع/٥٨١

سعادة الفاضل / م. محمد محسن العنزي
نائب المدير العام لقطاع الشئون الفنية

المحترم

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

بالإشارة إلى الموضوع المذكور أعلاه، نرفق لسيادتكم كتب الجهات المعنية لجمع بعض البيانات الخاصة بمشروع البحث المذكور أعلاه، وهم التالي:

1- الإدارة العامة للجمارك.
2- الهيئة العامة للزراعة والثروة السمكية.
3- الهيئة العامة للصناعة.
4- وزارة التجارة والصناعة.
5- وزارة الصحة.
6- شركة السحب العالمية.

وعليه، نأمل منكم الاطلاع واتخاذ ما ترونه مناسباً.

وتفضلوا بقبول فائق الاحترام والتقدير

مدير مكتب الأبحاث والدراسات
شيخة الإبراهيم

سعادة المدير العام للموقر
٣١٨

اعداد/ أحمد الصايغ

بدالة: 22208410 – 22208310 :Opr.
ص.ب: ٢٤٣٩٥ الصفاة – الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

وارد
مكتب الأبحاث والدراسات
رقم: م أ / ٦٠
التاريخ : ١٣ / ٢ / ٢٠١٧

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

التاريخ : ١٢/ ٢ /٢٠١٧
الرقم : ٥٠٤٠٥ ب/٤٠٣/٧٩٤

المحترم
سعادة الفاضل/ مدير عام الهيئة العامة للزراعة والثروة السمكية
تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

تتقدم الهيئة العامة للبيئة بوافر الشكر والتقدير لجهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بلدنا الكويت الحبيبة.

بالإشارة إلى الموضوع المذكور أعلاه، يسرنا إخطاركم بأن معهد الكويت للأبحاث العلمية يقوم حالياً بتنفيذ الدراسة المذكورة، وذلك بطلب ودعم من الهيئة العامة للبيئة، حيث تعتبر الدراسة أحد متطلبات اتفاقية (ميناماتا)، والتي تعدّ الكويت طرفًا فيها، وتتطلب هذه الدراسة جمع بعض البيانات المتعلقة بمشروع البحث سالف الذكر.

وعليه، نأمل منكم ترشيح ممثل من جهتكم الموقرة للتعاون ولتسهيل جمع البيانات والتنسيق معه خلال فترة المشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

12/2

الهيئة العامة للبيئة

لمزيد من الاستفسار:
السيد/ أحمد الصايغ - الهيئة العامة للبيئة هاتف: 99575159
السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 24989174

إعداد: أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن م ع للشئون الفنية: محمد العنزي
روجع: م ع

التراسل الإلكتروني G2G
البوابة العامة للبيئة

يحفظ
١٢/ ٢ /٢٠١٧

تلفون: 22208310 - فاكس : 22208455
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

التاريخ : ١٢/ ١٢/ ٢٠١٧
الرقم : ه ح ي/ ع م/ ٧٩٤

سعادة الفاضل/ مدير عام الإدارة العامة للجمارك المحترم

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

تتقدم الهيئة العامة للبيئة بوافر الشكر والتقدير لجهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بلدنا الكويت الحبيبة.

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وعليه، نأمل منكم ترشيح ممثل من جهتكم الموقرة للتعاون ولتسهيل جمع البيانات والتنسيق معه خلال فترة المشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

12/2

الهيئة العامة للبيئة

لمزيد من الاستفسار:
السيد/ أحمد الصايغ - الهيئة العامة للبيئة هاتف: 99575159
السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 24989174

إعداد: أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن.م.ع للشئون الفنية: محمد العنزي
روجع: م.ع

التراسل الإلكتروني G2G
الهيئة العامة للبيئة

يحفظ
١٢/ ١٢/ ٢٠١٧

تلفون: 22208310 - فاكس : 22208455
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

التاريخ : ١٢/ ٢/ ٢٠١٧
الرقم : ه ع ب/ ع م/ ٧٩٤

المحترم

سعادة الفاضل/ مدير عام الهيئة العامة للصناعة

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

تتقدم الهيئة العامة للبيئة بوافر الشكر والتقدير لجهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بلدنا الكويت الحبيبة.

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وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

12/2

الهيئة العامة للبيئة

لمزيد من الاستفسار:
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السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 24989174

إعداد: أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن.م.ع للشئون الفنية محمد العنزي
روجع: م.ع

التراسل الإلكتروني G2G الهيئة العامة للبيئة

تلفون: 22208310 - فاكس : 22208455
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

التاريخ : ٢٠١٧/٢/١٢
الرقم : ع.ع.ب/٧٩٤/٤٠٣/٢٠١٧

المحترم

سعادة الفاضل/ وكيل وزارة الصحة

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

تتقدم الهيئة العامة للبيئة بوافر الشكر والتقدير لجهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بلدنا الكويت الحبيبة.

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وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

12/2

الهيئة العامة للبيئة

لمزيد من الاستفسار:
السيد/ أحمد الصايغ - الهيئة العامة للبيئة هاتف: 99575159
السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 24989174

إعداد: أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن.م.ع للشئون الفنية: محمد العنزي
روجع: م.ع

التراسل الالكتروني G2G

٢٠١٧/٢/١٢

تلفون: 22208310 - فاكس : 22208455
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

التاريخ : ٢٠١٧/٢/١٢
الرقم : ه.ع-ب/٤٠٣/٧٩٤

المحترم

سعادة الفاضل/ وكيل وزارة التجارة والصناعة

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

تتقدم الهيئة العامة للبيئة بوافر الشكر والتقدير لجهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بلدنا الكويت الحبيبة.

بالإشارة إلى الموضوع المذكور أعلاه، يسرنا إخطاركم بأن معهد الكويت للأبحاث العلمية يقوم حالياً بتنفيذ الدراسة المذكورة، وذلك بطلب ودعم من الهيئة العامة للبيئة، حيث تعتبر الدراسة أحد متطلبات اتفاقية (مينا ماتا). والتي تعدّ الكويت طرفًا فيها، وتتطلب هذه الدراسة جمع بعض البيانات المتعلقة بمشروع البحث سالف الذكر.

وعليه، نأمل منكم ترشيح ممثل من جهتكم الموقرة للتعاون ولتسهيل جمع البيانات والتنسيق معه خلال فترة المشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

12/2

الهيئة العامة للبيئة

لمزيد من الاستفسار:
السيد/ أحمد الصايغ - الهيئة العامة للبيئة هاتف: 99575159
السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 24989174

إعداد: أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن.م.ع المشئون الفنية: محمد العنزي
روجع. م.ع

التراسل الالكتروني G2G
الهيئة العامة للبيئة

يحفظ

١٢/٢/٢٠١٧

تلفون: 22208310 - فاكس : 22208455
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

التاريخ : ١٢/ ٢/ ٢٠١٧
الرقم : ه ع ب/ ٧٩٤/ ٢٠١٧

المحترم

سعادة الفاضل/ مدير عام شركة السحب العالمية

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

تتقدم الهيئة العامة للبيئة بوافر الشكر والتقدير لجهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بلدنا الكويت الحبيبة.

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وعليه، نأمل منكم ترشيح ممثل من جهتكم الموقرة للتعاون ولتسهيل جمع البيانات والتنسيق معه خلال فترة المشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

12/2

الهيئة العامة للبيئة

لمزيد من الاستفسار:
السيد/ أحمد الصايغ - الهيئة العامة للبيئة هاتف: 99575159
السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 24989174

إعداد: أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن.م.ع للشئون الفنية: محمد العنزي
روجع: م.ع

14/2/17

تلفون: 22208310 – فاكس : 22208455
ص.ب: ٢٤٣٩٥ الصفاة – الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

Appendix D

Kuwait Environment Public Authority's Letters to Al-Souhub General Trading and Contracting Company

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

التاريخ : ١٢/ ٢/ ٢٠١٧
الرقم : ه ع ب/ ٧٩٤/ ٢٠١٢

المحترم

سعادة الفاضل/ مدير عام شركة السحب العالمية

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

تتقدم الهيئة العامة للبيئة بوافر الشكر والتقدير لجهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بلدنا الكويت الحبيبة.

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وعليه، نأمل منكم ترشيح ممثل من جهتكم الموقرة للتعاون ولتسهيل جمع البيانات والتنسيق معه خلال فترة المشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

12/2

الهيئة العامة للبيئة

لمزيد من الاستفسار:
السيد/ أحمد الصايغ - الهيئة العامة للبيئة هاتف: 99575159
السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 24989174

إعداد: أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن.م ع للشئون الفنية: محمد العنزي
روجع: م.ع

14/2/17

تلفون: 22208310 – فاكس : 22208455
ص.ب: ٢٤٣٩٥ الصفاة – الكويت ١٣١٠٤
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الموقع الالكتروني: www.epa.org.kw

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شركة السحب العالمية
للتجارة العامة والمقاولات

وارد
لقطاع شئون الرقابة البيئية
٢٠١٨ / ٨ / ١٣
٥٩٧٢

الهيئة العامة للبيئة
الوارد
الرقم: ٤٩٥٢
التاريخ: ١٨/٨/٨

الهيئة العامة للبيئة
صادر مكتب المدير العام
التاريخ: ١٤ / ٨ / ٢٠١٨
الرقم: م.ع/ ٤٦٠٣

رقم: ش.س.ع - 750/ 80 / 2018

الكويت في: 07 أغسطس 2018

وارد إدارة السلامة الكيميائية ١٦/٨/١٨
رقم ٣٧٠٣

	العمل اللازم	للإفادة	للعلم	مراجعتي	تجميع فردي
قسم تراخيص المواد الكيميائية					
قسم إنتاج وتداول المواد الكيميائية	✓				

١٨ ٨ ١٥ ١٩٠

السيد/ مدير عام الهيئة العامة للبيئة المحترم ،،،

تحية طيبة وبعد ،،

الموضوع: رد/ معلومات عن مادة الزئبق (Mercury) .

بالإشارة إلى كتابكم لنا بتاريخ 2018/07/12 – رقم: ه.ع.ب/ م.ع/ 4022 بخصوص الموضوع المذكور أعلاه – مرفق صورة الكتاب ،

تجدون مرفقا كشف توضيحي لعدد (6) شركات مستوردة لشحنات كانت تحتوي على مادة الزئبق " Mercury "بالإضافة لكمية الشحنة و وحدة قياس الوزن .

