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Project 00091381

Vietnam POPs and Sound Harmful Chemicals Management

Report No.4. Report on results of capacity-building program

Contract C. 2018-02-02

STRENGTHEN CAPACITY ON POP/PTS MONITORING OF LABS UNDER MONREs/DONREs

Hanoi, April – 2019

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LIST OF ABBREVIATIONS

CETASD	Research Centre for Environmental Technology and Sustainable Development
CVAAS	Cold vapor atomic absorption spectroscopy
CVAFS	Cold vapor atomic fluorescence spectrometry
DONRE	Department of Natural Resources and Environment
GC	Gas chromatography
GC-MS	Gas chromatography – mass spectrometry
GEF	Global Environment Facility
GLC	Gas-liquid chromatography
GSC	Gas-solid chromatography
HPLC	High-performance liquid chromatography
ICP-MS	Inductively coupled plasma mass spectrometry
LC	Liquid chromatography
MeHg	Methylmercury
MONRE	Ministry of Environment and Natural Resources
OCPs	Organochlorine pesticides
PAH	Polycyclic aromatic hydrocarbon
PBDE	Polybrominated diphenyl ethers
PCBs	Polychrorinated biphenyls
PMU	Project management unit
POP	Persistent organic pollutants
PTS	Persistent toxic Substance
SOP	Standard operating procedures
UNDP	United Nations Development Programme

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1. INTRODUCTION

Viet Nam POPs and Sound Harmful Chemicals Management Project is hosted by Ministry of Environment and Natural Resources (MONRE) and funded by the Global Environment Facility (GEF) and United Nations Development Programme (UNDP). The project objective is the continued reduction of environmental and health risks through POPs and harmful chemicals release reduction achieved by provision of an integrated institutional and regulatory framework covering management and reporting of POPs and harmful chemicals within a national sound chemicals management framework and targeted development of POPs contaminated sites management capacity that builds on experience from GEF-4 projects and specifically built a management plan at provincial level to assess risk and implement release reduction measures at all the persistent organic pollutants (POP) contaminated sites in two provinces. Funded by the Global Environment Facility, the project has been implemented from 2016 to 2018 including four components: (1) Policy framework for sound chemicals management, including POP/PTS developed and implemented; (2) Monitoring and reporting of POP and PTS; (3) Management of POPs contaminated sites and (4) National mercury baseline inventory and release reduction.

In the framework of the project, the project management unit (PMU) and Vietnam Environment Administration in collaboration with the Research Centre for Environmental Technology and Sustainable Development (CETASD) organized the program to strengthen the capacity on monitoring and analysis of POP/PTS for monitoring laboratories/centers under the Ministry of Natural Resources and Environment (MONRE)/Department of Natural Resources and Environment (DONRE). The program is structured into 01 basic training course (basic theory, discussion on need of laboratories), 03 technical training courses (intensive theory and mostly practical) along with inter-laboratory crosscheck program (this activity was practiced at their laboratories to assess the ability to analyze accurately before and after the training). The specific title of the above activities is as follows:

1. Basic training course on monitoring and analysis of POP/PTS
2. Technical training course on "*Analysis of Polycyclic aromatic hydrocarbon (PAH) in sludge samples by means of GC-MS*"
3. Technical training course on "*Sampling and analysis of mercury in stack gas*"
4. Technical training course on "*Determination of Polybrominated diphenyl ethers (PBDE) in plastic and wastewater samples by means of GC-MS*"

5. The inter-laboratory crosscheck program: the first time: *determination of organochlorine pesticides (OCPs) in a standard sample*, the second time: d*etermination of PAH in slugde sample*, the third time: *determination of mercury in water*.

These activities were implemented in 2018 to strengthen capacity on monitoring and analysis of POP/PTS for monitoring laboratories/centers under the MONRE/DONRE. Thereby the project will establish a network of laboratories working together, sharing experiences and towards providing reliable POP/PTS monitoring data to the Government and the Secretariat of Stockholm Convention. Also from the results of these capacity building activities, project will invest for some potential laboratories in strengthening the capacity on management following the international standards ISO17025 on laboratory operation management and they will be certified to analyze some POP/PTS.

The following report will present detailed information about the capacity building program that has been implemented.

2. BASIC TRAINING COURSES

2.1. Title and objectives

Title: ***Basic training course on monitoring and analysis of POP/PTS***

The basic training course was organized in the Northern region (on May 31, 2018 in Hanoi), the Southern region (on June 6, 2018 in Hochiminh City) and the Central region (on June 8, 2018 in Da Nang).

Objectives of training course:

+ To provide information on POP/PTS as the environmental pollutants and basic knowledge of analytical technique for determination of POP/PTS such as screening analytical methods, gas chromatography, liquid chromatography,...for managers and technical staffs of POP/PTS laboratories.
+ To discuss on the needs and plans of the laboratories in strengthening analytical capacity of POP/PTS (needs for facilities, human resource training, networking activities,...).
+ To enhance cooperation among the laboratories participating in the network of laboratories in order to improve the ability in analyzing POP/PTS

2.2. Organizing Committee of the training course:

A. Project Management Unit:

1. Mr. Le Hoai Nam, Director General of Pollution Control Department, Vietnam Environment Administration, Vice Director of Project Management Unit;
2. Mrs. Pham Thi Bich Ngoc, Project Manager;
3. Mrs. Dam Hai Van;
4. Mrs. Le Thi Thanh.

B. Lecturers:

1. Prof.Dr. Pham Hung Viet, Director of CETASD;
2. Assoc.Prof.Dr. Tu Binh Minh, VNU University of Science – Hanoi;
3. Assoc.Prof.Dr. Nguyen Van Dong, VNU University of Science – Hochiminh;
4. Assoc.Prof.Dr. Vu Duc Loi, Institute of Chemistry, VAST;
5. Assoc.Prof.Dr. Duong Hong Anh, Head of organic group, CETASD;
6. Dr. Nguyen Hung Minh, Center for Environmental Monitoring, MONRE.

2.3. Institutions participating in the basic training course

2.3.1. Basic training course in Hanoi

The course was successfully organized with the participation of 47 staffs from 18 centers under the Ministry of Natural Resources and Environment/ Department of Natural Resources and Environment in 14 provinces and cities of the Northern region, including Hanoi, Ha Tinh , Lai Chau, Ha Nam, Nam Dinh, Vinh Phuc, Hai Duong, Hai Phong, Bac Giang, Bac Ninh, Bac Kan, Thai Binh, Thai Nguyen and Hung Yen (list of staffs was shown in Annex 1).

Table 2.1. List of institutions participating in the training course in Hanoi

No.	Institutions	No.	Institutions
1	Center for Meteorology, Hydrology and Environment, Vietnam Meteorological and Hydrological Center	10	Center for Environmental Monitoring of Hai Phong
2	Center for Environmental Research, Vietnam institute of meteorology, hydrology and climate change	11	Center for Environmental Monitoring and Analysis of Hai Duong
3	Environmental Laboratory - Faculty of Environment, Hanoi University of Natural Resources and Environment	12	Center for Environmental Monitoring of Bac Giang
4	Institute of Environmental Sciences, Vietnam Environment administration	13	Center for Natural Resources and Environmental Monitoring of Bac Ninh
5	Center for Natural Resources and Environmental Monitoring of Hanoi	14	Center for Environmental Monitoring of Bac Kan
6	Center for Natural Resources and Environmental Monitoring of Ha Tinh	15	Center for Monitoring of Natural Resources and Environment of Thai Binh

7	Center for Natural Resources and Environmental Monitoring of Lai Chau	16	Center for Natural Resources and Environmental Monitoring of Thai Nguyen
8	Center for Environmental Monitoring and Analysis of Ha Nam	17	Center for Environmental Monitoring and Analysis of Hung Yen
9	Center for Environmental Monitoring and Analysis of Nam Dinh	18	Center for Resources & Environmental Protection of Vinh Phuc

2.3.2. Basic training course in Hochiminh City

24 staffs participated in the training course in Hochiminh City from laboratories under the Ministry of Natural Resources and Environment / Department of Natural Resources and Environment in 10 provinces and cities including Hochiminh City, Tay Ninh, Ba Ria - Vung Tau, Hau Giang, Tra Vinh, Soc Trang, Kien Giang, Ca Mau, Binh Duong and Dong Nai (list of staffs participating in the training course was shown in Annex 1).

Table 2.2. List of institutions participating in the training course in Hochiminh

No.	Institutions	No.	Institutions
1	Southern Division of Water Resources Planning and Investigation	8	Center for Monitoring and Environmental Engineering of Tra Vinh
2	Sub-institute of Hydrology and Climate Change, Institute of Meteorology, Hydrology and Environment	9	Southern regional Hydro-Meterological center
3	Southern Natural Resources and Environment Company	10	Center for Natural Resources and Environmental Monitoring of Kien Giang
4	Environmental Laboratory, University of Natural Resources and Environment of Ho Chi Minh City	11	Center for Natural Resources and Environmental Monitoring of Ca Mau

5	Center for Environmental Monitoring of Tay Ninh	12	Center for Monitoring and Environmental Engineering of Binh Duong
6	Center for Environmental Monitoring and Analysis of Ba Ria - Vung Tau	13	Center for Monitoring and Environmental Engineering of Dong Nai
7	Center for Natural Resources and Environmental Monitoring of Hau Giang	14	Center for Natural Resources and Environmental Monitoring of Soc Trang

2.3.3. Basic training course in Da Nang

27 staffs from laboratories under the Ministry of Natural Resources and Environment/ Department of Natural Resources and Environment in 10 provinces and cities including Quang Nam, Dak Lak, Lam Dong, Khanh Hoa, Dak Nong, Da Nang, Hue, Phu Yen, Nghe An and Binh Thuan participated in the basic training course in Da Nang (list of staffs participating in the training was shown in Annex 1).

Table 2.3. List of institutions participating in the training course in Da Nang

No.	Institutions	No.	Institutions
1	Center for Environmental Monitoring and Analysis of Quang Nam	7	Center for Environmental Engineering of Da Nang
2	Center for Environmental Monitoring and Analysis of Dak Lak	8	Center for Natural Resources and Environmental Monitoring of Thua Thien Hue
3	Center for Natural Resources and Environmental Monitoring of Lam Dong	9	Center for Environmental Monitoring of Phu Yen
4	Center for Natural Resources and Environmental Monitoring of Khanh Hoa	10	Trung tâm quan trắc tài nguyên và môi trường Nghệ An
5	Center for Natural Resources and Environmental Monitoring of Dak Nong	11	Center for Environmental Monitoring of Binh Thuan

6	Mid-central regional Hydro-Meterological center		

2.4. Training program

With the target of improving the technical capacity of the laboratories' staffs under MONRE/DONRE in monitoring and analyzing POP/PTS, the training course program fell into two main parts which were theoretical part and discussion on needs and plan of laboratories in strengthening the analytical ability of POP/PTS.

PROGRAM

Basic traning course on monirtoring and analysis of POP/PTS

Time	Content
8:00 – 8:30	**Registration**
8:30 – 8:40	**Opening speech of the training course**
8:40 – 8:55	***Lecture 1:*** Introduction of "Viet Nam POPs and Sound Harmful Chemicals Management Project" and contract No. 6 "Strengthen monitoring capacity of labs under MONRE/DONREs"
8:55 – 9:40	***Lecture 2:*** Overview information of POPs/PTSs: definition and classification of POPs/PTSs, toxicology, emission source, environmental transportation and distribution, actuality of POP/PTS management and pollution in the world in general and in Vietnam in particular
9:40– 10:00	***Coffee break***
10:00 – 10:40	***Lecture 3:*** Introduction of Stockholm convention and management of POPs/PTSs in Vietnam
10:40 – 11:10	***Lecture 4:*** Overview of monitoring capacity of POP/PTS in the environment in Vietnam
11:10 – 11:45	**Discussion on the needs of laboratories in strengthening analysis capacity for POP/PTS analysis**
11: 45 – 13:30	***Buffet lunch***
13:30 – 14:00	***Lecture 5:*** Several quick analytical methods for screening POP - Principles and disadvantages
14:00 – 14:45	***Lecture 6:*** Introduction about principles for means of instrumental analysis

	for mercury/heavy metals in environmental samples
14:45 – 15:00	***Coffee break***
15:00 – 15:45	***Lecture 7:*** Introduction about principles for means of gas chromatography (GC) and liquid chromatography (LC) to determine POP/PTS
15:45 – 16:30	**Discussion:** the needs and plan of laboratories in strengthening analytical capacity of POP/PTS (needs for facilities, training human resources, participating in network activities)
16:30 – 16:40	**Closing speech of the training course**

2.5. Implementing progress and results of the training course

2.5.1. Products – documents distributed to the trainees

Each trainee was distributed one document set including the following:

- ***Training program***
- ***07 theoretical lectures (slide):***

  Lecture 1: Introduction of "Viet Nam POPs and Sound Harmful Chemicals Management Project" and contract No. 6 "Strengthen monitoring capacity of labs under MONRE/DONREs"

  Lecture 2: Overview information of POPs/PTSs: definition and classification of POPs/PTSs, toxicology, emission source, environmental transportation and distribution, actuality of POP/PTS management and pollution in the world in general and in Vietnam in particular

  Lecture 3: Introduction of Stockholm convention and management of POPs/PTSs in Vietnam

  Lecture 4: Overview of monitoring capacity of POP/PTS in the environment in Vietnam

  Lecture 5: Several quick analytical methods for screening POP - Principles and disadvantages

  Lecture 6: Introduction about principles for means of instrumental analysis for mercury/heavy metals in environmental samples

  Lecture 7: Introduction about principles for means of gas chromatography (GC) and liquid chromatography (LC) to determine POP/PTS

2.5.2. Products – documents submitted to the PMU

- 02 document sets of the training course (including the documents distributed to the trainees)
- 02 sets of relevant text document including 07 lectures (in Vietnamese and English)

2.5.3. Summarization of the training progress

Introduction about the project and objectives of the training course

Before going into the training content, Mr. Le Hoai Nam – Deputy Director of "Viet Nam POPs and Sound Harmful Chemicals Management" Project, had an opening statement to introduce about the training activities on analysis capacity of POP/PTS for staffs and laboratories which have been implemented within the project framework.