الهيئة العامة للبيئة
إدارة السلامة الكيميائية
قسم انتاج وتداول المواد الكيميائية
التاريخ: ١٦ / ٨ / ٢٠١٨
وارد رقم: أ.ت.م.ك/ ٦٩٨

وتفضلوا بقبول فائق الشكر والاحترام ،،

المدير العام

	اجراء اللازم	للإفادة	مراجعتي	للعلم	اعداد الرد
نائب المدير العام للشئون الإدارية والمالية					
نائب المدير العام للشئون الفنية					
نائب المدير العام لشئون الرقابة البيئية	✓				

المدير العام

السيدة/ دانة المقرد
للعمل اللازم
١٦/٨

Dajeej - Dalal Complex - Mezzanine - Office No.: 27 - 28 - 29 - P.O.Box: 488 Abu Halifa 54755 Kuwait - Tel.No.: +965 24312172 - 24312178
الضجيج – مجمع دلال – الميزانين – مكتب رقم : ٢٧ – ٢٨ – ٢٩ – ص.ب ٤٨٨ أبو حليفة ٥٤٧٥٥ الكويت – تلفون رقم : ٢٤٣١٢١٧٨ – ٢٤٣١٢١٧٢ +٩٦٥
E-mail: al.souhub@hotmail.com : البريد الإلكتروني

الهيئة العامة للبيئة
دولة الكويت

مكتب المدير العام

التاريخ : ١٢/٧/٢٠١٨م
الرقم : ه ح ب/م ع/٢٠٢٢/٤

السيد الفاضل/مدير عام شركة السحب العالميه

المحترم

تحية طيبة وبعد،

الموضوع: طلب معلومات عن مادة الزئبق

بناء على مشروع قياس انبعاثات نسبة الزئبق في الهواء والمشترك بين الهيئة العامة للبيئة ومعهد الكويت للأبحاث العلمية، وكون دولة الكويت طرفا في اتفاقية ميناماتا فإنه يلزم تزويدنا بمعلومات عن مادة الزئبق (Mercury) وتوفير البيانات كما في الجدول المرفق. نأمل إفادتنا بالبيانات المطلوبة والمذكورة أعلاه بالسرعة الممكنة نظرا لارتباط دولة الكويت بالاتفاقيات.

اسم المادة	الشركات المستوردة	كمية كل شحنة	مواد يدخل في تركيبها الزئبق
الزئبق (Mercury)			

وتفضلوا بقبول فائق الاحترام والتقدير

المدير العام

م/محمد محسن العنزي
نائب المدير العام للشئون الفنية

الهيئة العامة للبيئة

م/دانه الفدغم
مدير إدارة السلامة الكيميائية: د. مشعل الابراهيم
نائب المدير العام لشئون الرقابة البيئية

بدالة: 22208310 - فاكس: 22208455
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
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شركة السحب العالمية
للتجارة العامة والمقاولات

شحنات تحتوى على الزيبق

	اسم الشركة المستوردة	اسم المادة	كمية الشحنة	وحدة الكمية
1	Atlas International Gen Trad	Mercury (Metal) AR 04596	25	KILOGRAM
2	Atlas Logistics & General Trading Co.	Mercury (Metal) AR 04596	25	KILOGRAM
3	Atlas Logistics & General Trading Co.	Mercury (Metal) AR 04596	40	KILOGRAM
4	Hamel Factory for Electrical Lighting	Mercury	5	KILOGRAM
5	Al Majid International Co	Mercury 261017	250	GRAM
6	Al Majid International Co	Mercury 261017	750	GRAM

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الضجيج - مجمع دلال - الميزانين - مكتب رقم : ٢٧ - ٢٨ - ٢٩ - ص.ب ٤٨٨ أبو حليفة ٥٤٧٥٥ الكويت - تلفون رقم : ٢٤٣١٢١٧٨ - ٢٤٣١٢١٧٢ +٩٦٥
E-mail: al.souhub@hotmail.com : البريد الإلكتروني

الهيئة العامة للبيئة
دولة الكويت

مكتب المدير العام

RECEIVED
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30 JUL 2019
No: 1614

التاريخ : ٢٠١٩/٧/٢٨
الرقم : ه ع ب/ام ع/ ٦٢٨١

المحترمة

سعادة الدكتورة/ سميرة السيد عمر
مدير عام معهد الكويت للأبحاث العلمية
تحية طيبة وبعد،

الموضوع: التدريب لمشروع قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي

يهديكم الهيئة العامة للبيئة خالص التحيات، شاكرة لكم عملكم الدؤوب وجهودكم المستمرة، وتعاونكم في تطوير البحث العلمي والمحافظة على البيئة.

بالإشارة إلى كتابكم رقم (م ع/912/22/909) المرسل بتاريخ 2019/4/29 بشأن الموضوع المذكور أعلاه، نرفق لكم نسخة ورقية والكترونية (قرص مدمج CD) بالبيانات الخاصة بمادة الزئبق ومركباته والتي تعتبر بيانات سرية يمنع الكشف عنها والإطلاع عليها من غير المصرح بهم، وهي خاصة فقط بالمشروع وتم الحصول عليها من قبل الجهات التالية:

1. إدارة المخلفات في الهيئة العامة للبيئة.
2. وزارة الصحة.
3. وزارة التجارة والصناعة.
4. الإدارة المركزية للإحصاء.
5. الإدارة العامة للجمارك.
6. شركة السحب العالمية.

كما نود أن نحيطكم علما بترشيح عدد (4) من موظفين الهيئة العامة للبيئة للتدريب على كيفية استخدام جهاز الزئبق وعمل التحاليل وكذلك جمع العينات والفحوصات من الورش وعيادات الأسنان وهم:

EMO87C

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الهيئة العامة للبيئة
دولة الكويت

مكتب المدير العام

التاريخ : ———————

الرقم : ———————

م	الاسم	الإدارة
.1	السيدة/ شهد السعدون	مركز المختبرات التحليلية
.2	السيد/ يوسف المنصور	مركز المختبرات التحليلية
.3	السيدة/ خلود المشموم	رصد جودة الهواء
.4	السيدة/ عهود الحميدي	رصد جودة الهواء

ونود أن نوجه عنايتكم بقيام معهد الكويت للأبحاث العلمية بتسليم الجهاز الخاص بقياس الزئبق إلى الإدارة المعنية في الهيئة العامة للبيئة فور انتهاء المشروع وذلك حسب ما ذكر في توصيات الاجتماع الخاص بمستجدات المشروع بتاريخ 2019/1/30 والذي عقد بين مكتب الأبحاث والدراسات والباحث الرئيسي السيدة/ليلى العوضي وفرق المشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة - المدير العام

28/7

* مرفق:
البيانات الخاصة بمادة الزئبق (قرص مدمج CD)

إعداد/ عذاري السعيد
مدير مكتب الأبحاث والدراسات

بدالة: 22208310 - فاكس: 22208455
ص. ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
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الموقع الالكتروني: www.epa.org.kw

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شركة السحب العالمية
للتجارة العامة والمقاولات

وارد	مستلم نوبة مكتب المدير العام لقطاع شئون الرقابة البيئية
٧٣٩	٢٠١٩/ ٢ / ٧

صادر	عبدالكريم نائب المدير العام لقطاع شئون الرقابة البيئية
٤٦٨	٢٠١٩ / ٢ / ١١

الكويت في: 04 فبراير 2019

رقم: ش.س.ع - 850/ 02 /2019

الهيئة العامة للبيئة
صادر مكتب المدير العام
07 FEB 2019
الرقم: م.ع/ ٩-١١

الهيئة العامة للبيئة
إدارة السلامة الكيميائية
قسم انتاج وتداول المواد الكيميائية
التوقيع ١٨ / ٢ / ٢٠١٩
الرقم المرجعي/ ٤٥٤

السيد/ مدير عام الهيئة العامة للبيئة المحترم ،،،

تحية طيبة وبعد ،،

الموضوع: طلب بيانات عن مادة الزئبق ومركباتها

بالإشارة إلى الموضوع المذكور أعلاه وردا على كتابكم لنا رقم (ه.ع.ب/ م.ع/ 278) المؤرخ في 2019/01/15،

نرفق لكم طيه كشف بالبيانات الخاصة بمادة الزئبق وذلك بحسب طلبكم موضحة الشحنات التي احتوت على مادة الزئبق ومركبات مادة الزئبق وكميات كل منها خلال الفترة من 2016 حتى 2018.

وتفضلوا بقبول فائق الشكر والاحترام ،،

وارد إدارة السلامة الكيميائية ٢٠١٩/٢/١٨
رقم ٩٤٠

	أصلاً	الإفادة	للعلم	مراجعتي	تعيينه
نسخة لنائب المدير العام لقطاع شئون الرقابة البيئية					
المدير العام لقطاع شئون الرقابة البيئية	✓				

المدير العام

					6/2
					✓

مكتب نائب المدير العام لقطاع شئون الرقابة البيئية

مرفق:
- ✓ صورة كتابكم المذكور أعلاه.
- ✓ كشف بالشحنات التي احتوت على مادة الزئبق خلال الفترة من 2016 حتى 2018.
- ✓ كشف بالشحنات التي احتوت على مركبات مادة الزئبق خلال الفترة من 2016 حتى 2018.

Dajoej -Dalal Complex - Mezzanine - Office No.: 27 - 28 - 29 - P.O.Box: 488 Abu Halifa 54755 Kuwait - Tel.No.: +965 24312172 - 24312178
الضجيج- مجمع دلال - الميزانين - مكتب رقم : ٢٧ - ٢٨ - ٢٩ - ص.ب ٤٨٨ أبو حليفة ٥٤٧٥٥ الكويت - تلفون رقم : ٢٤٣١٢١٧٨ - ٢٤٣١٢١٧٢ ٩٦٥+
E-mail: al.souhub@hotmail.com : البريد الإلكتروني

شحنات تحتوي على مركبات مادة الزئبق لسنة 2016

رقم البيان	وحدة القياس	كمية الشحنة	اسم المادة	التاريخ	اسم الشركة المستوردة
67042	KG	0.2500	Mercury Chloride	6/12/2016	Kuwait Lab Co.

شحنات تحتوي على مركبات مادة الزئبق لسنة 2017

رقم البيان	وحدة القياس	كمية الشحنة	اسم المادة	التاريخ	اسم الشركة المستوردة
99848	GRAM	300.0000	Mercuric Oxide Red	7/11/2017	Atlas Logistics & General Trading Co.
99848	KG	2.0000	Mercuric Chloride	7/11/2017	Atlas Logistics & General Trading Co.
118008	GRAM	500.0000	Mercury Chloride	10/8/2017	Atlas Logistics & General Trading Co.

شحنات تحتوي على مركبات مادة الزئبق لسنة 2018

رقم البيان	وحدة القياس	كمية الشحنة	اسم المادة	التاريخ	اسم الشركة المستوردة
142059	KG	2.5000	Mercury Chloride	6/9/2018	Al Salem Chemical Services & Contr. Co.
154246	KG	0.1000	Mercuric Chloride	10/15/2018	Chemtech Global Gen.Trad. & Cont. Company W.L.L.
154246	KG	0.1000	Mercuric Chloride	10/15/2018	Chemtech Global Gen.Trad. & Cont. Company W.L.L.