Through this introduction of Mrs. Pham Thi Bich Ngoc, the trainees had clear information about the objective of the project, the training course in project framework in specific, as well as in long term concerning to the implementation of management plan on POPs and Harmful Chemicals, in general.

CETASD was assigned by the Project Management Board to implement the Contract No. 6. On behalf of CETASD, Assoc.Prof.Dr. Duong Hong Anh informed about the plan of implementing the capacity improvement program, including basic training courses, technical training courses and inter-laboratory crosscheck program.

Lectures

Lecture 2: Overview information of POPs/PTSs: definition and classification of POPs/PTSs, toxicology, emission source, environmental transportation and distribution, actuality of POP/PTS management and pollution in the world in general and in Vietnam in particular

The lecture was presented by Prof. Pham Hung Viet, a leading expert in environmental chemistry, especially concerning to POPs in Vietnam.

In this lecture, variuos basic knowledge about POP and PTS has been reviewed. POPs is a group of 28 chemicals that have been selected, under the Stockholm Convention (up to May 2017). POPs have the following four characteristics: (i) persistence so they can persist in the environment for a long time, (ii) long-range transport, (iii) high bioaccumulation in the tissues of organisms, and (iv) toxicity. The list of POPs will continue to be revised.

Thereby, the trainees got an overview of POP, Stockholm convention, list of POPs following Stockholm, toxicity and main emission sources of POP.

With reliable data, quoted from a lot of studies of international and Vietnamese scientists in about 25 recent years about PCBs content and other popular POPs such as DDT existing in the air, sediment, mussel, resident birds, breast milk, the trainees have learned the status of PCB and POP pollution in the environment objects from unbiotic to biotic in Vietnam in particular and world in general as well as residual pollution trends of these compounds recently.

Among the new POPs included in the Stockholm Convention after 2009, polybrominated diphenyl ethers (PBDE) are of great interest in the world because they are common. PBDE, especially at levels of 5–30%, are incorporated into polyurethane foam, textiles, ready-made plastic products, and certain electronic equipment to prevent them from ever catching fire. With the data in Vietnam, it can be reported on the pollution levels, accumulation levels of PBDE in organism the environment of Vietnam.

Based on available data on PBDE, the amount of PBDE, the environmental pollution level and accumulation level in Vietnam can be preliminarily evaluated. PBDE has been detected in several environmental samples, with the main emission source being electric and electronic equipment, transportation vehicles and home furniture. The concentration of PBDE is very low in raw plastic beads, much lower than the allowance level given by Circular No 30/201/TT-BCT of the Ministry of Trade for toxic chemicals in electric and electronic products and the RoHs decision for plastic waste. In environmental samples such as dust, air, soil and sediment, the concentrations of PBDE have an average value if compared with other countries in the world. Even in large metropolitan cities such as Hanoi and Ho Chi Minh City, the concentration of PBDE is still around the background level.

The second part of the lecture focused on persistent hazardous substances (PTS). Substances that are persistent, bio-accumulative and possess toxic characteristics likely to cause adverse human health or environmental effects are called PTS (persistent and toxic substances). In this context, “substance” means a single chemical species, or a number of chemical species that form a specific group by virtue of (a) having similar properties and being emitted together into the environment; or (b) forming a mixture normally marketed as a single product. PTS are essentially poisonous, very dangerous to human health, some of which are identified as capable of endocrine disorders such as phtalate, bisphenol A. The usage and pollution of PTS in Vietnam is quite significant. Major cities in Vietnam are facing the problem of pollution caused by construction dust and traffic. The number of

cars and motorbikes increases significantly every year, resulting in pollutant contamination containing high levels of PAH in the air, leading to water, and sedimentation pollution. In addtion, Vietnam released in 2012 more than 11 tons of mercury in the atmosphere, accounting for 8% of ASEAN countries emissions. As described before, Vietnam's main sources of mercury are coal burning, cement production and ASGM (Artisanal and small scale gold mining).

Thus, through lecture No. 2, trainees had the necessary general information and knowledge about POP/PTS compounds in environmental components and the system of Vietnamese standards and regulations on POP/PTS monitoring.

Lecture 3: Introduction of Stockholm convention and management of POPs/PTSs in Vietnam

The Stockholm Convention on Persistent Organic Pollutants was signed by the representatives of governments in Stockholm on 22 May 2001. The Socialist Republic of Vietnam signed the Stockholm Convention on 23 May 2001 and ratifed it on 22 July 2002, offcially becoming the 14th member to the Stockholm Convention.

Stockholm Convention is a global legally binding instrument. Its objective is to protect human health, biodiversity and the natural habitat against the threat of hazardous waste such as POPs. The Stockholm Convention regulates the prohibition of production and use, reduction and fnal elimination of POPs created by human activities, and implementation of appropriate measures to continuously mitigate unintentional production of POPs from industrial and domestic activities or waste treatment. POPs have the following four characteristics: (i) persistence so they can persist in the environment for a long time, (ii) long-range transport, (iii) high bioaccumulation in the tissues of organisms, and (iv) toxicity. The Stockholm Convention on POPs divided POPs into three groups, including: (i) POPs that need to be removed in manufacture and use (Annex A); (ii) POPs that are limited in production and use (Annex B); and (iii) unintentionally produced persistent organic pollutants (Annex C).

The Stockholm Convention requests the Parties, as nations or regional economic integration organizations, to make efforts in sound management, reduction and fnal elimination of POPs in production and use. The main requirements of the Stockholm Convention are as follows:

- Parties should apply effective measures to eliminate the intentional production and use of POPs; and manage and safely treat POP waste and stockpiles.

- Eliminate the use of PCBs in equipment and PCBs in residual containers by 2025; and introduce environmentally sound management and treatment for PCB fluids and equipment with concentrations of PCBs higher than 0.005 percent. This should be done as soon as possible, but in any case no later than 2028; and reports on progress are to be prepared every five years.
- For unintentionally produced POPs: Parties are required to reduce and fnally eliminate their releases; develop an implementation plan for the reduction of unintentional releases of Dioxins/Furans and other POPs within two years after the Convention entered into force; review strategies adopted in the implementation every fve years; and apply best available technologies and best environmental practices in the reduction of unintentional production sources of POPs no later than four years after the Convention entered into force.
- Development of National Implmentation Plan on POPs within two years after the Convention entered into force (17 May 2004) and submit it to the Conference of Parties for approval through the Secretariat. The National Implementation Plan should include specifc action plans for reducing and eliminating POPs according to the requirements of the Convention. These plans should be integrated into policies for environmental protection and sustainable development of each country.
- Report, information exchange and support among member states of the Stockholm Convention.
- Support technology transfer of POPs pollution treatment.
- Technical and fnancial assistance activities.
- Other provisions for evaluating the Convention effectiveness, and adoption, approval and withdrawal from the Convention.

The lecture helped trainees better understand the Stockholm Convention and the implementation of Stockholm Convention in Vietnam.

Lecture 4: Overview of monitoring capacity of POP/PTS in the environment in Vietnam

This lecture is the result of an advisory research activity carried out within the project.

Currently, in Vietnam there are two systems for accreditation of laboratorial abilities in the field of chemical and biological testing: the VILAS system managed by Bureau of Accreditation, Vietnam and the VIMCERTSS system managed by Ministry of Natural Resources and environment. Bureau of Accreditation, Vietnam is a full member of

international organisation for accreditation bodies (ILAC) Mutual Recognition Arrangement.

In the management system of the Accreditation Office a total of 1070 laboratories have been certified VILAS standard ISO 17025. These laboratories operate in 7 areas of testing: Mechanical, Pharmaceutical, Electrical & Electronic, Measurement & Calibration, Non-Destructive, Chemistry and Biology. Of this, there are 593 laboratories operating in the field of chemical analysis (including indicators on chemical residues in the environment, in food, quality components of products ...). The number of laboratories registered for the analysis of pollutants POPs (mainly chemicals for plant protection, PCBs and dioxins) is 76 laboratories, accounting for about 13%.

As being mentioned elsewhere, in accordance with Degree 127/2014/ND-CP, Ministry of Natural Resources and Environment is in charge for carrying out evaluation and providing certificate of environmental monitoring services. The VIMCERTSS certified laboratories have to meet requirements for technical staffs, instruments, methodologies, laboratorial waste management as well as other supporting facilities. At the end of 2017, there were 212 laboratories being given the certificate for environmental monitoring and analysis which is named as VIMCERTSS. Among 212 VIMCERTSS certified laboratories, there are 40 laboratories registering for POPs analysis accounted for 18.6% (mostly for organochlorine pesticides), including 5 private laboratories and 35 state laboratories.

Comparison between the two systems we can see a large difference between the number of POPs analysis subscribers in VILAS system (76 laboratories) and those in VIMCERTSS system (40 laboratories). Specifically, the number of laboratories with VILAS for POPs analysis is about 2 times the number of laboratories granted VIMCERTSS. This difference is due to the different purpose and criteria of granting VILAS and VIMCERTSS.

This is because, laboratories in the VILAS system can provide all kind of testing service including drugs, industrial products, environmental monitoring, etc. On the other hand, VIMCERTS laboratories only provide testing service for environmental monitoring. Therefore, when assessing the monitoring capacity of POPs for environmental matrices, it may be preferable to carry out examination of laboratories in VIMCERTSS system.

Under this activity, questionnaires were also sent to 130 laboratories for collecting relevant information. Unfortunately, despite the support of VEA, the number of collected questionnaires was only 14 which is about 10%. This number is insufficient for the capacity assessment and therefore, the assessment has been based mainly on laboratorial database of VIMCERTSS system.

Lecture 5: Several screening test methods for POP - Principles and disadvantages

This lecture provided information on some screening methods for POP analysis. These are creening test methods for determining PCBs in oil samples and PBDE in plastic samples.

For the ion selective electrode method in PCBs screening analysis in transformer oil using device L2000DX, all organic compounds containing chlorine (PCBs or other chlorine-containing substances) will be decomposed by chemicals. Chlorine in these compounds is converted into inorganic chlorine separated into the water phase. The inorganic chlorine content (Cl- chloride) in the aqueous phase is measured by an ion selective electrode. Then value of total PCBs is calculated by inorganic chlorine content.

Total PCBs (ppm) = [Cl-] (mg/l) x 2,1 (Conversion ratio of Aroclor 1260)

Total PCBs content by rapid analysis method has only relative value. If the sample contains other organic compounds containing chlorine, this chlorine is also transferred to inorganic chlorine during sample processing, measured and converted into PCBs. In PCBs analysis using fast measuring equipment L2000DX, after measuring the inorganic chlorine content, the total PCB will be attributed to a technical PCBs mixture, here is Aroclor1260 (60% chlorine in PCB molecule). However, in fact there are many technical PCBs mixtures with different chlorine ratios in the molecule (from 32% to 70%). Therefore, if a single conversion factor is used, the result is only relative. The lecture illustrated the differences, causes and limitations of the rapid measurement method when comparing the results of rapid measurement and accurate analysis of 50,000 transformer oil samples by GC/MS in the framework of National inventory program.

One example of rapid measuring device in industry is the use of X-ray fluorescence devices to analyze some of the parameters that need to be restricted in plastic samples according to RoHS directive (Restriction of hazardous subtances) or restriction of hazardous substances in electrical and electronic equipment. Processing dangerous substances in electrical and electronic equipment. RoHS specifies 10 restricted substances including lead, mercury, cadmium, Polybrominated biphenyls (PCB), Polybrominated diphenyl ethers (PBDE), Bis (2-Ethylhexyl) phthalate (DEHP), Benzyl butyl phthalate (BBP), Dibutyl phthalate (DBP), Diisobutyl phthalate (DIBP). Among the above parameters, PCB, PBDE are classified into POP, phthalate is classified into PTS group.