Dajeej -Dalal Complex - Mezzanine - Office No.: 27 - 28 - 29 - P.O.Box 488 Abu Halifa 54755 Kuwait - Tel.No.: +965 24312172 - 24312178
الضجيج - مجمع دلال - الميزانين - مكتب رقم : ٢٧ - ٢٨ - ٢٩ - ص.ب ٤٨٨ أبو حليفة ٥٤٧٥٥ الكويت - تلفون رقم : ٢٤٣١٢١٧٨ - ٢٤٣١٢١٧٢ +٩٦٥
E-mail: al.souhub@hotmail.com : البريد الإلكتروني

شحنات تحتوى على مادة الزئبق لسنة 2017

رقم البيان	وحدة الكمية	كمية الشحنة	نوع المادة	التاريخ	اسم الشركة المستوردة
83595	KG	5.0000	Mercury	11/01/2017	Hamel Factory for Electrical Lighting

Appendix E

Letters to Ministry of Health Hospitals

وارد
مكتب الأبحاث والدراسات
رقم: م أ د / ١٧٠
التاريخ : ٩ / ٥ / ٢٠١٧

ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

التاريخ : ٧/٥/٢٠١٧
الرقم : ه ع ب/ع م/٢٣٠٣

المحترم

سعادة الفاضل/ وكيل وزارة الصحة

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي"

تتقدم الهيئة العامة للبيئة لكم بوافر الشكر والتقدير لجهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بلدنا الكويت الحبيبة.

بالإشارة إلى الموضوع المذكور أعلاه، يسرنا إخطاركم بأن معهد الكويت للأبحاث العلمية يقوم حالياً بتنفيذ الدراسة المذكورة، وذلك بطلب ودعم من الهيئة العامة للبيئة، حيث تعتبر الدراسة أحد متطلبات اتفاقية (مينا ماتا)، والتي تعدّ الكويت طرفًا فيها، وتتطلب هذه الدراسة جمع بعض البيانات المتعلقة بمشروع البحث سالف الذكر.

وعليه، نأمل منكم الموافقة على وضع أجهزة في عيادات الأسنان والمختبرات والمخازن وأي مكان يتواجد فيه الزئبق في المستشفيات والمستوصفات والعيادات الحكومية والخاصة، علماً بأنه هذه الأجهزة لا تأذي المرضى وهي صغيرة الحجم.

ونأمل ترشيح ممثل من جهتكم الموقرة للتعاون ولتسهيل وضع الأجهزة والتنسيق معه خلال فترة المشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

لمزيد من الاستفسار:
السيد/ أحمد الصايغ - الهيئة العامة للبيئة هاتف: 99575159
السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 99812418

إعداد/أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن.م.ع للشئون الفنية/ محمد العنزي
روجع: م.ع

الهيئة العامة للبيئة
التراسل الإلكتروني G2G

تلفون: 22208310 – فاكس : 22208455
ص.ب: ٢٤٣٩٥ الصفاة – الكويت ١٣١٠٤

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الهيئة العامة للبيئة
وارد مكتب المدير العام
التاريخ: ٢٠١٧/٥/٤
الرقم: م.ع/١٩٧٥

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT

وارد
نائب المدير العام للشئون الفنية
رقم: ١٦٥
تاريخ: ٢٠١٧/٤/٣٠ 20

التاريخ: ٢٠١٧/٤/٢٥
الرقم: م.أ.د/١٥٦

صادر
نائب المدير العام للشئون الفنية
رقم: ١٤١
تاريخ: ٢٠١٧/٥/٢ 20

المحترم

سعادة الفاضل / م. محمد محسن العنزي
نائب المدير العام لقطاع الشئون الفنية
تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي"

بالإشارة إلى الموضوع المذكور أعلاه، نرفق لسيادتكم الكتاب الموجه لوزارة الصحة والخاص بالمشروع البحثي سالف الذكر، وذلك لتسهيل عملية وضع أجهزة لقياس نسبة الزئبق بالعيادات والمختبرات والمخازن وأي مكان يستخدم فيه الزئبق بالمستشفيات والمستوصفات الحكومية أو الخاصة.

وعليه، نأمل منكم الاطلاع واتخاذ ما ترونه مناسباً.

وتفضلوا بقبول فائق الاحترام والتقدير

مدير مكتب الأبحاث والدراسات
شيخة الإبراهيم
٢٠١٧/٤/٢٤

سعادة المدير العام للوقر
٢٠١٧/٥/١

إعداد/ أحمد الصايغ

بدالة: Opr.: 22208310 - 22208410
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

معهد الكويت للأبحاث العلمية Kuwait Institute for Scientific Research
مكتب المدير العام Office of the Director General

التاريخ : 2019/06/30 Date :
مرجع رقم : م ع/1339/22/1211 Ref. No.:

السيد/ وكيل وزارة الصحة المحترم
وزارة الصحة

تحية طيبة وبعد،

الموضوع: مشروع بحث " قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي EM087C"

بدايةً يتقدم مركز أبحاث البيئة والعلوم الحياتية بمعهد الكويت للأبحاث العلمية بالشكر الجزيل لوزارتكم الموقرة على تعاونكم المستمر ودعمكم لنا وجهودكم المبذولة لإنجاح المشروع المذكور، ويسرنا إفادتكم بأن المعهد يقوم حالياً بمشروع بحثي بعنوان "قياس مستويات الزئبق ومصادرها المتوقعة فى الهواء" بالتعاون مع الهيئة العامة للبيئة، وتعتبر هذه الدراسة من الدراسات المهمة لمتطلبات اتفاقية (ميناماتا) الدولية التي تم التوقيع عليها مؤخراً من قبل دولة الكويت كطرف أساسي فيها، وعليه يرجى تزويدنا بالآتي:-

- كميات أو عدد حشوات الأسنان بالزئبق (حشوات الأملغمة) المستوردة من قبل وزارة الصحة بالكيلو جرام لكل سنة.
- مقدار الزئبق بالجرامات المستخدم في حشوة الأملغمة الواحدة في عيادات طب الأسنان.
- بيانات حول إجمالي مقدار الزئبق المستخدم في قطاع طب الأسنان بالدولة.
- كمية الحشوات المستهلكة أو المستخدمة بشكل سنوي لكل كيلو جرام لكل سنة.
- ما هي الطرق المتبعة لديكم للتخلص من نفايات أملغمة الأسنان المحتوية على الزئبق (حسب اتفاقية ميناماتا)
- بيانات حول النسبة المئوية من عيادات طب الأسنان التي تستخدم مرشحات أملغمة عالية الكفاءة.
- بيانات حول توزيع نفايات أملغمة الأسنان من عيادات طب الأسنان بين النفايات العامة وإعادة التدوير والنفايات الخطرة والنفايات الطبية.

ص.ب: 24885 الكويت - الصفاة 13109 - تلفون: 24836105 - 24817302 فاكس: 24836637 - الموقع الالكتروني: www.kisr.edu.kw
P.O.Box 24885 Safat, 13109 Kuwait - Telephone: 24836105 - 24817302 - Fax: 24836637 - Website: www.kisr.edu.kw

- ما هي استخداماتكم الأخرى لعنصر الزئبق ومركباته في وزارتكم الموقرة أي بمعنى (الزئبق المُشترى للإنتاج سنوياً).

كما أننا نأمل منكم الموافقة على وضع أجهزة صغيرة الحجم في بعض عيادات الأسنان الحكومية علماً بأن هذه الأجهزة لا تشكل ضرراً على صحة المرضى. كما نود توزيع استبيان عن عنصر الزئبق واستيفاءه من قبل أطباء الأسنان والأشخاص الذين يتعاملون مع هذا العنصر ومركباته في وزارتكم الموقرة. وعليه يرجى التكرم بترشيح ممثل للوزارة من قبلكم للتعاون معنا ولتسهيل عملية وضع الأجهزة والتنسيق معه خلال فترة المشروع.

للتنسيق والاستفسار حول هذا الموضوع يرجى التواصل مع رئيسة المشروع الباحثة/ ليلى العوضي على الأرقام التالية:- (نقال:99812418- داخلي: 24956585 -24989174) .آملين استمرار التعاون فيما بيننا لما يخدم مصلحة بلدنا الحبيب الكويت.

شاكرين لكم حسن تعاونكم معنا.

وتفضلوا بقبول فائق الاحترام ،،،

د. سهيرة أحمد السيد عمر

Appendix F

Letters to Kuwait Oil Company's Hospital (Dental Clinic) in Ahmadi

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

وارد
مكتب الأبحاث والدراسات
رقم: م أ د/ ١٧١
التاريخ: ٩ / ٥ / ٢٠١٧

التاريخ: ٧/٥/٢٠١٧
الرقم: ه ع-ب ا م/ ع-٣٢٢٠

المحترم

سعادة الفاضل الدكتور/ عماد عوض
مدير مستشفى شركة نفط الكويت

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي"

تتقدم الهيئة العامة للبيئة لكم بوافر الشكر والتقدير لجهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بلدنا الكويت الحبيبة.

بالإشارة إلى الموضوع المذكور أعلاه، يسرنا إخطاركم بأن معهد الكويت للأبحاث العلمية يقوم حالياً بتنفيذ الدراسة المذكورة، وذلك بطلب ودعم من الهيئة العامة للبيئة، حيث تعتبر الدراسة أحد متطلبات اتفاقية (مينا ماتا)، والتي تعدّ الكويت طرفًا فيها، وتتطلب هذه الدراسة جمع بعض البيانات المتعلقة بمشروع البحث سالف الذكر.

وعليه، نأمل منكم الموافقة على وضع أجهزة في عيادات الأسنان والمختبرات والمخازن وأي مكان يتواجد فيه الزئبق في المستشفى، علماً بأنه هذه الأجهزة لا تأذي المرضى وهي صغيرة الحجم.

ونأمل ترشيح ممثل من جهتكم الموقرة للتعاون ولتسهيل وضع الأجهزة والتنسيق معه خلال فترة المشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

715

لمزيد من الاستفسار:
السيد/ أحمد الصايغ - الهيئة العامة للبيئة هاتف: 99575159
السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 99812418

إعداد/أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن.م.ع للشئون الفنية/ محمد العنزي
روجع: م.ع

تلفون: 22208310 – فاكس: 22208455
ص.ب: ٢٤٣٩٥ الصفاة – الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

5

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT

الهيئة العامة للبيئة
وارد مكتب المدير العام
التاريخ: ٤ / ٥ / ٢٠١٧
الرقم: م ع / ١٩٧٩

وارد
نائب المدير العام للشئون الفنية
رقم: ١٠٦٣ /
تاريخ: ٣٠ / ٤ / 20١٧

التاريخ : ٢٠١٧/٤/٩٦
الرقم : ١٥٩/د.أ.ب.م

صادر
نائب المدير العام للشئون الفنية
رقم: ١٤٥ /
تاريخ: ٢ / ٥ / 20١٧

المحترم

سعادة الفاضل / م. محمد محسن العنزي
نائب المدير العام لقطاع الشئون الفنية
تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي"

بالإشارة إلى الموضوع المذكور أعلاه، نرفق لسعادتكم الكتاب الموجه لمدير مستشفى شركة نفط الكويت والخاص بالمشروع البحثي سالف الذكر، وذلك لتسهيل عملية وضع أجهزة لقياس نسبة الزئبق بالعيادات والمختبرات والمخازن وأي مكان يستخدم فيه الزئبق بالمستشفى التابع لشركة نفط الكويت.

وعليه، نأمل منكم الاطلاع واتخاذ ما ترونه مناسباً.