The lecture presented the principle of PBDE screening analysis in products using a fast non-destructive method using X-ray fluorescence (XRF). The system uses a source of X-ray projection to the sample → The secondary X-ray emitted will be detected by a detector → through the signal processing system → that displays the spectrum on the screen →

based on the characteristics of the peak to determine qualitative and quantitative elements. PBDE was determined based on the concentration of Br radical through X-ray fluorescence analysis technique. The difference between rapid measurement of PBDE and accurate analysis of individual PBDE compounds by chromatography technique has been illustrated and analyzed.

Lecture 6: Introduction about principles for means of instrumental analysis for mercury/heavy metals in environmental samples

Mercury (Hg) widely exists in nature, including the lithosphere, pedosphere, hydrosphere, biosphere, and atmosphere. Hg has three chemical states (0, +1, +2) and exists as elemental, inorganic, and organic Hg in the environment. Concentrations of Hg usually represent much lower levels than other heavy metals in the natural environment, like Cu, Cd, Pb. etc. It is a great challenge to accurately analyze the trace level Hg species in samples, such as uncontaminated water samples, which hampered the understanding of the Hg biogeochemical cycle and the estimation of the potential Hg exposure in aquatic food chain.

Biogeochemical cycling of Hg in aquatic ecosystems involves the distribution, transportation, and transformation of Hg in sediment, water, sediment/water interface, water/air interface, phytoplankton, zooplankton, shellfish, fish, etc. Elemental Hg (Hg^0), divalent Hg (Hg^{2+}), and methylmercury (MeHg) are the main concerned Hg species in aquatic ecosystem. Hg0 mainly exists in the atmosphere due to its high volatility, and accounts for more than 95% of Hg in the atmosphere. The Hg^0 exchange between water/air interface is a key transportation process between the two large Hg pools, including both emission and deposition process. The deposition of Hg from the atmosphere to the water includes wet deposition and dry deposition. The deposition can directly input into water surface or input from the watershed to the water body as runoff after it deposited on the land. Divalent Hg (Hg^{2+}) is the main fraction of Hg in water, which is regarded as high activity, named as reactive Hg (RHg). MeHg is the most concerned species due to its high toxicity, bioaccumulation, and biomagnification through the food chains. Generally, MeHg is the predominant form of Hg in fish tissues. MeHg is formed from inorganic Hg (such as Hg^0, Hg^{2+}, etc.) via methylation usually involving with bacteria. Sediment is the pool of Hg in aquatic system and its anaerobic environment favors the methylation of Hg. The diffusion of Hg^{2+} and MeHg between sediment/water interface is the key transportation process from sediment to water body.

In chemistry, speciation analysis refers to the analytical activities of identifying and/or measuring the quantities of one or more individual chemical species in a sample (IUPAC 1997). For Hg, the speciation analysis includes both chemical defined species, like MeHg, ethylmercury (EtHg), etc., and operationally defined species, like dissolved Hg (DHg), reactive Hg (RHg), etc. In general, the analytic species are first extracted from the sample matrix, then following separation of Hg species, and detected by an appropriate detector. With regard to different sample media, acid or alkaline digestion technique will be processed before organic solvent extraction. Chromatographic technique is often applied for the separation of different chemical forms, such as high-performance liquid chromatography (HPLC), gas chromatography (GC), supercritical Fluid chromatography (SFE), or capillary zone electrophoresis (CZE). A number of detection methods are available, but its sensitivity, multielemental capability, and the possibility of isotopic information make inductively coupled plasma mass spectrometry (ICP-MS) the detector of first choice. Hg detectors usually include cold vapor atomic absorption spectroscopy (CVAAS), ICP-MS, cold vapor atomic fluorescence spectrometry (CVAFS), and atomic emission spectroscopy (AES), in which CVAFS is most popular due to its high sensitivity and low cost. The lecture provided very useful knowledge about sampling procedures and methods of analyzing mercury in water, sediment and coal.

Lecture 7: Introduction about principles for means of gas chromatography (GC) and liquid chromatography (LC) to determine POP/PTS

POP/PTS compounds that exist in the environment are mostly organic substances in trace amounts, exist in complex mixtures with many of the same properties. Therefore, chromatography is the main method used to accurately analyze the occurence of these pollutants in environmental contaminants. The lecture presented the separation and identification principle of substances and equipment components of gas chromatography and liquid chromatography. It also provided information on how to select the technical condition of chromatogram in an appropriate way to analyze specific objects and groups of POP/PTS contamination.

Gas chromatography (**GC**) is a separation technique where **volatile**, **thermally stable** solutes migrate through a column containing a stationary phase at rates dependence on their distribution ratios. These are inversely proportional to their volatilities, which in turn are determined by their **partial vapor pressures** and hence their **boiling points**. Solutes are therefore generally eluted in order of increasing boiling point, except where there are specific interactions with the stationary phase. The gaseous mobile phase elutes the solutes from the end of the column where they pass through a detector that responds to each one.

An elevated temperature, usually in the range 50–350^{0}C, is normally employed to ensure that the solutes have adequate volatility and are therefore eluted reasonably quickly.

There are two modes of gas chromatography: **Gas-liquid chromatography** (**GLC**), which employs a liquid stationary phase in which solutes can dissolve, the sorption process being **partition**. Specific interactions of solutes with the stationary phase may alter the order of elution from that of increasing boiling points. GLC is by far and away the more widely used mode of GC, the large number of alternative stationary phases enabling many types of sample to be analyzed. **Gas-solid chromatography** (**GSC**) employs a solid, sometimes polymeric, sorbent as the stationary phase, the sorption process being **surface adsorption**. GSC has limited specialist applications, being used mainly for analyzing mixtures of gases or solvents with relatively low relative molecular masses.

For each group of organic pollutants analyzed by gas chromatography, it depends on properties such as volatility, polarity, molecular structure ...to choose capillary separation column with suitable packed material, the thickness of the stationary phase film. Moreover, the temperature program changes so that the components can be separated from each other. Depending on the concentration range and molecular properties, a suitable detector can be selected to identify pollutants, such as universal or selective detectors.

Groups of difficult volatile organic substances that cannot be analyzed by gas chromatography, liquid chromatography should be used. High-performance liquid chromatography (HPLC) is a separation technique where solutes migrate through a column containing a microparticulate stationary phase at rates dependent on their distribution ratios. These are functions of the relative affinities of the solutes for the mobile and stationary phases, the elution order depending on the chemical nature of the solutes and the overall polarity of the two phases. Very small particles of stationary phase are essential for satisfactory chromatographic efficiency and resolution, and the mobile phase must consequently be pumped through the column, resulting in the generation of a considerable back-pressure, this requires ultra performance liquid chromatography (UPLC). The solutes are eluted from the end of the column through the detector to identify targets such as conductivity, photometric, fluorescent, and mass detectors. Similar to gas chromatography, depending on the concentration range and properties of the pollutant groups, the conditions for liquid chromatography column, solvent program, and detector type can be selected to separate, identify, quantify them most selectively and sensitively.

2.5.4. Discussion

Subject of discussion: the needs and plan of laboratories in strengthening analytical capacity of POP/PTS (needs for facilities, training human resources, participating in network activities) .

The members of each basic training course were divided into small groups that gather ideas about: pollution issues that had or may be locally, the advantages and disadvantages of the lab on current analysis and monitoring, the needs of laboratory in strengthening analysis/monitoring capacity in general and especially with new objects such as POP/PTS. Representatives of each group presented their general ideas and discuss with the teachers and members of the class.

Discussion can be summarized as follows:

In terms of tasks, laboratories under DONRE/MONRE have tasks of analyzing and monitoring polluted objects that are regulated in the current system of legal regulations of Vietnam. Among these regulated pollutants, POP/PTS that only accounts for very little (organochlorine pesticides, dioxin/Furan, PCBs, PAH, Hg) is new to the laboratories both in terms of knowledge and technical capability.

- In each province, depending on natural conditions and socio-economic development as well as previous history, POP/PTS pollution may exist or arise. Laboratories under provinces can only identify organochlorine pesticides in hot spot areas such as old warehouses, POP-dioxins/furans may be emitted from specific industries, Hg in gold mining. Other local POP/PTS objects do not have any information nor are they regulated in the current system of legal regulations in Vietnam.
- In terms of management and technical conditions, most laboratories have been certified with VIMCERTS and VILAS that means laboratory of management has a procedure to comply with ISO 17025. Technically, some laboratories have been VIMCERTS/VILAS certifications to analyze POP targets of organochlorine pesticides and Hg in environmental objects, but the practical experience is not much due to the assigned tasks.
- To improve the capacity of the laboratories in general and monitoring, analysis of POP/PTS group, the participants wish to:
    - Be provided basic knowledge of POP/PTS
    - Be practiced to monitor and analyze specific objects in the laboratory
    - Be exchanged and shared information, experience, questions and answers during the practice as well as long term

2.6. Evaluation results of basic training courses from trainees

After each training course, participants were given and filled out evaluation forms on the training course. Based on the collected form, the Organizing Committee could draw experience for organizing the next course. The evaluation form was shown in Annex 2 and the evaluation results of participants on the basic training course werw summaried as follows:

1. Evaluation of the content:

Classification	No. of votes	Percentage %
Easy to understand	65/66	98%
Difficult to understand	1/66	2%
Very difficult to understand	0/66	0%

General remarks:

+ Shoud be focused on equipment and analysis procedure

+ The content is interesting, useful and adequate but many pages are difficult to see due to black and white printing

2. Evaluation of the lecturer:

Classification	No. of votes	Percentage %
Very interesting	26/66	40%
Interesting	40/66	60%
Normal	0/66	0%
Not interesting	0/66	0%

3. Through the content of lectures and presentations, how well do you know the following basic knowledge about POP/PTS?

a/ Classification, characteristics, origin:

Classification	No. of votes	Percentage %
Very good	10/66	15%
Good	51/66	77%
Ordinary	5/66	8%
Bad	0/66	0%

b/ Regulations on management related to POP/PTS in the environment

Classification	No. of votes	Percentage %
Very good	6/66	9%
Good	41/66	60%

Ordinary	19/66	31%
Bad	0/66	0%

c/ Basic technical conditions for monitoring and analysis of POP/PTS

Classification	No. of votes	Percentage %
Good	46/66	70%
Ordinary	13/66	20%
Bad	0/66	0%

4. After discussion session, could you please let us know the needs of your lab for monitoring and analysis of POP/PTS?
   A. We do not have the needs for monitoring and analysis of POP/PTS: 0/66
   B. We have the needs for monitoring and analysis of POP/PTS: 31/66
   C. We have the needs for training on analytical method of GC (for example: GC-MS, LC-MS): 36/66
   D. We have the needs for training on sampling methods: 30/66
   E. We have the needs for training on sampling methods (kinds of samples: sediment, wastewater, air, VOC): 33/66

5. If you score the training course, how much will be on the below scale?

Classification	No. of votes	Percentage %
Very interesting	15/66	23%
Interesting	50/66	75%
Normal	1/66	2%
Bad	0/66	0%
Very bad	0/66	0%

6. Other comments of trainees:
   + I suggest organizing advanced training course on POP/PTS analysis
   + I hope there are more training courses in the laboratory
   + I think lectures should be shortened further to increase discussion time
   + We have the need to be trained on sampling for VOC, stack gas and ambient air
   + I wish to attend training courses on equipment
   + I wish to be trained on POP/PTS analysis by GC-MS
   + We need intensive training on preservation of samples and analysis of POP/PTS
   + I wish to receive documents via email
   + I suggest organizing long-term training courses

2.7. Conclusions of basic traning course

The trainees participating in the course are technical staffs of the laboratories, some of them are experienced staffs in sample treatment and using gas chromatography - mass spectrometry for analyzing some POPs. Members of the training course participated enthusiastically, with high responsibility, gave ideas and implemented the practice seriously, effectively. Lecturers are experienced experts with a number of years studying in the field of environmental chemistry on POP/PTS.

The program was suitable, met the objectives of the training course: (i) to provide information, basic knowledge on POP/PTS such as screening analytical methods, gas chromatography, liquid chromatography,...for managers and technical staffs of POP/PTS laboratories, (ii) to discuss on the needs and plans of the laboratories in strengthening analytical capacity of POP/PTS (needs for facilities, human resource training, networking activities,...), (iii) to enhance cooperation among the laboratories participating in the network of laboratories in order to improve the ability in analyzing POP/PTS.

Through the theoretical lectures, the participants were provided with overview theoretical knowledge about POP/PTS such as classification, origin, toxicity, pollution status in Vietnam and analytical methods of POP/PTS. Documents provided to the trainees are helpful documents to assist the trainees in practice, development and improvement of analysis procedure at their laboratories later on.