وتفضلوا بقبول فائق الاحترام والتقدير

مدير مكتب الأبحاث والدراسات
شيخة الإبراهيم
٢٠١٧/٤/٩٦

سعادة المدير العام للوقر
٥/٤

إعداد/ أحمد الصايغ

بدالة: Opr.: 22208310 - 22208410
ص.ب : ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

التاريخ : 2019/6/25
مرجع رقم :

Date :
Ref. No. :

الدكتور/ عبدالعزيز القبندي المحترم
رئيس فريق خدمات طب الأسنان
مستشفى شركة نفط الكويت

تحية طيبة وبعد،

الموضوع: مشروع بحث " قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي EM087C"

بالإشارة إلى الموضوع المذكور أعلاه، يرجي العلم بأن مركز أبحاث البيئة والعلوم الحياتية بمعهد الكويت للأبحاث العلمية يقوم حالياً بدراسة لتحديد مستويات الزبئق ومصادرها فى البيئة وذلك بالتعاون مع الهيئة العامة للبيئة، وتعتبر هذه الدراسة من الدراسات المهمة لمتطلبات اتفاقية (مينماتا) الدولية التي تم التوقيع عليها مؤخراً من قبل دولة الكويت كطرف أساسي فيها

وعليه يرجى تزويدنا بالآتي:

1- كميات أو عدد حشوات الأسنان بالزئبق (حشوات الأملغمة) المستوردة من قبل شركتكم بالكيلو جرام لكل سنة.
2- مقدار الزئبق بالجرامات المستخدم في حشوة الأملغمة الواحدة في عيادات طب الأسنان.
3- متوسط عدد الحشوات للفرد من شركتكم لكل سنة خلال الخمس سنوات السابقة.
4- بيانات حول إجمالي مقدار الزئبق المستخدم في قطاع طب الأسنان لشركتكم الموقرة.
5- كمية الحشوات المستهلكة أو المستخدمة بشكل سنوي لكل كيلو جرام لكل سنة.
6- ما هي الطرق المتبعة لديكم للتخلص من نفايات أملغمة الأسنان المحتوية على الزئبق (حسب اتفاقية مينماتا)
7- بيانات حول النسبة المئوية من عيادات طب الأسنان التي تستخدم مرشحات أملغمة عالية الكفاءة.
8- بيانات حول توزيع نفايات أملغمة الأسنان من عيادات طب الأسنان بين النفايات العامة وإعادة التدوير والنفايات الخطرة والنفايات الطبية.

ص.ب: ٢٤٨٨٥ الكويت - الصفاة 13109 - تلفون: ٢٤٩٨٩٠٠٠ - فاكس: ٢٤٨٤٦٨٩١ - الموقع الالكتروني: www.kisr.edu.kw
P.O.Box 24885 Safat, 13109 Kuwait - Telephone: 24989000 - Fax: 24846891 - Website: www.kisr.edu.kw

للتنسيق والاستفسار حول الموضوع يرجى التكرم بالاتصال على الباحثة/ ليلى العوضي (نقال:99812418-داخلي: 24956585-24989174) .آملين استمرار التعاون فيما بيننا لما يخدم مصلحة بلدنا الحبيب الكويت.

شاكرين لكم حسن تعاونكم معنا.

وتفضلوا بقبول فائق الاحترام ،،،

الدكتور/ محمد الراشد

القائم بأعمال المدير التنفيذي

لمركز أبحاث البيئة والعلوم الحياتية

السيد الدكتور / محمد الراشد المحترم

تحيه طيبه وبعد :

الموضوع / مشروع بحث قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي

بالاشاره الي الموضوع اعلاه وردنا علي أسنلتكم كل الأتيه:-

1-عدد حشوات الاسنان بالزئبق المستوردة سنوياً 500 حبه (Megalloy EZ)

Contents 600mg alloy

Contains 42% Mercury 252mg

2- مقدار الزئبق للحشوه الواحده 252mg للكبسوله

3- متوسط عدد الحشوات للفرد لكل سن 1.4 حشوه

4-مقدار الزئبق المستخدم 252×571.1=143,9174 mg سنوياً

5- كميه الحشوات المستهلكه 600×571.1=342,660Mg سنوياً

6- الموردون منوطون بهذا الأمر ويعملون بموجب المعايير العالمية .

7- جميع العيادات تستخدم مرشحات عاليه الكفاءه حسب المواصفات العالميه ومواصفات وزاره الصحه

8- الموردون منوطون بهذا الأمر ويعملون بموجب المعايير العالمية .

د عبدالعزيز القبندي

رئيس فريق خدمات طب الاسنان

مستشفى شركة نفط الكويت

Dr. Abdulaziz AlQabandi
Medical Consultant (Orthodontics)
Ahmadi Hospital

Appendix G

Letters to Kuwait Cement Company

Kuwait Institute for Scientific Research معهد الكويت للأبحاث العلمية

Date : 14 July 2019 التاريخ :
Ref. No. : ED/ELSRC 10/63/133 مرجع رقم :

Rashed Abdulaziz Al-Rashed
Chairman
Kuwait Cement Company

Dear Mr. Al-Rashed,

Subject: Project entitled "Measurement of Mercury Levels in Ambient Air with their Probable Sources" – EM087C

Kuwait Environment Public Authority (KEPA) has requested Kuwait Institute for Scientific Research (KISR) to conduct an extensive study on mercury pollution in order to establish a standard baseline for mercury levels in air and to align Kuwait EPA with the latest international trends in reduction of mercury emissions from its sources. The State of Kuwait has become a signatory to the United Nation Minamata Convention on Mercury and the requested information will be beneficial for the State of Kuwait. We appreciate if the following are provided:

1. A visit to the main site
2. Types/Quantities of raw materials used such as coke, fuel, oil/gas, rock.
3. Raw materials and fuel samples (e.g. pebbles, coal, clinker and cement)
4. Fill out the attached questionnaire

Furthermore, we would be grateful if the Kuwait Cement company assigns a staff who will be the focal point for Kuwait Cement Company for all the activities related to this project. This will help in executing the project tasks smoothly and will assist in completing all the project objectives as planned.

We would appreciate your kind understanding and support in this regard.

Yours sincerely,

Dr. Mohammed Al-Rashed
Acting Executive Director
Environment and Life Sciences Research Center

ص.ب : ٢٤٨٨٥ الكويت – الصفاة 13109 – تلفون: ٢٤٩٨٩٠٠٠ – فاكس: ٢٤٨٤٦٨٩١ – الموقع الالكتروني: www.kisr.edu.kw
P.O.Box 24885 Safat, 13109 Kuwait - Telephone: 24989000 - Fax: 24846891 - Website: www.kisr.edu.kw

Your production facility for cement production with own clinker production has been identified as a potential source for releases of mercury

In order to more accurately compile our national inventory please provide us with and enter your data as requested in the table below. PLEASE FILL IN ALL THE BLANK BOXES IN THE TABLE BELOW. Kindly provide available data from 2010 onward till date.

Does your operation cover any of the following activities?	**Yes or No**	**Requested data covering your company's activity in KUWAIT**	**Annual production/use**	**Year for data provided**
Cement production		Tonnes cement produced per year		

We anticipate that you have the types of data requested above; should you however only have other data types for the same operations, please provide us with these data with clear indication of the units used.

For your production of cement (if any), please tick off (X) below the main air pollution control system you have in place in your facility (choose the configuration that is closest to the configuration in your facility):

For your production of cement, please describe your type of air pollution control system setup:_____

_____

Please also tick off (X) below the main air pollution control system you have in place in your facility (choose the configuration that is closest to the configuration in your facility):

Source sub-category	**Mercury control name**	**Explanation**	**Tick of pollution control system in your facility (X)**
Cement production	No filter		
	Simple particle control (ESP / PS / FF)	Simple particle control with electrostatic precipitators (ESP), particle scrubbers (PS) or fabric filters (FF, also called bag filters)	
	Optimized particle control (FF+SNCR / FF+WS / ESP+FGD / optimized FF)	"Optimized" particle control with fabric filters (FF) + selective non-catalytic reduction (SNCR) OR Fabric filters (FF)+ wet scrubbers (WS) OR Electrostatic precipitator (ESP) + flue gas de-sulphurisation (FGD) OR Optimized fabric filters (FF)	
	Efficient air pollution control (FF+DS / ESP+DS / ESP+WS / ESP+SNCR)	Efficient air pollution control with fabric filters (FF) + dry scrupper (DS) OR Electrostatic precipitator (ESP) + dry scrupper (DS) OR Electrostatic precipitator (ESP) + wet scrupper (WS) OR Electrostatic precipitator (ESP) + selective non-catalytic reduction (SNCR)	
	Very efficient Hg pollution control (wetFGD+ACI / FF+scrubber+ SNCR)	Very efficient Hg pollution control with wet flue gas de-sulphurisation (wetFGD) + activated carbon injection (ACI) OR Fabric filter (FF) + scrubber + selective non-catalytic reduction (SNCR)	

Please also forward us, as feasible, any additional documentation for the numbers provided and other information you may have at hand (e.g. direct measurements or information about emission controls in place).

Name and location of facility:

_____

Name and contact data for your contact person in case of questions:

_____

Kindly return your reply to this questionnaire to Ms. Layla Al-Awadi NO LATER THAN 2 weeks from receiving it:

Layla Al-Awadi
lawadi@kisr.edu.kw
CDS/ELSRC
Kuwait Institute for Scientific Research
P. O. Box 24885, 13109
Safat, Kuwait.
Tel. no.: +965-99812418

Thank you for your cooperation in this regard!

Sincerely

Ms. Layla Al-Awadi

KUWAIT CEMENT COMPANY K.S.C.P
شركة أسمنت الكويت ش.م.ك

Established in Accordance with Amiri Decree on 5 Nov. 1963 Paid Up Capital K. D. 73,330,387 E-mail: kcemco@kuwaitcement.com Website: www.kuwaitcement.com

REF. 1466/2019 الإشارة

Kuwait الكويت 01st August 2019

M/s. Kuwait Institute for Scientific Research,
P.O. Box 24885,
Code 13109 Safat,
KUWAIT.

Attn: Dr. Mohammed Al-Rashed, Acting Executive Director
Environment and Life Sciences Research Center
Ms. Layla Al-Awadi

Dear Sir/Madam,

Sub: Project entitled "Measurement of Mercury Levels in Ambient Air with their Probable Sources – EM087C

We acknowledge receipt of your letter ref. ED/ELSRC 10/63/133 dated 14th July 2019 regarding the subject matter, and have duly noted the contents therein.

As requested by you, please find attached herewith the questionnaire, duly filled-in, along with the types and quantities of raw materials used in the enclosed table. Also, you may visit our Cement Plant facility at East Shuaiba Industrial Area and can collect the required samples during your visit to our facility.

Please be informed that the following gentleman will be the Company's focul point for all the activities related to this project:

Eng. Saad Al-Suwaidan
Asst. Executive Director – Operations
Mobile# 9986-4744

Thank you for your co-operation.

Yours faithfully,
KUWAIT CEMENT COMPANY

(Abdulmutaleb I. Behbehani)
CHIEF EXECUTIVE OFFICER

شركة اسمنت الكويت (ش.م.ك.ع)
KUWAIT CEMENT COMPANY (K.S.C.P)

Encl. as above

تلفون: ٢٢٤٠١٧٠٠ (٩٦٥) - فاكس: ٢٢٤٤٠٨٩٦ - ٢٢٤٣٢٩٥٦ (٩٦٥) - ص . ب ٢٠٥٨١ الصفاة ١٣٠٦٦ الكويت - برقيا: سميتكو - سجل تجاري ١٥٣٢
Tel.: (965) 22401700 - Fax : (965) 22432956 - 22440896 - P.O.Box: 20581 Safat, 13066 Kuwait - Cable: SMEETCO - C.R.: 1532
Cement House - Sharq-Al-Sawaber - At intersection of Al-Shuhada St. with Khalid Bin Al-Waleed St. بيت الأسمنت - الشرق الصوابر - تقاطع شارع الشهداء مع شارع خالد بن الوليد

Your production facility for cement production with own clinker production has been identified as a potential source for releases of mercury

In order to more accurately compile our national inventory please provide us with and enter your data as requested in the table below. PLEASE FILL IN ALL THE BLANK BOXES IN THE TABLE BELOW. Kindly provide available data from 2010 onward till date.

Does your operation cover any of the following activities?	**Yes or No**	**Requested data covering your company's activity in KUWAIT**	**Annual production/use**	**Year for data provided**
Cement production	YES	Tonnes cement produced per year	ASPER THE DATA SHEET ENCLOSED	

We anticipate that you have the types of data requested above; should you however only have other data types for the same operations, please provide us with these data with clear indication of the units used.

For your production of cement (if any), please tick off (X) below the main air pollution control system you have in place in your facility (choose the configuration that is closest to the configuration in your facility):

For your production of cement, please describe your type of air pollution control system setup: As per the sheet enclosed.

Please also tick off (X) below the main air pollution control system you have in place in your facility (choose the configuration that is closest to the configuration in your facility):

Source sub-category	Mercury control name	Explanation	Tick of pollution control system in your facility (X)
Cement production	No filter		
	Simple particle control (ESP / PS / FF)	Simple particle control with electrostatic precipitators (ESP), particle scrubbers (PS) or fabric filters (FF, also called bag filters)	✓
	Optimized particle control (FF+SNCR / FF+WS / ESP+FGD / optimized FF)	"Optimized" particle control with fabric filters (FF) + selective non-catalytic reduction (SNCR) OR Fabric filters (FF)+ wet scrubbers (WS) OR Electrostatic precipitator (ESP) + flue gas de-sulphurisation (FGD) OR Optimized fabric filters (FF)	
	Efficient air pollution control (FF+DS / ESP+DS / ESP+WS / ESP+SNCR)	Efficient air pollution control with fabric filters (FF) + dry scrupper (DS) OR Electrostatic precipitator (ESP) + dry scrupper (DS) OR Electrostatic precipitator (ESP) + wet scrupper (WS) OR Electrostatic precipitator (ESP) + selective non-catalytic reduction (SNCR)	
	Very efficient Hg pollution control (wetFGD+ACI / FF+scrubber+ SNCR)	Very efficient Hg pollution control with wet flue gas de-sulphurisation (wetFGD) + activated carbon injection (ACI) OR Fabric filter (FF) + scrubber + selective non-catalytic reduction (SNCR)	

Please also forward us, as feasible, any additional documentation for the numbers provided and other information you may have at hand (e.g. direct measurements or information about emission controls in place).

Name and location of facility:

Kuwait Cement Company Factory, East Shuaiba Industrial Area

Name and contact data for your contact person in case of questions:

Eng. Saad Al-Suwaidan - Assistant Executice Director (Operations) - Mob: 99864744

Kindly return your reply to this questionnaire to Ms. Layla Al-Awadi NO LATER THAN 2 weeks from receiving it:

Layla Al-Awadi
lawadi@kisr.edu.kw
CDS/ELSRC
Kuwait Institute for Scientific Research
P. O. Box 24885, 13109
Safat, Kuwait.
Tel. no.: +965-99812418

Thank you for your cooperation in this regard!

Sincerely

Ms. Layla Al-Awadi

KUWAIT CEMENT COMPANY

ANNUAL RAW MATERIAL, FUEL,CEMENT REPORT IN METRIC TONS

	CEMENT		LIME STONE	IRON ORE	BAUXITE	SAND	GYPSUM	CLAY	SLAG	COPPER SLAG	LATERITE	FUEL OIL	COAL	TYRE CHIP
YEAR	PRODUCED	CONSUMED	RAW MATERIALS (CONSUMED)											
2010	1286064	1274880	1,011,101	28,382	70,457	134,301	39,125	14,309	0	0	0	354	8,637	0
2011	2068051	2061592	2,007,963	88,229	130,673	238,299	61,269	161,169	5,531	0	0	482	180,824	0
2012	2380041	2379865	2,767,060	53,800	149,632	364,697	65,889	66,068	28,028	19,318	33,975	270	255,762	0
2013	2427250	2415132	2,427,170	22,532	139,444	343,269	98,760	0	47,100	63,432	6,294	767	249,060	0
2014	2870396	2873024	3,187,121	0	205,776	483,861	119,311	0	46,920	118,819	0	436	326,954	0
2015	3083312	3078454	354,687	0	226,805	555,771	126,679	0	88,635	162,003	0	303	358,101	0
2016	3135978	3134018	3,603,327	12,884	234,920	523,626	125,232	0	178,336	152,684	0	256	353,899	0
2017	2971293	2972260	2,978,997	0	189,579	427,742	123,261	0	200,944	139,837	0	174	303,235	700
2018	3020264	3024238	3,029,124	10,381	178,969	431,794	135,201	0	147,472	129,614	0	248	302,517	0
2019	1592142	1592196	1,792,208	0	127,832	276,610	72,552	0	48,116	77,938	0	176	174,839	0

KUWAIT CEMENT COMPANY					
DUST MONITORING EQUIPMENTS					
KILN - 1 SECTION					
S.No	Location		Function	supplier	Equip No
1	Main stack	After bag filter	Dust monitoring	SICK	SICK OMD 41
2	Cooler stack	After ESP	Dust monitoring	SICK	SICK OMD 41

KILN - 2 SECTION					
S.No	Location		Function	supplier	Equip No
1	Main stack	After bag filter	Dust monitoring	DURAG	DR300B
2	Main stack	After bag filter	Continuous emmission monitoring system	FLS Airloq system	S-081774-CEMS-5
3	Cooler stack	After ESP	Dust monitoring	DURAG	DR300B

Kuwait Institute for Scientific Research معهد الكويت للأبحاث العلمية

Date : 21 October 2019
Ref. No. : ED/ELSRC 14/63/218

التاريخ :
مرجع رقم :

Mr. Rashed Abdulaziz Al-Rashed
Chairman
Kuwait Cement Company

Dear Mr. Al-Rashed,

Subject: Mercury Emissions Information from Raw-materials and Cement Production

As per the above-mentioned subject, KISR team has visited cement factory at Shuaiba Industrial Area on Sept. 26, 2019. We met Engr. Saad Al- Suwaidan and Executive Director, Mr. Rajesh Kumar and we appreciate their kind support for arranging the tour of the industrial laboratories and control rooms and explained the process details. They claimed that there are no mercury emissions, all particulate matter from the bag filters and electrostatic precipitators (ESP) was recycled to Klin to form clinkers.

Please provide the following informations

1. Information about the efficiency of emission control devices (bag filters & ESP).
2. Test report from NAPESCO as a softcopy to use it in the report for Kuwait-EPA project.
3. Full report from Fraunhofer UMSICHET prepared on March 20, 2017, as a softcopy to use it in the report for Kuwait-EPA project.
4. Total PM concentration from the stack
5. Stack emission of flue gas and volumetric flow rate at given (P, T) from the top of stack.
6. Detailed analysis of raw-materials and particular mercury concentrations that result in mercury emissions during the production process? This vital information is required for this project to access the mercury emissions.
7. Particulate matters samples that are produced during the process and collected on bag filters and electrostatic precipitators from the stack in order to have it analyzed in KISR laboratories.

We would appreciate your kind understanding and support in this regard.

Awaiting your reply.

Yours sincerely,

Dr. Mohammed Al-Rashed
Acting Executive Director
Environment and Life Sciences Research Center

ص.ب: ٢٤٨٨٥ الكويت - الصفاة 13109 - تلفون: ٢٤٩٨٩٠٠٠ - فاكس: ٢٤٨٤٦٨٩١ - الموقع الالكتروني: www.kisr.edu.kw
P.O.Box 24885 Safat, 13109 Kuwait - Telephone: 24989000 - Fax: 24846891 - Website: www.kisr.edu.kw

Appendix H

Kuwait Institute for Scientific Research's Team Visit to the Kuwait Cement Company

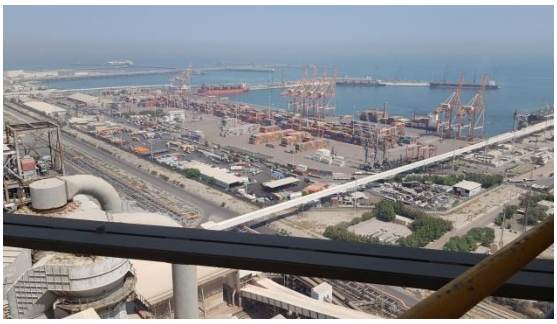







Plate H1. Random pictures taken during KISR's team visit to the Kuwait Cement Company.



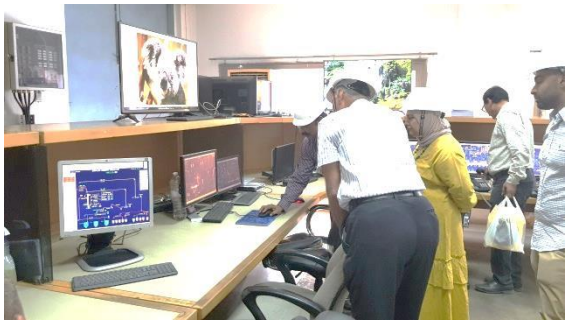





Plate H2. Random pictures taken during KISR's team visit to the Kuwait Cement Company.

Appendix I

Kuwait Institute for Scientific Research's Team Visit to the Kuwait Oil Company's Oil Fields



Plate I1. KISR's team with fire resistant clothing, safety boots, and helmets worn during the visit to KOC's oil fields.

Appendix J

Letters to Kuwait Petroleum Company and Kuwait Oil Company

وارد
مكتب الأبحاث والدراسات
رقم: م أ د / ٥٩
التاريخ : ١٣ / ٢ / ٢٠١٧ 20

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

التاريخ : ١٢/ ٢/ ٢٠١٧
الرقم : ه ع ب/ ٤٠٣/ ٧٩٥

المحترم
سعادة الفاضل/ الرئيس التنفيذي لمؤسسة البترول الكويتية

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

تتقدم لكم الهيئة العامة للبيئة بوافر الشكر والتقدير على جهودكم المبذولة وتعاونكم المستمر في تطوير العمل البيئي والمحافظة على بيئة بلدنا الحبيب.