The discussion sessions took place quite enthusiastically, and some laboratories shared the need for capacity building as well as the advantages and disadvantages of laboratories in monitoring and analysis of POP/PTS. Some laboratories have invested devices that have the ability to analyze some classical POPs and mercury such as gas chromatography electron capture detector (GC-ECD), gas chromatography mass spectrometry (GC- MS), high-performance liquid chromatography (HPLC), atomic absorption spectrometer (AAS), ...However the basic knowledge on POP/ PTS as well as in-depth knowledge of analytical capacity are limited. Therefore, trainees wish to participate in the upcoming intensive course, propose the Organizing Committee to provide standard operating procedures (SOP) and organize theoretical and practical training courses.

3. TECHNICAL TRAINING COURSES

3.1. Technical training courses 1 on "*Determination of poly aromatic hydrocarbons (PAH) in sludge samples by gas chromatography - mass spectrometry (GC-MS)*"

3.1.1. Objectives

Technical training course No. 1 was held at Research Centre for Environmental Technology and Sustainable Development (CETASD), VNU University of Science, Vietnam National University from August 27 to 31, 2018 with objectives:

+ To provide information, basic knowledge for technical staffs on PAH such as classification, origin, toxicity, pollution status in Vietnam
+ To provide standard operating procedures (SOP) of PAH using gas chromatography mass spectrometry.
+ To guide the participants to carefully perform the practical exercise **"Determination of poly aromatic hydrocarbons (PAH) in sludge samples by gas chromatography - mass spectrometry (GC-MS)"**.

Lecturers:

– Prof.Dr. Pham Hung Viet, Director of CETASD
– Assoc.Prof.Dr. Duong Hong Anh, Head of organic group, CETASD
– MSc. Nguyen Thuy Ngoc, Head of Environmental chemistry laboratory, CETASD

Institutions participating in the technical training course 1

The course was successfully organized with the participation of 22 staffs from 15 laboratories under the Ministry of Natural Resources and Environment/Department of Natural Resources and Environment including monitoring centers in Bac Ninh, Hung Yen, Hai Phong, Nam Dinh, Thai Nguyen, Vinh Phuc, Hai Duong, Ha Tinh, Da Nang, Nghe An, Quang Nam, Binh Duong, Dong Nai, Ba Ria - Vung Tau and Can Tho (list of staffs participating in the training course was shown in Annex 1).

3.1.2. Program of training course

The detailed program of the training course is presented in the following table:

Time	Content
August 27, 2018	
08:30 - 08:45	Opening speech of the training course
08:45 - 09:30	***Lecture 1:*** Introduction of PAH in the environment: sources, human health effects, regulations and the ocurrence in environment compartments
09:30 - 10:00	***Lecture 2:*** Sample preparation for determination of PAH in soil/sediment

10:00 - 10:20	Coffee break
10:20 - 10:40	***Lecture 3:*** Instrumental analysis of PAH by means of GC/MS - Qualitative, Quantitative analysis including QA/QC
10:40 - 11:30	Introduction of the training course and practical experiment, division of groups
11:30 - 13:00	Lunch
13:00 - 14:00	Introduction of GC/MS equipment and setting up analytical parameter for GC-MS
14:00 - 17:00	Preparation of the calibration Preparation of chemicals and apparatus
August 28-29, 2018	
08:30 - 17:00	Sample preparation: extraction, clean-up, enrichment
August 30, 2018	
08:00 - 11:30	Injection of sample to GC and calculation of the results
13:00 - 16:30	Discussion of the analytical results
16:30 - 17:00	Certificate delivery and closing speech
August 31, 2018	
8:00 - 17:00	Trainees conducted the experiment in their laboratory

3.1.3. Implementing progress and results of the technical training course 1

❖ ***Products – documents distributed to the trainees***

Each trainee was distributed one document set including the following:

- ***Program of training course***
- ***03 theoretical lectures:***

  Lecture 1: Introduction of PAH in the environment: sources, human health effects, regulations and the ocurrence in environment compartments

  Lecture 2: Sample preparation for determination of PAH in soil/sediment

  Lecture 3: Instrumental analysis of PAH by means of GC/MS - Qualitative, Quantitative analysis including QA/QC

- ***Standard operating procedure (SOP) for qualitative and quantitative analysis of PAH in sediment samples by GC-MS:*** SOP includes: detailed description of preparation step (chemicals, devices, preparation of chemicals, devices, dilution of standard chemicals), sample treatment step (separation, extraction, cleanup, enrichment of sediment samples), instrumental analysis step by GC-MS (specific condition for machine operation, condition for quality assurance, quality control (QA/QC) of analysis procedure, calibration data on recovery productivity, repeatability, and notes during the implementation process).

❖ ***Products – documents submitted to Project Management Unit:***

- 02 document sets of the training course (including the documents distributed to the trainees)

Summarization of the training progress

❖ **Theoretical part**

Lecture 1: Introduction of PAH in the environment: sources, human health effects, regulations and the ocurrence in environment compartments

The lecture was presented by Prof. Pham Hung Viet. Polycyclic aromatic hydrocarbon compounds (PAH) are released into the environment from two natural and anthropogenic sources. A large proportion of the PAH released into the environment arise from anthropogenic sources such as coal-fired electricity power plants, incinerators, open burning, and motor vehicle exhausts. Industrial processes, residential combustion for heating, mobile transport emissions, and incineration are the most significant sources of PAH production. PAH are present in many environmental components such as air, dust, sediment, water, organisms, food ... These are sources that can lead to exposure PAH into the human body. Risk of lung cancer induced by inhalation exposure to PAH in the five Asian countries including China, Japan, Korea, Vietnam has been studied. The results showed that the risk level for residents in Hanoi is only ranked second in Beijing, much higher than those in Nhat Ban and South Korea. Because some PAH have been classified as carcinogenic, potentially carcinogenic compounds and abnormal morphological and physiological development in fish, some government including the European community, NIOSH or the US Environmental Protection Agency (US EPA) issued the limited concentrations of PAH in air, water and soil. In Vietnam, there is a regulation on the concentration threshold of PAH in bottled drinking water, air waste of steel smelting and sediment.

Lecture 2. Sample preparation for determination of PAH in soil/sediment

The lecture provided information on the principles of preparation steps to extract, clean up and enrich PAH from solid matrices (sludge). Basically, procedure of sample preparation includes steps as follows: extracting with acetone-hexane solvent, being anhydrous with Na_2SO_4, removing sulfur by copper, cleaning up with silica gel, enrichment of sample.

Lecture 3. Instrumental analysis of PAH by means of GC/MS - Qualitative, Quantitative analysis including QA/QC

The lecture provided information on qualitative and quantitative analysis conditions of PAH using gas chromatography mass spectrometry equipment. These includes separation conditions of gas chromatography (column, temperature program), detective conditions of mass spectrometry, qualitative method and internal standard methods to quantify PAH in samples.

Practice of analyzing sediment samples:

After the theoretical lectures, the trainees moved to the practical part of sample treatment. In order to ensure that all the trainees participated in practical procedure, the class was divided into 15 groups; all the members in each group together directly did the treatment of blank sample, sediment sample with the assistant of the guiders.

Sample objects:

The laboratories were asked to bring the local dry sediment samples to the laboratory of CETASD to use for the training. Ten laboratories brought samples to the course including soil samples, sand samples and dried sediments. Some have been grinded, sieved and can be used. Some have not been sieved, therefore trainees practice grinding and sieving samples. Five laboratories, namely Dong Nai, Hung Yen, Can Tho, Nam Dinh and Thai Nguyen, did not carry samples, so they used samples from other laboratories.

Detailed steps:

The groups were given a real sample of sediment (soil sample or sand sample) according to the guided procedure.

Preparation of samples:

- Grind and sieve the sample with particle size below 0.5mm
- Weigh the sample for extraction and determination of humidity
- Extract the sample by cetone and hexane solvent a, shake for 1 hour with each solvent.

- Extract the sample extract with water to remove polar substances
- Concentrate sample and remove sulfur that are very much in sediment
- Clean up the extract by silica gel column
- Concentrate the final extract under 1 ml by nitrogen and inject into GC-MS

Practice on GC and calculation of results:

- Prepare a 6-point standard line of 16 PAH
- Identify all PAH in the sample
- Apply each sample to the calibration curve to quantify 16 PAH in the sample
- Calculate PAH concentration in real samples after having data on GC

Report on results of groups:

Each group reported on the results of their analysis on the last day of the training course. In addition, they shared their difficulty in conducting the experiment.

The results include a full excel sheet with information about name of trainees, laboratory and results:

- Humidity of samples, dry sample weight after calculation.
- Recovery efficiency of 5 PAH surrogate standards.
- Concentration of 16 PAH in the real sample after multiplying by efficiency of surrogate substance, except for result of the blank sample.
  (Results for each group enclosed)

3.1.4. Evaluation results of the technical training courses 1 from trainees

After the training course finished, participants were given and filled out evaluation forms on the training course. Based on the collected form, the Organizing Committee could draw experience for organizing the next courses. The evaluation form was presented in Annex 3. The following section summarizes the evaluation results of the participants on the technical training course 1.

	Strongly Disagree (1)	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**
TRAINING CONTENT				

1. Contents of the training activity were useful to my work	**0** (0%)	**0** (0%)	**0** (0%)	**17/17** (100%)
2. The duration of the training activity was appropriate to cover the planned content	**0** (0%)	**1/17** (6%)	**1/17** (6%)	**15/17** (88%)
3. The training activity provided me with new knowledge	**0** (0%)	**0** (0%)	**0** (0%)	**17/17** (100%)
4. The steps of the training activity were appropriate	**0** (0%)	**1/17** (6%)	**2/17** (12%)	**14/17** (82%)
5. The time I spent on the training activity was worthwhile	**0** (0%)	**0** (0%)	**1/17** (6%)	**17/17** (100%)
6. My expectations from the training activity were met	**0** (0%)	**0** (0%)	**2/17** (12%)	**15/17** (88%)
7. I am interested to introduce this training activity to other people	**0** (0%)	**0** (0%)	**1/17** (6%)	**16/17** (94%)
TRAINING MATERIALS				
8. The training materials helped me understand the training contents.	**0** (0%)	**0** (0%)	**1/17** (6%)	**16/17** (94%)
9. The training materials were very useful to my work	**0** (0%)	**0** (0%)	**2/17** (12%)	**15/17** (88%)

General remarks:

- Time should be reduced in the overview content to serve for practice.
- Content and training materials are very useful.
- The training content meets the purpose and desires of individuals and my laboratory.
- Training course is very useful and very practical.
- The content is very useful for me.

Training methodology	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**
10. The methodology to conduct the training activity was approproate to deliver the contents	**0** (0%)	**0** (0%)	**3/17** (18%)	**14/17** (82%)
11. The examples used were relevant to and helped illustrate the subject matters.	**0** (0%)	**0** (0%)	**4/17** (24%)	**13/17** (76%)

12. The timing for practices/ exercises was appropriate.	**0** (0%)	**1/17** (6%)	**2/17** (12%)	**14/17** (82%)
General remarks: - Time for training can be shorter. - The method of theoretical training in combination with practice is very appropriate. - I fully agree with the method of the training course. - The analytical procedure is specific, clear, but it is necessary to clearly explain the analytical procedure for students to understand. Explain in detail the steps. - I think the time is reasonable. - It is recommended to reduce extraction time during practice and arrange more reasonable time.				
Logistical support				
13. I was happy with the training venue.	**0** (0%)	**0** (0%)	**0** (0%)	**17/17** (100%)
14. I was happy with other support services (refreshment, etc...).	**0** (0%)	**0** (0%)	**5/17** (29%)	**12/17** (71%)
15. The training facilities were adequate.	**0** (0%)	**1/17** (6%)	**1/17** (6%)	**15/17** (88%)
General remarks: - Organizing committee should choose equipment that laboratories have in order that the trainees can know how to operate the software and hardware. - Organizing committee arranged very reasonable accommodation and safety. - If possible, the location is near Hoan Kiem district for convenient transportation. - The services provided are very adequate. - I am very pleased with the logistical support of the training. - Suitable location, reasonable service, relatively adequate learning facilities - Thoughtful support				
Resource persons	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**
16. The resource person(s) was/were knowledgeable about the subject matters.	**0** (0%)	**0** (0%)	**1/17** (6%)	**16/17** (94%)
17. The resource person(s) was/were dedicated to the training activity.	**0** (0%)	**0** (0%)	**1/17** (6%)	**16/17** (94%)

18. The resource person(s) gave satisfactory answers to my questions.	**0** (0%)	**0** (0%)	**1/17** (6%)	**16/17** (94%)
19. The resource person(s) made satisfactory presentation(s) on their topics.	**0** (0%)	**0** (0%)	**5/17** (29%)	**12/17** (71%)
20. The resource person(s) made proper preparations for the training activity.	**0** (0%)	**0** (0%)	**3/17** (18%)	**14/17** (82%)
21. The resource person(s) had good skills to engage trainees in discussions.	**0** (0%)	**0** (0%)	**4/17** (24%)	**13/17** (76%)

General remarks:

- Enthusiastic lecturers and laboratories need the next support to be able to analyze these substances better.
- Lecturers are very enthusiastic
- I am very satisfied with teaching and guiding practice of lecturers
- Lecturers are enthusiastic with good knowledge
- The lecturers are very enthusiastic to train and support me, the learning atmosphere is fun and receptive

22. I wish to add the following comments on the training activity:

- The following course should train for 5 days (from Monday to Friday) or 1 month (1 month/1 course) due to busy work of laboratories.
- I hope the following training courses will be practiced more to be able to detect errors in the analytical process and have time to conduct the experiment again.
- For training course on GC-MS, organizing committee should invite trainees who participated in this course to throughout the process and have in-depth knowledge to be able to retrain staff of their laboratories.
- Organizing committee should send to each laboratory at least 2-3 samples with more standards, internal standards and surrogate standards because it may have to conduct again, optimize analytical conditions.