بالإشارة إلى الموضوع المذكور أعلاه، يسرنا إخطاركم بأن معهد الكويت للأبحاث العلمية يقوم حالياً بتنفيذ الدراسة المذكورة سلفاً، وذلك بطلب ودعم من الهيئة العامة للبيئة، وهذه الدراسة تتطلب بعض البيانات وهي:

1- طلب بيانات التحاليل عن ملوثات الزئبق، وتكون هذه البيانات تفصيلية (يومي-شهري-سنوي) من عام 2012 حتى الآن، وتقدم هذه البيانات ببرنامج إكسل.
2- زيارة ميدانية للباحث للتعرف على الأجهزة المستخدمة وكيفية استخدام هذه الأجهزة وبعض الأسئلة التي سيقوم الباحث بالاستفسار عنها.

كما نأمل منكم ترشيح ممثل عن مؤسستكم الموقرة، وذلك للتنسيق معنا.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة – المدير العام

12/2

ولمزيد من الاستفسارات:

- السيد/ أحمد الصايغ الهيئة العامة للبيئة هاتف: 99575159
- السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية هاتف: 24989174

إعداد: أحمد الصايغ
مدير م. أ. د/ شيخة الإبراهيم
ن.م.ع للشئون الفنية: محمد العنزي
روجع: م.ع

الهيئة العامة للبيئة
التراسل الإلكتروني G2G الهيئة العامة للبيئة

تلفون: 22208310 - فاكس: 22208455
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104

الهيئة العامة للبيئة
ENVIRONMENT PUBLIC AUTHORITY KUWAIT

الهيئة العامة للبيئة
وارد مكتب المدير العام
التاريخ: ٩ / ٤ / ٢٠١٧
الرقم: م.ع/ ٥٨٩

صادر
نائب المدير العام للشئون الفنية
رقم: ٣١٢ /
تاريخ: ٨ / ٤ / 2017

التاريخ : ١٥/ ٤/ ٢٠١٧
الرقم : م.ع/ ١٥

المحترم

سعادة الفاضل / م. محمد محسن العنزي
نائب المدير العام لقطاع الشئون الفنية
تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

بالإشارة إلى الموضوع المذكور أعلاه، نرفق لسيادتكم الكتاب الموجه لمدير عام مؤسسة البترول الكويتية لأخذ بعض البيانات المطلوبة والتي تخدم المشروع المذكور أعلاه، وكذلك زيارة ميدانية للاطلاع على الأجهزة وكيفية استخدامها.

وعليه، يرجى التكرم بالاطلاع واتخاذ ما ترونه مناسباً.

وتفضلوا بقبول فائق الاحترام والتقدير

مدير مكتب الأبحاث والدراسات
شيخة الإبراهيم
٢٠١٧/ ٤/ ٢

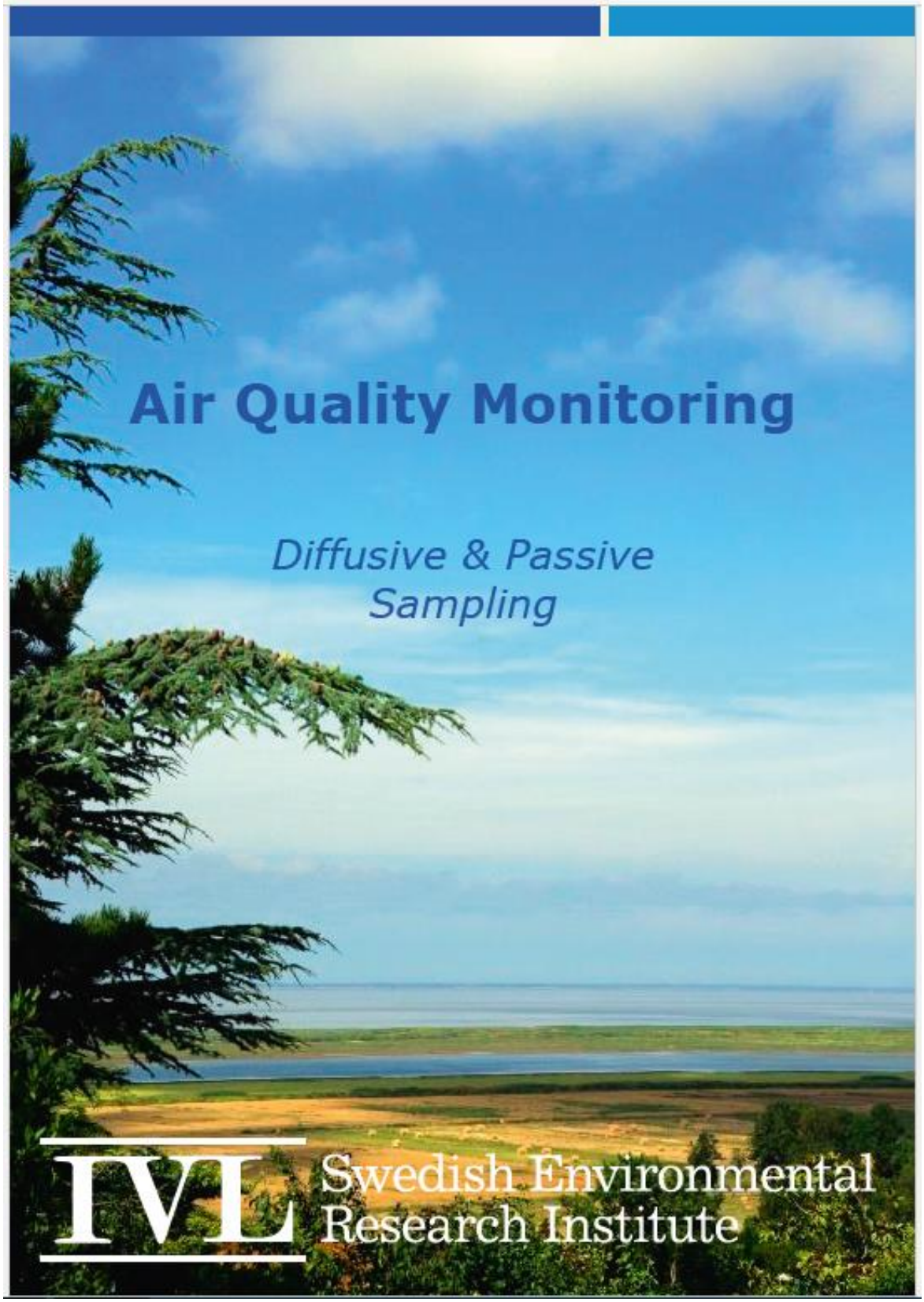
سعادة المدير العام للوقر
١٨/ ٤

إعداد/ أحمد الصايغ

بدالة: 22208310 - 22208410 Opr.:
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

Appendix K

Diffusive Passive Sampling Technique


Air Quality Monitoring
Diffusive & Passive Sampling
IVL
Swedish Environmental Research Institute

Consult IVL

IVL offers analysis of gas concentrations in ambient and indoor air using diffusive samplers. We can also offer investigations to solve specific problems.

Applicability

- Mapping concentration patterns in cities
- Air quality measurements at remote sites
- Personal monitoring
- Indoor monitoring
- Corrosion studies
- Study of long-term trends with no gaps in data
- Model validations
- Infrastructure planning
- Selection of sites for real-time monitors
- Epidemiological studies



www.diffusivesampling.ivl.se

Diffusive sampling technique

The technique is based on molecular diffusion of gases. The gas molecules diffuse into the sampler where they are quantitatively collected, which gives a concentration value integrated over time.

Turbulent diffusion inside the sampler is avoided by using a membrane at the inlet. Correct air concentrations are obtained if theoretical sampling rates are used.



Air concentration patterns being mapped in Johannesburg.

IVL's diffusive sampler is designed to avoid effects from wind and humidity as well as interferences and losses during storage. The samplers are thoroughly tested and verified and continually assessed. More components are added as needed.

The IVL laboratory is accredited according to ISO/IEC 17025 and performs about 15.000 analyses for diffusive samplers annually.



Advantages

- small, silent and light weight
- does not need electricity
- flexible with the exposure site location
- samplers can be stored at room temperature
- no skilled personnel needed at the sampling site
- samplers are conveniently sent to IVL by regular mail
- analysed at IVL's accredited laboratories

www.diffusivesampling.ivl.se

Passive particle sampler

Particular matter cannot be collected quantitatively using diffusive sampling. However, with a passive collector particles with a high deposition rate can be sampled and analysed.



This sampler has extensively been used in connection with corrosion studies as well as screening studies.

For more information about our passive sampler, please visit our website www.diffusivesampling.ivl.se

References

IVL's samplers have been used all over the world and in various locations, for example:

- Emission inventory validation in Kathmandu
- Mapping of air concentration in Johannesburg
- Corrosion studies in Athens
- Studies of volcanic gases in Italy

More references and areas of use can be found on our website www.diffusivesampling.ivl.se

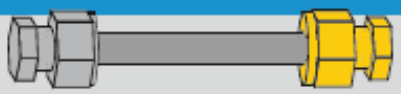
Short history

Our diffusive sampler was first developed in 1989 by IVL researcher Martin Ferm, who has developed several sampling techniques, for example a horizontal flux sampler for ammonia and a series of low cost PM_x samplers.

The first sampler including diffusion was the denuder, used for measuring very low NH_3 concentrations and first used in 1977.



www.diffusivesampling.ivl.se

Gas	Samplers
Sulphur dioxide (SO_2)	
Nitrogen dioxide (NO_2)	
Ammonia (NH_3)	
Ozone (O_3)	
Organic acids, HCl, HF	
Mercury (Hg)	
Nitric acid (HNO_3)	
VOC	

Two kits of samplers are available, one for indoor air and one for corrosion studies. We also supply for separate orders of individual samples.

IVL Swedish Environmental Research Institute is Sweden's leading institute for applied research in the fields of climate, energy, environment and sustainable growth.

IVL has accredited laboratories which ensure reliable, high quality analyses.

Please visit our websites for more information:

www.diffusivesampling.ivl.se

www.ivl.se

Contact persons:
Karin Sjöberg
+46-31-725-6245
karin.sjoberg@ivl.se

Martin Ferm
+46-31-725-6224
martin.ferm@ivl.se

Gunilla Pihl-Karlsson
+46-31-725-6208
gunilla.pihl.karlsson@ivl.se

IVL Swedish Environmental Research Institute

Appendix L

Letter to Kuwait Municipality

Kuwait Institute for Scientific Research
معهد الكويت للأبحاث العلمية
Office of the Director General
مكتب المدير العام

التاريخ : 2017/08/3
مرجع رقم : م ع/1617/30/1496

Date :
Ref. No.:

السيد/ مدير عام بلدية الكويت المحترم
بلدية الكويت

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

بالإشارة إلى الموضوع المذكور أعلاه، نود إحاطتكم علماً بأن مركز أبحاث البيئة والعلوم الحياتية بمعهد الكويت للأبحاث العلمية يقوم بإجراء مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة" بتمويل من قبل الهيئة العامة للبيئة. وعليه نرجو التكرم بالموافقة لفريق عمل المشروع بالدخول لمواقع ردم النفايات التابعة لإدارة شئون البيئة من أجل وضع أجهزة لجمع وقياس معدن الزئبق في الهواء الجوي.