Overall assessment on the training activity (including suggestions for improvement):

- The course needs to focus on QCVN/BTNMT regulation and the Circular 24/BTNMT

- I wish to have more time to practice on the equipment, more detailed for different matrices. If possible, two persons of each laboratory will be arranged to attend training course.
- Through this training, I was very pleased with the program, plan and implementation, the training provided me practical knowledge and skills. It is hoped that the next training courses need to provide more videos on experimental steps to better understand the students before conducting the experiment.
- Courses should focus on the Circular 24/BTNMT
- The training course brought a lot of knowledge, the trainees were directly conducted in the laboratory, so it was very practical, I think organizing committee need to organize more practical training courses on real samples such as analyzing PCB in waste sludge, VOC in air and waste gas.
- For samples to practice in the training course, if each locality brings samples for analysis, there should be more detailed instructions. For example, this training course on PAH requires that laboratories prepare 0.5 - 1kg of sediment samples (sediment in rivers, ditches ... or sludge from systems of industrial wastewater treatment). If laboratory do not bring them, organizing committee should prepare samples for trainees.
- I'm interested in organizing to practice in the laboratory, it helped me to understand steps and skills, conduct to analyze PAH in samples.
- Thank the organizing committee, lecturers, staffs who organized, trained and supported us during the training course.
- I look forward to participating in the following training courses
- Because each equipment has the different software, we can not be applied them as equipment of CETASD. There are many localities that do not have enough standard and internal standards to apply practical analysis.

3.1.5. Conclusions of technical training course 1

- PAHs are completely new analytical objects for trainees. For quantitative analysis, the use of internal standards and surrogates is also new compared to the analysis of traditional chlorine pesticides that trainees have experienced.
- Practical results showed that: Regarding the sample preparation, some trainees obtained the low recovery efficiency of surrogate substances, especially Naphthalene-d8 and acenaphthalene-d10. That means there is a loss in the process

of sample preparation, trainees need to practice experimental skills. Regarding the analysis using GC-MS equipment, trainees are proficient in identifying PAHs signals and calculating excel both the injected concentration and the concentration of real sample.

- Through the first technical training course, participants received information and knowledge about PAHs in general and skills to practice analyzing these compounds in solid samples such as sludge, soil and sediment by GC/MS.

3.2. Technical training course 2 on "Sampling and analysis of mercury in stack gas"

3.2.1. Objectives

Technical training course No. 2 was held at Research Centre for Environmental Technology and Sustainable Development (CETASD), VNU University of Science, Vietnam National University from September 24 to 27, 2018 with objectives:

+ To provide information, basic knowledge for technical staffs on mercury in stack gas, provide SOP of stack gas/isokinetic sampling and determination of mercury in stack gas by cold-vapor atomic absorption (CVAA).
+ To guide the participants to carefully perform the practical exercise **"Sampling and analysis of mercury in stack gas"** including sampling at Vissai Cement Joint Stock Company and experimental analysis in the laboratory.

Lecturers:

– Prof.Dr. Pham Hung Viet, Director of CETASD
– Assoc.Prof.Dr. Nguyen Van Dong, VNU University of Science - Hochiminh
– Dr. Nguyen Van Thuong, Center for environmental monitoring, MONRE
– MSc. Vu Thi Duyen, VNU - Shimadzu Laboratory, CETASD

Institutions participating in the technical training course 2

The course was successfully organized with the participation of 19 technical staffs from 12 centers under the Ministry of Natural Resources and Environment/ Department of Natural Resources and Environment including monitoring centers of Hanoi, Thai Nguyen, Bac Ninh, Thai Binh, Quang Ninh, Nghe An, Ha Tinh, Da Nang, Quang Nam, Ba Ria - Vung

Tau, Dong Nai and Binh Duong (list of staffs participating in the training was shown in Annex 1).

3.2.2. Program of the technical training course 2

The training course was presented in the following table:

Course	Content of training course
September 24, 2018	
08:30 - 08:40	Opening speech
08:40 - 09:20	***Lecture 1.*** Mercury in ambient air and stack gas
09:20 - 10:00	***Lecture 2.*** Sampling method for monitoring of metals emision from stationary sources
10:00 - 10:15	Coffee break
10:15 - 11:00	***Lecture 3.*** Analysis of mercury in stack gas by cold-vapor atomic adsorption (CVAA) spectrometry
11:00 - 11:30	Introduction of the experimental procedure, division of groups
11:30 - 13:00	Lunch
13:00 - 14:00	Introduction of the cold-vapor atomic adsorption (CVAA) spectrometry equipment
14:00 - 17:00	Preparing the apparatus and chemicals, Creating the calibration curve
September 25, 2018	
07:30 - 17:00	Stack gas sampling in Vissai Ha Nam Joint stock company, Ha Nam
September 26, 2018	
08:00 - 17:00	Sample treatment and analysis in the laboratory
September 27, 2018	
08:00 - 11:30	Analysis and calculation of results
11:30 - 13:00	Lunch
13:00 - 16:30	Discussion on the analytical results of groups and suggestion for the participants
16:30 - 17:00	Certificate delivery and closing speech

3.2.3. Implementing progress and results of the technical training course 2

❖ ***Products – documents distributed to the trainees***

Each trainee was distributed one document set including the following:

- ***Program of training course***
- ***03 theoretical lectures:***

  Lecture 1. Mercury in ambient air and stack gas

  Lecture 2. Sampling method for monitoring of metals emision from stationary sources

  Lecture 3. Analysis of mercury in stack gas by cold-vapor atomic adsorption (CVAA) spectrometry
- **SOP of stack gas/isokinetic sampling**
- **SOP of determination of mercury in stack gas by cold-vapor atomic absorption (CVAA)**

❖ ***<u>Products – documents submitted to Project Management Unit:</u>***

- 02 document sets of the training course (including the documents distributed to the trainees)

Summarization of the training progress 2:

Theoretical part

Lecture 1: Mercury in ambient air and stack gas

The lecture provided information on the sources of mercury emission into the atmosphere, the current concentration levels and the regulations of mercury in air and in stack gas in the world, in Vietnam. An important part of the lecture introduced the principle of sampling mercury methods in stack gas on the basis in a solution or coal trap. The techniques of total mercury analysis in stack gas were presented such as directly analysis of Hg in solid samples and CVAAS or CVAFS for sample treatment of amalgam to analyze mercury.

Lecture 2: Sampling method for monitoring of metals emision from stationary sources

The lecture provided detailed information on sampling of stack gas according to EPA 29 that applies to monitor metal emissions (including mercury) from stationary sources.

Lecture 3: Analysis of mercury in stack gas by cold-vapor atomic adsorption (CVAA) spectrometry

The lecture provided detailed information on the preparation procedure of the collected samples after absorpted by the EPA 29 method, the procedure of qualitative and quantitative analysis on CV-Almalgam AAS system and the calculation method of mercury concentration in stack gas samples.

Practice

Sampling of stack gas in Vissai Ha Nam Joint stock company, Ha Nam

Nineteen staffs under 12 laboratories, 03 lecturers and support staffs (Assoc.Prof.Dr. Nguyen Van Dong, Assoc.Prof.Dr. Duong Hong Anh, BSc. The Anh) participated in the training course. Most of the technical laboratories have experience in sampling of stack gas in their laboratories.

Sample objects:

Samples used in the practical part are artificial samples of Hg that prepared by CETASD including:

2B (Impingers 1-3):	300 mL, HNO_3 3% + H_2O_2 6%
5A (Impinger 4):	100 mL, HNO_3 0.1N
5B (Impinger 5):	300 mL, $KMnO_4$ 2% + H_2SO_4 5%
5C (Impinger 6):	25 mL, HCl 8N

Steps of implementation:

Preparation of samples:

- Mix 150 ml of artificial sample 5B prepared with 10 ml of hydroxylamine (to desorb all adsorbed mercury on MnO_2 in solution). The treated samples were directly measured by cold-vapor atomic absorption.
- The remaining artificial samples were measured directly on amalgam-AAS

Analysis on amalgam-AAS and calculation of result:

- Preparation of gas calibration curve and 5-point liquid calibration curve of Hg
- Quantitative analysis of mercury concentration in artificial samples 2B, 5A, 5B and 5C, each sample was measured 3 times
- Calculation of mercury concentration in real sample using data on AAS

Table 3.1. Report on the results of the practical session on the equipment

No	Sample name	Peak height	Conc. (ppb)	DF	Actual conc. (ppb)	Mean (ppb)	SD	% RSD	Remark
1	2B L1	0.41	0.74	100	73.9				

2	2B L2	0.58	1.06	100	106.2				Out of range
3	2B L3	0.51	0.93	100	92.9				
4	2B L4	0.36	0.64	200	128.8				
5	2B L5	0.34	0.61	200	121.2	125.0	5.4	4.3	
6	5A L1	0.2	0.34	20	6.8				
7	5A L2	0.2	0.34	20	6.8	6.8	0.0	0.0	
8	Blank	0.004	-0.03	1	-0.03				
9	5C L1	0.44	0.80	50	39.8				
10	5C L2	0.47	0.85	50	42.7	41.2	2.0	4.9	
11	5B L1	0.4	0.72	200	144.0				
12	5B L1	0.43	0.78	200	155.4	149.7	8.1	5.4	
13	Blank	0.005	-0.03	1	0.0				
14	STD 0.5	0.3	0.53	1	0.5				%R = 106%

3.2.4. Evaluation results of the technical training courses 2 from trainees

	Strongly Disagree (1)	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**
Training content				
1. Contents of the training activity were useful to my work	**0** (0%)	**0** (0%)	**1/18** (6%)	**17/18** (94%)
2. The duration of the training activity was appropriate to cover the planned content	**0** (0%)	**0** (0%)	**4/18** (22%)	**14/18** (78%)
3. The training activity provided me with new knowledge	**0** (0%)	**0** (0%)	**1/18** (6%)	**17/18** (94%)
4. The steps of the training activity were appropriate	**0** (0%)	**1/18** (6%)	**3/18** (16%)	**14/18** (78%)
5. The time I spent on the training activity was worthwhile	**0** (0%)	**0** (0%)	**3/18** (16%)	**15/18** (84%)

6. My expectations from the training activity were met	**0** (0%)	**0** (0%)	**4/18** (22%)	**14/18** (78%)
7. I am interested to introduce this training activity to other people	**0** (0%)	**0** (0%)	**2/18** (11%)	**16/18** (89%)
Training materials				
8. The training materials helped me understand the training contents.	**0** (0%)	**0** (0%)	**0** (0%)	**18/18** (100%)
9. The training materials were very useful to my work	**0** (0%)	**0** (0%)	**0** (0%)	**18/18** (100%)
General remarks: - I fully agree with the content and training materials. - The course is very useful, helping me have more knowledge. - There should be more training courses -				
Training methodology	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**
10. The methodology to conduct the training activity was approproate to deliver the contents	**0** (0%)	**0** (0%)	**6/18** (33%)	**12/18** (67%)
11. The examples used were relevant to and helped illustrate the subject matters.	**0** (0%)	**1/18** (6%)	**5/18** (28%)	**12/18** (66%)
12. The timing for practices/ exercises was appropriate.	**0** (0%)	**1/18** (6%)	**4/18** (22%)	**13/18** (72%)
General remarks: - Good				
Logistical support				
13. I was happy with the training venue.	**0** (0%)	**0** (0%)	**3/18** (16%)	**15/18** (84%)
14. I was happy with other support services (refreshment, etc...).	**0** (0%)	**0** (0%)	**2/18** (11%)	**16/18** (89%)

15. The training facilities were adequate.	**0** (0%)	**0** (0%)	**0** (0%)	**18/18** (100%)

General remarks:

- Accommodation near the venue of the course is convenient for moving

Resource persons	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**
16. The resource person(s) was/were knowledgeable about the subject matters.	**0** (0%)	**0** (0%)	**0** (0%)	**18/18** (100%)
17. The resource person(s) was/were dedicated to the training activity.	**0** (0%)	**0** (0%)	**0** (0%)	**18/18** (100%)
18. The resource person(s) gave satisfactory answers to my questions.	**0** (0%)	**0** (0%)	**0** (0%)	**18/18** (100%)
19. The resource person(s) made satisfactory presentation(s) on their topics.	**0** (0%)	**0** (0%)	**1/18** (6%)	**17/18** (94%)
20. The resource person(s) made proper preparations for the training activity.	**0** (0%)	**0** (0%)	**1/18** (6%)	**17/18** (94%)
21. The resource person(s) had good skills to engage trainees in discussions.	**0** (0%)	**0** (0%)	**1/18** (6%)	**17/18** (94%)

General remarks:

- Lecturers are experienced and enthusiastic to share knowledge
- The training course should be improved:
  + More practice time
  + More time for actual sampling
  + Determination of Hg in hazardous solid waste
  + Determination of Hg in water, sludge, sediment,...

Overall assessment on the training activity (including suggestions for improvement):

- The content of the training course is suitable to my work

3.2.5. Conclusions of technical training courses 2

- Many trainees have experience in sampling of stack gas to monitor metal emissions in stationary source. In terms of analysis, mercury is not a new analytical object for trainees. However, the amalgam-AAS system is quite new for trainees, so their implemention of practical steps on the equipment were embarrassing.
- Practical results showed that for the sample preparation, the trainees were quite proficient in experiment. Regarding the analysis of using amalgam-AAS equipment, after the teacher's guide, the trainees were proficient in the preparation of the calibration curve, calculation of the results.
- Through the second intensive training course, the participants received information, knowledge about Hg in air and stack gas in general and practical skills to analyze these compounds in water samples using amalgam- AAS system, sampling skills to monitor metal emissions in stationary source.

3.3. Technical training courses 3 on "*Determination of polybrominated diphenyl ethers (PBDE) in plastic and wastewater samples by gas chromatography - mass spectrometry (GC-MS)*"

3.3.1. Objectives, participants

Technical training course No. 3 was held at Research Centre for Environmental Technology and Sustainable Development (CETASD), VNU University of Science, Vietnam National University from November 6 to 9, 2018 with objectives:

+ To provide information, basic knowledge for technical staffs on PBDE such as emissions, regulation, contamination status and human exposure risk, sampling method, standard operating procedures (SOP) of PAH using gas chromatography mass spectrometry.

+ To guide the participants to carefully perform the practical exercise **"Determination of polybrominated diphenyl ethers (PBDE) in plastic and wastewater samples by gas chromatography - mass spectrometry (GC-MS)"**.

Lecturers:

- Prof.Dr. Pham Hung Viet, Director of CETASD.
- Assoc.Prof.Dr. Tu Binh Minh, VNU University of Science - Hanoi.
- Assoc.Prof.Dr. Duong Hong Anh, Head of organic group, CETASD.
- MSc. Nguyen Thuy Ngoc, Head of Environmental Chemistry Department, CETASD.

The detailed program of the training course was presented in the following table 3

The course was successfully organized with the participation of 14 staffs from 10 centers under the Ministry of Natural Resources and Environment/Department of Natural Resources and Environment of 10 provinces and cities in the North, including: Bac Ninh, Vinh Phuc, Thai Nguyen, Hai Duong, Hung Yen, Hai Phong, Nam Dinh, Thai Binh, Ha Tinh and Binh Duong (list of staffs participating in the training was shown in Annex 1).

3.3.2. Program of technical training courses 3

The detailed program of the training course was presented in the following table:

Time	Content
November 6th, 2018	
8:30 - 8:45	Opening ceremony
8:45 - 9:45	**Lecture 1:** Introduction of PBDE: emissions, regulation, contamination status and human exposure risk
9:45 – 10:30	**Lecture 2:** Preparation of samples for determination of PBDE in plastics and wastewater
10:30 - 10:45	Coffee break
10:45 - 11:30	**Lecture 3:** Instrumental analysis of PBDE by means of GC/MS - Qualitative, Quantitative analysis including QA/QC
11:30 - 13:00	Lunch
13:00 - 14:30	Delivery of the Standard Operation Procedure (SOP), group separation for practicum
14:30 - 17:00	Introduction of GC/MS equipment, setting up GC/MS conditions
November 7th, 2018	
8:30 - 17:00	Sample preparation: extraction, clean-up, enrichment
November 8th, 2018	

8:30 - 17:00	Sample preparation: extraction, clean-up, enrichmen Injection of samples into GC/MS,
November 9th, 2018	
8:00 - 11:30	Integration and result calculation
14:30 - 16:00	Discussion on results, comments for participants
10:00 - 16:30	Certificate delivery and Closing Remarks

3.3.3. Implementing progress and results of the technical training course 3

❖ ***Products – documents distributed to the trainees***

Each trainee was distributed one document set including the following:

- ***Program of training course***
- ***03 theoretical lectures:***

  Lecture 1: Introduction of PBDE: emissions, regulation, contamination status and human exposure risk.

  Lecture 2: Preparation of samples for determination of PBDE in plastics and wastewater

  Lecture 3: Instrumental analysis of PBDE by means of GC/MS - Qualitative, Quantitative analysis including QA/QC
- ***Standard operating procedure (SOP) for qualitative and quantitative analysis of PBDE in plastic samples by GC-MS***
- ***Standard operating procedure (SOP) for qualitative and quantitative analysis of PBDE in wastewater samples by GC-MS***. SOP includes: detailed description of preparation step (chemicals, devices, preparation of chemicals, devices, dilution of standard chemicals), sample treatment step (separation, extraction, cleanup, enrichment of sediment samples), instrumental analysis step by GC-MS (specific condition for machine operation, condition for quality assurance, quality control (QA/QC) of analysis procedure, calibration data on recovery productivity, repeatability, and notes during the implementation process).

❖ ***Products – documents submitted to Project Management Unit:***

- 02 document sets of the training course (including the documents distributed to the trainees)

Summarization of the training progress

Theoretical part

Lecture 1: Introduction of PBDE: emissions, regulation, contamination status and human exposure risk.

The lecture provided information on PBDE that is the new POP group included in the Stockholm Convention in 2009, covering the following factors: characteristics, applications, sources of discharge into the environment, pollution status in the world in general and in some location in Vietnam in particular and human exposure. Initial data on the preliminary inventory of PBDE in electronic devices, calculation of PBDE emission factors from the production and use of plastic products in Vietnam according to the life cycle were also reported.

Lecture 2: Preparation of samples for determination of PBDE in plastics and wastewater

The lecture provides information on the principles of sample preparation steps for extracting, cleaning up and enriching PBDE from the resin and waste water samples. Basically, the sample preparation procedure includes soxhlet extraction with toluene solvent, polymer precipitation, multi-step cleaning up with sulfuric acid, multi-layer silicagel column. For waste water samples, first we conducted to perform liquid-liquid extraction with dichloromethane solvent, then wash with base and acid, convert to n-hexan solvent, clean up with florisil column, concentrate and enrich sample.

Lecture 3: Instrumental analysis of PBDE by means of GC/MS - Qualitative, Quantitative analysis including QA/QC

The lecture provided information on qualitative and quantitative analysis conditions of PBDE using gas chromatography mass spectrometry including separation conditions of gas chromatography (column, temperature program), conditions for detection, qualitative methods and use of the internal standard method to quantify PBDE in the sample.

Practice

After the theoretical lectures, the trainees moved to the practical part of sample treatment. In order to ensure that all the trainees participated in practical procedure, the class was divided into 14 groups; all the members in each group together directly did the treatment of blank sample, sediment sample with the assistant of the guiders.

Sample objects

Wastewater: samples were collected from some rivers and lake system in Hanoi by CETASD. Monitoring center of Hai Duong brought one water sample for analysis at CETASD.

Plastic: samples were collected from the body of the old analytical equipment at CETASD that has not been used for 20 years.

Detailed steps

Each trainees directly analyzed one water sample, 04 or 03 trainees were in charge of extracting one plastic sample, then the plastic sample extract was divided equally for the trainees for their practice according to 02 guided procedures.

As a result, each trainees will have 01 water sample data and 01 plastic sample data.

Preparation of plastic sample:

- The small cutted polymer pieces were crushed by a universal mill several times. After that the sample was sieved with particle size below 0.5 mm.
- 03-04 trainees conducted to performe 1 plastic sample extraction (due to the limitation of soxhlet extraction system) for 16 hours (2 days).
- After extraction of the sample, each participant got a portion of the extract (corresponding to the weight ratio of the sample).
- Each trainees continued to prepare plastic samples according to the SOP
- Precipitation of polymer and cleaning up by multi-layer silica gel column
- Pumping on GCMS after extraction

Preparation of wastewater sample:

- Wastewater sample was extracted with dichloromethane solvent 3 times, 10 minutes each time
- Extract was washed by alkali and acid to remove impurities that are soluble in alkalis and acids.
- Extraction and cleaning up by florisil column
- Elution of PBDE in sample and pumping to GCMS

Practice on GC and calculation of results:

- Prepare a 6-point standard line of 8 PBDE and 8 surrogate substances
- Identify all PBDE in the sample

- Apply each sample to the calibration curve to quantify 8 PAH and 8 surrogate substances in the extract of 2 plastic and wastewater sample
- Calculate PBDE concentration in real samples after having data on GC

Report on results of groups:

Each group reported on the results of their analysis on the last day of the training course. In addition, they shared their difficulty in conducting the experiment.

The results include a full excel sheet with information about name of trainees, laboratory and results:

- Recovery efficiency of 8 PBDE surrogate standards.
- Concentration of PBDE in the real sample after multiplying by efficiency of surrogate substance, except for result of the blank sample.
  (Results for each group enclosed)

3.3.4. Evaluation results of the technical training courses 3 from trainees

	Strongly Disagree (1)	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**
Training content				
1. Contents of the training activity were useful to my work	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
2. The duration of the training activity was appropriate to cover the planned content	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
3. The training activity provided me with new knowledge	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
4. The steps of the training activity were appropriate	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
5. The time I spent on the training activity was worthwhile	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
6. My expectations from the training activity were met	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)

7. I am interested to introduce this training activity to other people	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
Training materials				
8. The training materials helped me understand the training contents.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
9. The training materials were very useful to my work	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
General remarks: - The course is very good - Content and training materials are appropriate and meet the needs				
Training methodology	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**
10. The methodology to conduct the training activity was approproate to deliver the contents	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
11. The examples used were relevant to and helped illustrate the subject matters.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
12. The timing for practices/ exercises was appropriate.	**0** (0%)	**0** (0%)	**1/14** (7%)	**13/14** (93%)
General remarks: - Training methods meet my needs				
Logistical support				
13. I was happy with the training venue.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
14. I was happy with other support services (refreshment, etc...).	**0** (0%)	**0** (0%)	**1/14** (7%)	**13/14** (93%)
15. The training facilities were adequate.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)

General remarks:

- Venue is suitable

Resource persons	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)
16. The resource person(s) was/were knowledgeable about the subject matters.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
17. The resource person(s) was/were dedicated to the training activity.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
18. The resource person(s) gave satisfactory answers to my questions.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
19. The resource person(s) made satisfactory presentation(s) on their topics.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
20. The resource person(s) made proper preparations for the training activity.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)
21. The resource person(s) had good skills to engage trainees in discussions.	**0** (0%)	**0** (0%)	**0** (0%)	**14/14** (100%)

General remarks:

- Enthusiastic and thoughtful lecturers
- Lecturers provide me with many useful knowledge and experiences

I wish to add the following comments on the training activity:

- I suggest organizing a training course on pesticide, organochlorine pesticides, organophosphorus insecticides.
- I wish to have more time to exchange with lecturers and other trainees.

Overall assessment on the training activity (including suggestions for improvement):

3.3.5. Conclusions of technical traning course 3

- Trainees are proficient in identifying PBDE signals, calculating concentration of PBDE in real samples by excel based on data of GC.
- Many laboratories and trainees obtained the high recovery efficiency (> 120%), especially those with many bromine atoms in the molecule; the recovery efficiency of PBDE with the less bromine atoms is lower.
- Some PBDE were detected in plastic samples but not in wastewater samples.
- Participants in the class are enthusiastic, positive and interested in doing experiments. Most of them usually conduct experiments in the laboratory, therefore they proficiently used apparatus or equipment for sample preparation and analysis.

Reasons:

- This is the first sample to be practiced so it is inevitable that the operation is not yet proficient in the steps of the analytical procedure. For example, some trainees took surrogate and stuffed multi-layer silica gel column inaccurately, column is severely dry, there is a lot of silica gel on the cup...
- For plastic samples, polymer precipitation and acid wash are very important, these step must be done very carefully; multi-layer silica gel column or florisil must be wet to avoid breakage and air bubbles in the column.

4. INTER-LABORATORY CROSSCHECK PROGRAM ON POP/PTS

4.1. Objectives

To evaluate the ability of laboratories in analyzing accurately some of POP/PTS objects.

4.2. Method of evaluation

The proficiency of laboratories is assessed by Z-score according to ISO 13258:2005, *Statistical methods for use in proficiency testing by Inter-laboratory comparisons*.

Z-score

Proficiency of laboratories is evaluated based on Z-score index (ISO 13258:2005, “Statistical methods for use in proficiency testing by inter-laboratory comparisons”).