وللتنسيق حول هذا الموضوع يرجى الاتصال على الأرقام التالية (السيدة/ ليلى العوضي – رئيس المشروع "نقال: 99812418 – السكرتارية: 24989091).

شاكرين لكم حسن تعاونكم معنا ...
وتفضلوا بقبول فائق الاحترام ،،،

مكتب المدير العام
د. سميرة أحمد السيد عمر

ص.ب: ٢٤٨٨٥ الكويت – الصفاة 13109 – تلفون: ٢٤٨٣٦١٠٥ – ٢٤٨١٧٣٠٢ – فاكس: ٢٤٨٣٦٦٣٧ – الموقع الالكتروني: www.kisr.edu.kw
P.O.Box 24885 Safat, 13109 Kuwait - Telephone: 24836105 - 24817302 - Fax: 24836637 - Website: www.kisr.edu.kw

Appendix M

Kuwait Environment Public Authority's Letters to the Ministry of Education





وزارة التربية
وكيل وزارة التربية

التاريخ : ١٤٣٨/٤/٢٥ هـ
الرقم : ٩٧١٠٢٩

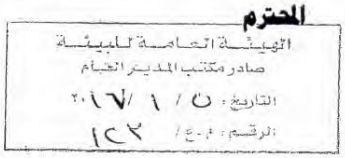
Ref. :

٤٧
٢٠١٧/١/٤

سعادة الشيخ / عبد الله احمد الحمود الصباح

رئيس مجلس الإدارة و المدير العام للهيئة العامة للبيئة

المحترم



تحية طيبة وبعد

١٧ ١ ١٨ ٢٥

الموضوع : مشروع بحث قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعه

بالإشارة إلي الموضوع أعلاه، والى كتابكم رقم ه.ع.ب/٦٠٣٧/٤٠٣ بتاريخ ٢٠١٦/١٢/٢٠ والخاص بمشروع بحث قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة للمدارس في وزارة التربية نحيطكم علما بأنه لا مانع لدينا بوضع أجهزة ومعدات لقياس تلوث الهواء بمدارس الكويت. وأيضا بناءا على طلبكم وانطلاقا من روح التعاون بين وزارة التربية والهئية العامة للبيئة نحيطكم علما بأنه تم ترشيح مهندسة فينوس عادل العنزي (ت ٩٠٩٢١٢١٩) كممثل لوزارة التربية وللتنسيق ومتابعة الأمور المتعلقة بالمشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

وكيل وزارة التربية





نسخة
الوكيل المساعد للمنشآت التربوية والتخطيط
م.فينوس العنزي

السيد / احمد الصالح
لتحمل الاثر
٩٧١٠٢٩

Tel.: 24839825 - 24839826 - 24839827
Fax 24817751
P.O.Box : 7 Safat - 13001 Kuwait
E-mail : tu@moe.edu.kw www.moe.edu.kw
75 / 30 / EA 0095392 / 15 /30000

كلفون: ٢٤٨٣٩٨٢٥ - ٢٤٨٣٩٨٢٦ - ٢٤٨٣٩٨٢٧
فاكس: ٢٤٨١٧٧٥١
ص.ب: ٧ الصفاة - ١٣٠٠١ الكويت

الهيئة العامة للبيئة
مكتب المدير العام

وزارة التربية
مراقبة السجل العام - قسم الوارد
وكيل الوزارة
الموافقات: 40505
الرقم:
التاريخ:

التاريخ : ٢٠/١٢/٢٠١٦
الرقم : ص.ع.ب/٦٠٢٧/٤٠٢/١٦

المحترم

سعادة الفاضل/ وكيل وزارة التربية

تحية طيبة وبعد،

الموضوع: مشروع بحث "قياس مستويات الزئبق في الهواء الجوي ومصادرها المتوقعة"

تتقدم لكم الهيئة العامة للبيئة بوافر الشكر والتقدير لجهودكم المبذولة في تطوير العمل البيئي في بلدنا الحبيبة الكويت.

بالإشارة إلى الموضوع المذكور أعلاه، يسرنا إخطاركم بأن معهد الكويت للأبحاث العلمية يقوم حالياً بتنفيذ الدراسة المذكورة، وذلك بدعم من الهيئة العامة للبيئة، وهذه الدراسة تتطلب وضع أجهزة ومعدات لقياس تلوث الهواء بمدارس دولة الكويت.

وعليه، نأمل من سعادتكم الموافقة على وضع تلك الأجهزة داخل المدارس التي سيتم تحديدها لاحقاً، إضافة إلى توفير بعض الأماكن التي تتطلبها لإنجاز هذه الدراسة (مختبرات، فصول، ... إلخ)، وذلك بالتنسيق مع المعنيين بوزارتكم الموقرة.

كما نأمل ترشيح ممثل من وزارتكم الموقرة للتنسيق معه خلال فترة المشروع والتي قد تستغرق عامين.

وتفضلوا بقبول فائق الاحترام والتقدير

المدير العام
إلياس محمد محسن العنزي
نائب المدير العام للشؤون الفنية

الهيئة العامة للبيئة

التواصل الإلكتروني G2G

ولمزيد من الاستفسار يرجى الاتصال:
السيد/ أحمد الصايغ - الهيئة العامة للبيئة هاتف: 99575159
السيدة/ ليلى العوضي - معهد الكويت للأبحاث العلمية (رئيس المشروع) هاتف: 24989174

إعداد: أحمد الصايغ
مدير مكتب الأبحاث والدراسات: شيخة الإبراهيم
نائب المدير العام للشئون الفنية: م. محمد العنزي
روجع: م ع

تلفون: 22208310 - فاكس: 22208455
ص.ب: ٢٤٣٩٥ الصفاة - الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

Appendix N

Calculation Procedure for PM_{10} and Total Particulate Mercury Levels in Air

Sequential Samples of Dust Collected for 24 h

Air is sucked over at an average flow rate of 16.7 liter per minute or $16.7x10^{-3}$ x60x24 m^3 per day by a glass fiber filter for 24 hour and accumulated dust PM_{10} concentration is determined as daily mean value in micro-gram per cubic meter ($\mu g\ m^{-3}$):

$$PM\left(\frac{\mu g}{m^3}\right)=\left(\frac{\text{wt of the filter after time t - wt of the filter before exposure}}{16.7x10^{-3}x60x24}\right)x10^6$$

where wt. is in g and PM value is the daily mean in micro-gram (μg).

Using pyrolytic extension in Zeeman RA915+, mercury has been quantified as ppb:

$$\left(\frac{\mu g}{kg}\right) \text{ or } \left(\frac{ng}{g}\right) \text{ or } \left(\frac{10^{-9}g}{g}\right)$$

Mercury is calculated in air as a daily average value by multiplying PM and mercury on accumulated dust (from pyrolysis) as follows:

$$PM\left(\frac{\mu g}{m^3}\right) \text{ x } \left(\frac{ng}{g}\right)=\left(\frac{10^{-15}\text{g}}{\text{m}^3}\right)=\left(\frac{fg}{m^3}\right)=\left(\frac{1000\,pg}{m^3}\right)$$

$\left(\frac{pg}{m^3}\right)$ Concentration is converted into volume units "Parts per quadrillions" by multiplying with the ratio of molar volume (0.02445 m^3) to Atomic Mass of Hg $(200.6\ g/gmole)$ = $\left(\frac{0.02445}{200.6}\right)$ as ppt.

Part per quadrillion (ppq) is 10^{-15} = ppt x 1000 = $\left(\frac{pg}{m^3}\right)\left(\frac{0.02445x1000}{200.6}\right)=\left(\frac{pg}{m^3}\right)\left(\frac{24.45}{200.6}\right)$ as ppq

Example : wt of filter after time t =0.6453 g

Wt before =0.6581 g

Wt of dust in 24 hours =0.0128 g or 12.8 mg

a): Daily dust concentration in ambient air = a = $\frac{0.0128x10^6}{16.7x10^{-3}x60x24}$ = 532.3 μg m^{-3}

b): Mercury concentration in dust sample (from pyrolysis) = b = $\left(\frac{587\mu g}{kg}\right)$ or $\left(\frac{587ng}{g}\right)$

Daily mercury in ambient air = a x b =532.3 x 587 = $312460.1x10^{-15}$ g m^{-3}=$3.12x10^{-10}$ g m^{-3}

= 0.312 ng m^{-3} = 312 pg m^{-3} = 0.038 ppt = 38.0 ppq

Note:

- *micro (μ)g is 10^{-6}g,* *part per million (ppm) is 10^{-6},*
- *nano (n)g is 10^{-9}g,* *part per billion (ppb) is 10^{-9},*
- *pico (p)g 10^{-12}g,* *part per trillion (ppt) is 10^{-12}*
- *femto (f)g 10^{-15}g,* *part per quadrillion (ppq) is 10^{-15}*

Appendix O

Letters to the Environment Public Authority Staff for Training on Zeeman RA915+ Analyzer

بسم الله الرحمن الرحيم

معهد الكويت للأبحاث العلمية Kuwait Institute for Scientific Research

مكتب المدير العام Office of the Director General

التاريخ : 2019/04/29 Date :

مرجع رقم : م ع/912/22/909 Ref. No.:

المحترم

الشيخ/ عبد الله أحمد الحمود الصباح

رئيس مجلس الإدارة – المدير العام

الهيئة العامة للبيئة

تحية طيبة وبعد،

الموضوع: التدريب لمشروع قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي

بدايةً يتقدم معهد الكويت للأبحاث العلمية بالشكر الجزيل لهيئتكم الموقرة على المجهودات التي تبذلونها في المحافظة على البيئة. وبالإشارة إلى الموضوع أعلاه، يشكر فريق البحث بالمعهد هيئتكم الكريمة وعلى وجه الخصوص العاملين في الضبطية القضائية بإدارة الالتزام البيئي وإدارة السلامة الكيميائية ومكتب الدراسات والأبحاث على تعاونهم ومشاركتهم لأعضاء الفريق في أخذ العينات من ورش الذهب وعمليات الجرد وتسهيل الأعمال.

ويرجى العلم بأن المعهد بصدد تنظيم برنامج تدريبي على كيفية استخدام جهاز الزئبق وعمل التحاليل اللازمة للزئبق بالهواء والاتربة والرسوبيات النفطية، لذا يرجى التكرم وترشيح عدد (4) موظفين من هيئتكم الموقرة لحضور هذا البرنامج التدريبي على الجهاز. كما يرجى أيضاً ترشيح عدد (2) من الموظفين الفنيين لديكم للتدريب على جمع العينات والفحوصات التي يقوم بها فريقنا خلال الزيارات الميدانية للورش وعيادات الأسنان لفحص الزئبق.