Z-score is calculated as:

$$\text{Z-score} = (x - x_a)/\sigma_p$$

In which:

x analyzing result provided by participated laboratories

x_a assigned value

σ_p fitness-for-purpose-based "standard deviation for proficiency assessment"

Evaluation

Based on the calculated Z-score as above, the analysis results are evaluated as below:

IZI ≤ 2	Satisfactory performance
2 <IZI < 3	Questionable performance (need to re-check the result)
3 ≤IZI <6	Unsatisfactory performance (need to have solutions)
IZI ≥ 6	Extreme performance (need to re-check the whole procedure)

Assigned value

According to Z-score formula, assigned value X_a is required to identify Z-score. In the case that the blind sample is not CRM sample which can produce directly assigned values, there are two methods to determine assigned values. The first method is to identify assigned values based on the analysis results collected from participated laboratories which means median of analysis results is calculated after removing raw errors. This method is conducted when there are many laboratories participated with relative proficiency. The second method is to use results of one expert laboratory as assigned values.

4.3. Inter-laboratory crosscheck program on PAH

4.3.1. Time, participating institution and content of the program

After the basic training course is organized in the North, Central and South of Vietnam, the Project Management Board and Research Centre for Environmental Technology and Sustainable Development (CETASD) organized three preliminary technical training courses. "***Determination of poly aromatic hydrocarbons (PAH) in sludge samples by gas chromatography - mass spectrometry (GC-MS)***" was the first training course that was held from August 27 to 30, 2018. To assess the capacity of laboratories after the technical training on PAH, the Organizing Committee conducted an Inter-laboratory crosscheck program entitled "determination of poly aromatic hydrocarbons (PAH) in sludge samples by gas chromatography - mass spectrometry (GC-MS)".

In order to carry out this task, the Organizing Committee conducted preparation of standard samples of PAH including 16 congeners, real samples and delivered to laboratories for analysis. This program includes steps:

- ✓ Purchase of certified standard substance, preparation of test samples

- ✓ Delivery of samples and direction to conduct inter-laboratory crosscheck program.
- ✓ Each participating laboratory will use the provided methods and equipment to analyze the sample and report the results.

Participants

All of monitoring center participating in the technical training course on **"*Determination of poly aromatic hydrocarbons (PAH) in sludge samples by gas chromatography - mass spectrometry (GC-MS)*"** were delivered test samples.

Table 4.1. Institutions participating in the Inter-laboratory crosscheck program on PAH

Code	Institution
1	Center for Natural Resources and Environmental Monitoring of Ba Ria - Vung Tau
2	Center for Natural Resources and Environmental Monitoring of Da Nang
3	Center for Monitoring and Environmental Engineering of Binh Duong
4	Center for Natural Resources and Environmental Monitoring of Bac Ninh
5	Center for Natural Resources and Environmental Monitoring of Ha Tinh
6	Center for Monitoring and Environmental Engineering of Dong Nai
7	Center for Natural Resources and Environmental Monitoring of Thai Nguyen
8	Center for Environmental Monitoring of Hai Phong
9	Center for Natural Resources and Environmental Monitoring of Nghe An
10	Center for Natural Resources and Environmental Monitoring of Hung Yen
11	Center for Natural Resources and Environmental Monitoring of Hai Duong
12	Center for Natural Resources and Environmental Monitoring of Can Tho
13	Center for Natural Resources and Environmental Monitoring of Vinh Phuc
14	Center for Natural Resources and Environmental Monitoring of Quang Nam
15	Center for Natural Resources and Environmental Monitoring of Nam Dinh

Content

Project management board prepared standard samples and real samples to delivery to the participating laboratories including:

- 01 vial of PAH standard, 1ml, concentration of 1 µg/ml in xylohexane, (code of sample: STD-PAH)

- 01 vial of PAH surrogate, 1ml, concentration of 1 µg/ml in xylohexan, (code of sample: SR Mix-PAH)
- 01 vial of PAH internal standard, 1ml, concentration of 1 µg/ml in xylohexan, (code of sample: IS-PAH)
- 01 vial of sediment sample, 12 g, dried and grinded sample.

Standard solutions, surrogate and internal standards are chemicals that have been used for the training. The testing of sample homogeneous was implemented by CETASD Center.

Standards and test samples were accompanied by a notice of the Inter-laboratory crosscheck program phase 2, the report form of result and information on the analytical procedure (see Annex 3).

Laboratories analyzed PAH in sediment samples immediately after training for 1 month (September 1-30, 2018). Laboratories are recommended to fully apply the trained analytical procedure "***Determination of poly aromatic hydrocarbons (PAH) in sludge samples by gas chromatography - mass spectrometry (GC-MS)"***. In case, there are additions or changes in the procedure of PAH analysis, they must be clearly reported.

- Analytical results of the laboratories were sent to CETASD in order that the experts evaluated data, compared and wrote assessment reports on analytical results.

4.3.2. Preparation of PAH standards, real sample and homogeneity test

Original standards:

The standard solutions were prepared from the below original standards. Three original solutions included:

Table 4.2. List of original standard

No.	Name of substance, concentration, solvent	Origin	Code	Quantity	Calculation Unit
1	Standard: PAH Mix 63, 1000 µg/ml in Toluene	LGC	DRE-YA06100300TO	1	1ml

2	Surrogate: PAH Mix 33, 2000 µg/ml in Toluene	LGC	DRE-YA08273300TO).	1	1ml
3	Internal standard: Pyrene-d10, 200 µg/ml	LGC	ICA-6K-231)	1	1ml

Preparation of PAH standards, surrogate and internal standard:

The original solutions were diluted in a 50 ml volumetric flask to obtain solutions of 1 µg/ ml concentration. Cyclohexane solvent was used for gas chromatography (GC), specialized glass syringe was used for standard phase. The solutions are shaken well with a Vortex shaker before being stored in a brown glass bottle (4 ml) with PTFE cap.

Table 4.3. Standard preparation procedure

No.	Standard	Original concentration (µg/ml)	Prepared V (ml)	Prepared concentration (µg/ml)	V (µl)
1	Standard: PAH Mix 63	**1000**	50	1	50
2	Surrogate: PAH Mix 33,	**2000**	50	1	25
3	Internal standard: Pyrene-d10	**200**	50	1	250

Preparation of real sample:

Sediment samples that were issued to laboratories for analysis of PAH collected at Yen So Lake, Hanoi. Surface sediments are taken by specialized bucket. About 2 kg of wet sediment were dried at room temperature, grind and sieved with a size of 0.5 mm. Samples after grinding, sieving were stored in a glass jar and shaked well for 24 hours. 12 g each of sediment samples were divided into a 20 ml glass jars.

Homogeneity test of PAH standard and real samples:

The testing of sample homogeneous was implemented according to [1] Michael Thompson et al. (2006), "*The international Harmonized Protocol for the Proficiency Testing of Analytical Chemistry Laboratories (IUPAC Technical Report)*", Pure Appl. Chem., Vol.78, No.1, pp. 145-196, and [2]. ISO 13258:2005, "*Statistical methods for use in proficiency testing by inter-laboratory comparisons*".

Sampling

From each sample set corresponding to different concentrations, 7 vials of sample were randomly selected to test the homogeneity of sample preparation.

Content of each individual vial was homogenized and two test portions were taken for treatment and analysis by GC-MS in the same conditions and in a random order.

- ✓ For standard solutions, the solutions were diluted and analyzed on GC-MS equipment.
- ✓ For real samples, the samples were prepared according to the training procedure of PAH analysis in sediment before being analyzed on GC-MS equipment.

Statistical Analysis

Cochran test:

Duplicated results for 7 sample vials were checked with Cochran test statistic (m=7 at p=95%) to eliminate raw errors in the results. Results shown in table 2.1 indicate that all the Cochran test statistic (C calculated) are less than the critical value C, so there is no evidence for analytical outlier. Hence the homogeneity test was preceded with the complete data set.

Table 4.4. Cochran results in homogenous test of standards

No.	Substance	Critical value C *(m = 7, p = 95%)*	Cochran test C
1	Naphthalene	0,727	0,558
2	Acenaphthylene	0,727	0,725
3	Acenaphthene	0,727	0,364
4	Fluorene	0,727	0,456
5	Phenanthrene	0,727	0,535
6	Anthracene	0,727	0,272
7	Fluoranthene	0,727	0,598
8	Pyrene	0,727	0,589
9	Benz[a]anthracene	0,727	0,340
10	Chrysene	0,727	0,536

11	Benzo[b]fluoranthene	0,727	0,486
12	Benzo[k]fluoranthene	0,727	0,581
13	Benzo[a]pyrene	0,727	0,430
14	Indeno[1,2,3-cd]pyrene	0,727	0,359
15	Dibenzo[a,h]anthracene	0,727	0,480
16	Benzo[ghi]perylene	0,727	0,488

Table 4.5. Cochran results in homogenous test of surrogates (SR-PAH)

No.	Substance	Critical value C *(m = 7, p = 95%)*	Cochran test C
1	Naphthalene-d8	0,727	0,321
2	Acenaphthene-d10	0,727	0,338
3	Phenanthrene -d10	0,727	0,598
4	Chrysene -d12	0,727	0,381
5	Perylene-d12	0,727	0,494

Table 4.6. Cochran results in homogenous test of internal standard (IS-PAH)

No.	Substance	Critical value C *(m = 7, p = 95%)*	Cochran test C
1	Pyrene -d10	0,727	0,361

Table 4.7. Cochran results in homogenous test of sediment sample

No.	Substance	Critical value C *(m = 7, p = 95%)*	Cochran test C
1	Naphthalene	0,727	0,633
2	Acenaphthylene	0,727	0,363
3	Acenaphthene	0,727	0,426
4	Fluorene	0,727	0,515

5	Phenanthrene	0,727	0,423
6	Anthracene	0,727	0,364
7	Fluoranthene	0,727	0,468
8	Pyrene	0,727	0,413
9	Benz[a]anthracene	0,727	0,319
10	Chrysene	0,727	0,360
11	Benzo[b]fluoranthene	0,727	0,345
12	Benzo[k]fluoranthene	0,727	0,377
13	Benzo[a]pyrene	0,727	0,501
14	Indeno[1,2,3-cd]pyrene	0,727	0,334
15	Dibenzo[a,h]anthracene	0,727	0,387
16	Benzo[ghi]perylene	0,727	0,338

Homogeneity test

The Analytical variance **San** (the difference between rep 1 and rep 2 in one sample vial) and Sampling variance **Ssam** (difference of Between sample variance and Analytical variance) were calculated by using the recommended procedure for homogeneity test given by "The international Harmonized Protocol (1)"

$\mathbf{S_{an}}$ and $\mathbf{S_{sam}}$ were then used to calculate the $\mathbf{S^2_{sam}}$. Results in table 2.2 shows that the Sampling variance $\mathbf{S^2_{sam}}$ are smaller than the Critical Value (m = 7 at p = 95%) (table 3.4 - 3.7). Hence, the prepared samples are sufficiently homogeneous.

Table 4.8. Analytical variance **San** and Sampling variance **Ssam** of standard solutions

No.	Substance	S_{an} (%)	S_{sam} (%)	S^2_{sam}	Critical value
1	Naphthalene	3,9	7,8	0,001	0,045
2	Acenaphthylene	1,3	6,3	0,001	0,041
3	Acenaphthene	3,7	5,1	0,000	0,044
4	Fluorene	3,3	4,8	0,000	0,040
5	Phenanthrene	1,0	6,3	0,001	0,035
6	Anthracene	0,7	3,6	0,000	0,038
7	Fluoranthene	0,8	3,0	0,000	0,037
8	Pyrene	0,3	4,3	0,000	0,036
9	Benz[a]anthracene	2,4	7,0	0,001	0,035
10	Chrysene	1,3	6,9	0,001	0,039
11	Benzo[b]fluoranthene	4,9	8,2	0,000	0,043

12	Benzo[k]fluoranthene	2,4	3,8	0,000	0,046
13	Benzo[a]pyrene	3,2	1,4	0,001	0,043
14	Indeno[1,2,3-cd]pyrene	1,4	7,0	0,001	0,037
15	Dibenzo[a,h]anthracene	1,3	9,5	0,002	0,034
16	Benzo[ghi]perylene	1,5	7,0	0,001	0,036

Table 4.9. Analytical variance **San** and Sampling variance **Ssam** of surrogates

No.	Substance	S_{an} (%)	S_{sam} (%)	S^2_{sam}	Critical value
1	Naphthalene-d8	2,9	7,8	0,001	0,040
2	Acenaphthene-d10	1,5	2,1	0,000	0,041
3	Phenanthrene -d10	1,6	3,3	0,000	0,040
4	Chrysene -d12	2,3	7,6	0,001	0,034
5	Perylene-d12	1,6	6,4	0,001	0,036

Table 4.10. Analytical variance **San** and Sampling variance **Ssam** of **IS**

No.	Substance	S_{an} (%)	S_{sam} (%)	S^2_{sam}	Critical value
1	Pyrene -d10	0,4	1,5	0,000	0,035

Table 4.11. Analytical variance **San** and Sampling variance **Ssam** of real sample

No.	Substance	S_{an} (%)	S_{sam} (%)	S^2_{sam}	Critical value
1	Naphthalene	11,4	29,5	**152**	279
2	Acenaphthylene	9,7	23,7	**1,8**	6
3	Acenaphthene	10,1	22,5	**2,2**	9
4	Fluorene	6,5	13,4	**7,3**	53
5	Phenanthrene	6,4	9,5	**11,3**	811
6	Anthracene	15,5	22,4	**0,53**	51
7	Fluoranthene	5,8	9,4	**29**	709
8	Pyrene	5,2	8,6	**39**	844
9	Benz[a]anthracene	7,6	11,4	**1,7**	94
10	Chrysene	5,6	13,8	**33**	145

11	Benzo[b]fluoranthene	9,8	26,7	**144**	258
12	Benzo[k]fluoranthene	6,7	18,1	**11**	34
13	Benzo[a]pyrene	8,3	13,0	**3,4**	91
14	Indeno[1,2,3-cd]pyrene	6,6	10,3	**2,3**	77
15	Dibenzo[a,h]anthracene	8,7	15,2	**0,66**	9
16	Benzo[ghi]perylene	11,6	22,5	**130**	607

The testing of sample homogeneous was implemented according to the above procedure, the results showed that the prepared samples are sufficiently homogeneous.