كما يرجى التكرم وتزويدنا بجميع الردود التي حصلتم عليها من الهيئات والمؤسسات التي تخص الزئبق والبيانات والمعلومات التي لها صلة بالموضوع والتي تم التنسيق فيها فيما بيننا وذلك من أجل استقراء النتائج ووضعها في الدراسة. للتنسيق والمتابعة يرجى التكرم بالاتصال على م. ليلى العوضي على هاتف رقم 24989174 – أو بريد الكتروني lawadi@kisr.edu.kw .

وتفضلوا بقبول فائق الاحترام والتقدير،،،

المدير العام

د. سميرة أحمد السيد عمر

ص.ب: ٢٤٨٨٥ الكويت – الصفاة 13109 – تلفون: ٢٤٨٣٦١٠٥ – ٢٤٨١٧٣٠٢ – فاكس: ٢٤٨٣٦٦٣٧ – الموقع الالكتروني: www.kisr.edu.kw

P.O.Box 24885 Safat, 13109 Kuwait - Telephone: 24836105 - 24817302 - Fax: 24836637 - Website: www.kisr.edu.kw

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT
مكتب المدير العام

RECEIVED
KISR DG'S OFFICE
30 JUL 2019
No: 1614

التاريخ : ٢٠١٩/٧/٢٨
الرقم : ع ب/ص/٦٢٧١

سعادة الدكتورة/ سميرة السيد عمر
مدير عام معهد الكويت للأبحاث العلمية
تحية طيبة وبعد،

المحترمة

الموضوع: التدريب لمشروع قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي

تهديكم الهيئة العامة للبيئة خالص التحيات، شاكرة لكم عملكم الدؤوب وجهودكم المستمرة، وتعاونكم في تطوير البحث العلمي والمحافظة على البيئة.

بالإشارة إلى كتابكم رقم (م ع/912/22/909) المرسل بتاريخ 2019/4/29 بشأن الموضوع المذكور أعلاه، نرفق لكم نسخة ورقية وإلكترونية (قرص مدمج CD) بالبيانات الخاصة بمادة الزئبق ومركباته والتي تعتبر بيانات سرية يمنع الكشف عنها والإطلاع عليها من غير المصرح بهم، وهي خاصة فقط بالمشروع وتم الحصول عليها من قبل الجهات التالية:

1. إدارة المخلفات في الهيئة العامة للبيئة.
2. وزارة الصحة.
3. وزارة التجارة والصناعة.
4. الإدارة المركزية للإحصاء.
5. الإدارة العامة للجمارك.
6. شركة السحب العالمية.

كما نود أن نحيطكم علما بترشيح عدد (4) من موظفين الهيئة العامة للبيئة للتدريب على كيفية استخدام جهاز الزئبق وعمل التحاليل وكذلك جمع العينات والفحوصات من الورش وعيادات الأسنان وهم:

EMO87C

بدالة: 22208310 – فاكس: 22208455
ص.ب: ٢٤٣٩٥ الصفاة – الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

الهيئة العامة للبيئة
دولة الكويت
ENVIRONMENT PUBLIC AUTHORITY KUWAIT

مكتب المدير العام

التاريخ : ——————

الرقم : ——————

م	الاسم	الإدارة
.1	السيدة/ شهد السعدون	مركز المختبرات التحليلية
.2	السيد/ يوسف المنصور	مركز المختبرات التحليلية
.3	السيدة/ خلود المشموم	رصد جودة الهواء
.4	السيدة/ عهود الحميدي	رصد جودة الهواء

ونود أن نوجه عنايتكم بقيام معهد الكويت للأبحاث العلمية بتسليم الجهاز الخاص بقياس الزئبق إلى الإدارة المعنية في الهيئة العامة للبيئة فور انتهاء المشروع وذلك حسب ما ذكر في توصيات الاجتماع الخاص بمستجدات المشروع بتاريخ 2019/1/30 والذي عقد بين مكتب الأبحاث والدراسات والباحث الرئيسي السيدة/ليلى العوضي وفرق المشروع.

وتفضلوا بقبول فائق الاحترام والتقدير

عبدالله أحمد الحمود الصباح
رئيس مجلس الإدارة - المدير العام

28/7

الهيئة العامة للبيئة

الهيئة العامة للبيئة
التراسل الإلكتروني G2G

■ **مرفق:**
البيانات الخاصة بمادة الزئبق (قرص مدمج CD).

إعداد/ عذاري السعيد

مدير مكتب الأبحاث والدراسات

بدالة: 22208310 – فاكس: 22208455
ص.ب: ٢٤٣٩٥ الصفاة – الكويت ١٣١٠٤
P.O.Box: 24395 Safat - Kuwait 13104
الموقع الالكتروني: www.epa.org.kw

Kuwait Institute for Scientific Research معهد الكويت للأبحاث العلمية
Office of the Director General مكتب المدير العام

التاريخ : 2019/09/12
مرجع رقم : م ع/1815/22/1594

Date :
Ref. No. :

الشيخ/ عبدالله أحمد الحمود الصباح المحترم
رئيس مجلس الإدارة –المدير العام
الهيئة العامة للبيئة

تحية طيبة وبعد،

الموضوع:" التدريب على جهاز قياس مستويات الزئبق ومصادرها المتوقعة في الهواء الجوي"

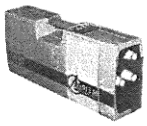
بالإشارة إلى كتابكم رقم (هـ.ع.ب/ م.ع/3621) المؤرخ في 2019/7/28 بخصوص الموضوع المذكور أعلاه، نود إحاطتكم علماً بأن البرنامج التدريبي سيعقد بالمعهد خلال الفترة من 6–10 اكتوبر 2019 والرجاء التأكد من المرشحين للحضور في الوقت المحدد. كما نود التأكد على انه سيتم تسليم الجهاز الخاص بالزئبق فور الانتهاء من المشروع حسب العقد المبرم بين المعهد وهيئتكم الموقرة.
حيث أن التدريب سيكون فى قاعة اجتماعات مبنى 45 وبالإضافة الى الجزء العلمي بالمختبرات بالمبنى للتنسيق والاستفسار يمكن الاتصال على الباحثة/ ليلي العوضي (نقال 99812418).

شاكرين لكم حسن تعاونكم معنا،،،

مرفق
- البرنامج التدريبي

المدير العام
د. سعيرة أحمد السيد عمر

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PROGRAM FOR TRAINING
MERCURY ANALYZERS RA-915M

Date	Subject
	Day 1
8:30-11:30	Organizational issues.
	Presentations and Discussion: Lumex Mercury Analyzers Overview. Lumex Mercury Analyzers. Applications.
	Familiarization with the RA-915M mercury analyzer. Principles of operation, appearance and functional controls. Operation with the console. Serviceability check-up («Test» mode). Maintenance.
11:30-12:30	Break
12:30-16:00	Familiarization with the RAPID software. Installation, user interface, principles of operation.
	Serviceability check-up procedure using software.
	Mercury in air measurements. Monitoring of the mercury concentration in the air using data logging in stand-alone and controlled by software modes.
	Day 2
8:30-12:00	Mercury determination in the solid and liquid samples using thermal decomposition method (pyrolysis).
	PYRO 915+ attachment. Design and operation. Assembling the system. Pre-operational procedures and maintenance.
	Measurement procedure using PYRO 915+ attachment. Calibration for mercury determination in the solid samples (using solid CRM of mercury).
	Calibration using mercury ions stock solutions.
12:00-13:00	Break

13:00-16:30	QA/QC procedures
	Practical works. Solid samples analysis: soil, sediments, dust filters, etc.
	Day 3
8:30-12:00	Practical works. Solid samples analysis: soil, sediments, dust filters, etc.
	Practical works. Liquid samples analysis: waste water, condensate and effluent water
	Waste water, condensate and effluent water analysis.
12:00-13:00	Break
13:00-16:30	High mercury concentration range. Calibration. Analysis of sludge and highly contaminated soil.
	Day 4
8:30-12:00	Mercury measurements in crude oil and oil products. Mercury measurements in foodstuff, agricultural products.
12:00-13:00	Break
13:00-16:30	Mercury measurements in biological samples.
	Thermoscanning. Mercury thermospeciation in the solid samples.
	Day 5
	Verification procedure.
	Questions and answers. Examination and consolidation of the information obtained during training.

Appendix P

Response to the Comments of Environment Public Aauthority's Reviewers on the Reports

Response to the Comments of EPA Reviewers on the Reports

The Project Leader (PL) and the Kuwait Institute for Scientific Research team would like to thank and appreciate the reviewers for their valuable comments from the start of the project till date. The PL has taken into consideration some of the comments while some of them could not be considered as it required further study.

1. With reference to the comments from Reviewer No. 2 requesting for the measurements of Hg levels in the ground soil/ sand to be measured near the emission source of Hg (reference / background areas), please note that PL has carried out measurements of the Hg levels in the ground soil/sand from important areas in Kuwait, which cover the source and reference points. See section 9 of this report.
2. Reviewer No. 2 of the third progress report has requested to mention the minimum detection limit in application of passive samples produced by IVL Swedish Environmental Research Center and mentioned that the total mercury must be reported instead of the concentration. The Reviewer has also requested for the accuracy of the method and that evidence was needed for the same. Please refer to Section 6 of this report.
3. Reviewer has requested to do further research, namely, a study and a survey to be conducted on other possible sources of Hg emission such as the following:
    a. Three medical waste incinerators
    b. Shuaibah hazardous waste incinerator
    c. Desalination / power plants
    d. Cement factories

    Please note that this kind of emission inventory study is out of the scope of this research study's objective. Our study is to create a baseline of the Hg in ambient air as seen in the objectives mentioned in the Proposal and the Final Report (please refer to the objectives in this report).
4. Kuwait Environment Public Authority's (EPA) staff have been trained on the handling of Zeeman RA915+ analyzer and measuring of mercury content in the air, soil, sludge, suspended dust, water, etc. (see Section 10). The EPA's staff were present during Hg measurements in the gold workshops but were unavailable for

other tasks. A letter has been issued to return the instrument and the attachments to EPA at the end of the project, as agreed in the contract.

5. The PL was requested to present the study from the beginning of the project until the findings of the last report, i.e., the 3rd Progress Report. The presentation was conducted at Kuwait EPA for the managers of various departments of EPA and the concerned staff. All areas of the project (objectives, tasks, progress, etc.) were covered in the presentation.
6. The PL has fully cooperated with the EPA staff in conducting the survey task. There were many difficulties faced with various Kuwait governmental sectors as mentioned in the limitations in each section of this report. Yet, the PL and the team have tried their best to overcome these obstacles and to meet the objectives of the project.
7. This extensive study of mercury concentrations in the ambient air of Kuwait will establish a baseline (database) for mercury levels, to align with the latest trends in the world related to the reduction of the emission of mercury used in various life applications. This research study will serve the Kuwait EPA and the population of Kuwait. The output of this research study will be useful for the Minamata Initial Assessment Report for the State of Kuwait.
8. With reference to conducting workshops and environmental awareness, the PL and PI will arrange a presentation, which will include panel discussions and an awareness talk in EPA for the staff and the public, after the completion of the project. This will cover the project findings and create awareness on the probable sources of mercury. KISR and EPA will cooperate to conduct this event.

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