Assigned values and standard deviation used to determine inter-laboratories crosscheck performance on analyzing 16 PAH in sediment samples

During this program, the organizing committee selected assigned values of 16 PAH based on the average value of 14 times when testing sample homogeneous. The relative standard deviations of substances corresponding to different PAH was also calculated according to those of CETASD when testing sample homogeneous. Table 3.12 showed assigned values and standard deviation used to determine inter-laboratories crosscheck performance on analyzing 16 PAH in sediment samples.

Table 4.12. Assigned values and standard deviation used to determine inter-laboratories crosscheck performance on analyzing 16 PAH in sediment samples

No.	Analyte	Assigned values - x_a (ng/g)	Relative standard deviation	Standard deviation - σ_p (ng/g)
1	Naphthalene	100	16	16,4
2	Acenaphthylene	14	13	1,9
3	Acenaphthene	17	13	2,2
4	Fluorene	55	8	4,4
5	Phenanthrene	248	7	16,3
6	Anthracene	33	16	5,1
7	Fluoranthene	241	6	15,0

8	Pyrene	279	6	15,7
9	Benz[a]anthracene	71	8	5,5
10	Chrysene	102	8	8,0
11	Benzo[b]fluoranthene	105	15	15,5
12	Benzo[k]fluoranthene	43	10	4,3
13	Benzo[a]pyrene	66	9	5,8
14	Indeno[1,2,3-cd]pyrene	67	7	4,7
15	Dibenzo[a,h]anthracene	18	10	1,8
16	Benzo[ghi]perylene	148	14	20,4

4.3.3. Analysis result of inter-laboratory crosscheck program on PAH

The organizing commitee deliveried samples to 15 laboratories. After analysis (3 weeks - 1 month) using the procedure provided at the training course, eight laboratories sent results to the organizing committee. Among seven remaining laboratories, some laboratories did not respond, some reported that the results could not be sent due to some broken equipments and lack of technicians. The following table summarizes the results that the laboratories performed in inter-laboratory crosscheck program on PAH.

Table 4.13. Result of Inter-laboratory crosscheck program on PAH

Code	**Concentration of PAH sediment sample (ng/g)**							
	1	**3**	**4**	**6**	**7**	**8**	**9**	**11**
Monitoring center	**Ba Ria - VT**	**Binh Duong**	**Bac Ninh**	**Dong Nai**	**Thai Nguyen**	**Hai Phong**	**Nghe An**	**Hai Duong**
Naphthalene	63	130	886	80	23.6	1375	780	67
Acenaphthylene	12	139	24	0	4.3	19	40	3
Acenaphthene	10	261	16	0	4.4	33	44	17
Fluorene	31	307	37	4.4	11.9	39	146	19
Phenanthrene	123	288	152	113	68.6	166	267	88
Anthracene	50	1665	265	0	36.8	26	399	10
Fluoranthene	161	932	102	64	85.3	113	153	69

Pyrene	167	2088	164	79	94.5	209	201	94
Benzo[a]anthracene	67	1047	67	69	28.9	127	85	30
Chrysene	64	15	123	70	22.4	170	158	44
Benzo[b]fluoranthene	72	245	190	na	56.1	87	139	62
Benzo[k]fluoranthene	68	481	146	na	42.9	5	122	19
Benzo[a]pyrene	50	91	188	na	25.3	99	155	30
Indeno[1,2,3-cd]pyrene	-	30	183	na	-	163	131	50
Dibenzo[a,h]anthracene	13	247	53	na	-	20	36	20
Benzo[ghi]perylene	21	1066	227	na	-	153	170	89

Note:

na: no analysis;

- : no detection.

The following table summarizes the analytical methods that the laboratories performed in the inter-laboratory crosscheck program on PAH.

Table 4.14. Analytical method

Table 4.14.A. Preparation of sample

Code	Laboratory/ Center	SOP of training course	Surrogate (SR)	Solvent/ Volume	Extract method	Clean up	Note
1	Ba Ria- Vung Tau	A part	No	Hexane	SOP of training course	SOP of training course	
3	Binh Duong	A part	No	-	Extracted 3 times	-	
4	Bac Ninh	-	-	-	-	-	
6	Dong Nai	Yes					
7	Thai Nguyen	Yes					Shaked by hand
8	Hai Phong	Yes					Extracted by magnetic stirring
9	Nghe An	Yes					

11	Hai Duong	-	-	-	-	-	

"-": no information;

Center for Natural Resources and Environmental Monitoring of Bac Ninh and Hai Duong reported the results in excel file.

Table 4.14B. Analysis on GC

Code	Center	Detector	GC Column	(1)	(2)	(3)	(4)	(5)	(6)
1	Ba Ria-Vung Tau	MS	DB17	-	1-200ppb R^2> 0.996	Yes	-	Yes, 81.32 %	Yes
3	Binh Duong	FID	TG5-MS	-	-	-	-	-	-
4	Bac Ninh	-	-	-	-	-	-	-	-
6	Dong Nai	MS	DB35	Yes	0.001 – 0.20 mg/L, R^2>0.99	Pyrene – d10	Yes, 46-119%	No	Yes
7	Thai Nguyen	MS	SQC	No	50-250ppb	Yes, 2-Fluorobiphenyl	Yes, H= 50,6-67,8 %	Yes, H= 56,8-68,8%	Yes
8	Hai Phong	MS	DB5	Yes	20-200ppb R^2> 0,992	Yes	Yes	No	Yes
9	Nghe An	MS	VF-Xms	-	-	-	-	-	-
11	Hai Duong	-	-	-	-	-	-	-	-

Note: "-": no information; Center for Natural Resources and Environmental Monitoring of Bac Ninh and Hai Duong reported the results in excel file

(1) Laboratory changed SIM mode for PAH congeners
(2) Range of calibration curve for 16 PAH, correlation coefficient
(3) IS: (Yes/ No, which substance did the laboratory use?)
(4) Calibration of surrogate (Yes/ No), efficiency?
(5) Recovery sample (Yes/ No), efficiency?
(6) Calibration of blank (Yes/ No)

4.3.4. Evaluation result of inter-laboratory crosscheck program on PAH

The proficiency of laboratories was assessed by Z-score according to ISO 13258: 2005 that described in Section 4.1 (formula Z, assigned values, standard deviation of substances in Table 4.12, results values of each laboratory in table 4.13). The specific evaluation results (z - score) for each laboratory with each object of analysis were presented in Table 4.15.

Table 4.15. Evaluation result of inter-laboratory crosscheck program on PAH according to Z score

Code of laboratory	**Z score**							
	1	**3**	**4**	**6**	**7**	**8**	**9**	**11**
Center	**Ba Ria - VT**	**Binh Duong**	**Bac Ninh**	**Dong Nai**	**Thai Nguyen**	**Hai Phong**	**Nghe An**	**Hai Duong**
Naphthalene	-2.2	1.9	47.9	-1.2	-4.6	77.7	41.5	-2.0
Acenaphthylene	-1.0	67.5	5.5		-5.1	2.8	14.1	-5.8
Acenaphthene	-3.1	110.2	-0.4		-5.6	7.3	12.2	0.0
Fluorene	-5.5	57.0	-4.1	-11.5	-9.8	-3.7	20.5	-8.2
Phenanthrene	-7.7	2.4	-5.9	-8.3	-11.1	-5.1	1.1	-9.9
Anthracene	3.4	320.4	45.6		0.8	-1.3	71.9	-4.4
Fluoranthene	-5.3	46.0	-9.3	-11.8	-10.4	-8.5	-5.9	-11.5
Pyrene	-7.2	115.5	-7.3	-12.8	-11.8	-4.5	-5.0	-11.8
Benzo[a]anthracene	-0.6	176.2	-0.6	-0.3	-7.5	10.2	2.6	-7.3
Chrysene	-4.7	-10.9	2.7	-4.0	-10.0	8.6	7.1	-7.2
Benzo[b]fluoranthene	-2.2	9.0	5.5		-3.2	-1.2	2.2	-2.8

Benzo[k]fluoranthene	5.9	102.6	24.2		0.0	-8.9	18.5	-5.6
Benzo[a]pyrene	-2.8	4.2	20.9		-7.1	5.6	15.3	-6.3
Indeno[1,2,3-cd]pyrene		-8.0	24.7			20.5	13.6	-3.7
Dibenzo[a,h]anthracene	-2.9	130.7	19.9			1.1	10.2	1.1
Benzo[ghi]perylene	-6.2	45.1	3.9			0.3	1.1	-2.9
Total (Max: 160)	**58**	**18**	**40**	**24**	**32**	**57**	**36**	**52**
Ranking	1	8	4	7	6	2	5	3

Results of each congener and concentration range were presented in Table 4.16. It can be found that satisfactory or questionable performance accounts for only 0-50%, the rest are unsatisfactory or extreme performance.

Table 4.16. Classification of the Z-score according to each substance and concentration range

Standard	Z – result				Z – % result			
	IZI ≤ 2	2 <IZI < 3	3 ≤IZI <6	IZI ≥ 6	IZI ≤ 2	2 <IZI < 3	3 ≤IZI <6	IZI ≥ 6
Naphthalene	3	1	1	3	37.5%	12.5%	12.5%	37.5%
Acenaphthylene	1	1	3	3	12.5%	12.5%	37.5%	37.5%
Acenaphthene	2	0	2	4	25%	0%	25%	50%
Fluorene	0	0	3	5	0%	0%	37.5%	62.5%
Phenanthrene	1	1	2	4	12.5%	12.5%	25%	50%
Anthracene	2	0	2	4	25%	0%	25%	50%
Fluoranthene	0	0	2	6	0%	0%	25%	75%
Pyrene	0	0	2	6	0%	0%	25%	75%
Benzo[a]anthracene	3	1	0	4	37.5%	12.5%	0%	50%
Chrysene	0	1	2	5	0%	12.5%	25%	62.5%
Benzo[b]fluoranthene	1	3	2	2	12.5%	37.5%	25%	25%
Benzo[k]fluoranthene	1	0	2	5	12.5%	0%	25%	62.5%

Benzo[a]pyrene	0	1	2	5	0%	12%	25%	62.5%
Indeno[1,2,3-cd]pyrene	0	0	1	7	0%	0%	12.5%	87.5%
Dibenzo[a,h]anthracene	2	1	0	5	25%	12.5%	0%	62.5%
Benzo[ghi]perylene	2	1	1	4	25%	12.5%	12.5%	50%

In order to calculate points for laboratories in this assessment, it was considered that the score of each laboratory were the total score of the reported results. After being evaluated, laboratories were ranked in order from low to high as shown in Table 4.17.

Z-score	Evaluation result	Point
IZI ≤ 2	Satisfactory performance - S	10
2 <IZI < 3	Questionable performance (need to re-check the result) - Q	5
3 ≤IZI <6	Unsatisfactory performance (need to have solutions) - U	3
IZI ≥ 6	Extreme performance (need to re-check the whole procedure) - E	0

Table 4.17. Evaluation and ranking of laboratories participating in inter-laboratory testing of PAH

Code	Laboratory	Percentage of evaluation result (%)				Point	Ranking
		IZI ≤ 2	2 <IZI < 3	3 ≤IZI <6	IZI ≥ 6		
1	Ba Ria - VT	13%	25%	37%	25%	58	1
8	Hai Phong	25%	6%	25%	44%	57	2
11	Hai Duong	18%	13%	25%	44%	52	3
4	Bac Ninh	13%	6%	31%	50%	40	4
9	Nghe An	13%	13%	13%	61%	36	5
7	Thai Nguyen	13%	0%	25%	63%	32	6
6	Dong Nai	13%	0%	6%	81%	24	7
3	Binh Duong	6%	6%	6%	82%	18	8

4.4. Inter-laboratory crosscheck program on Hg

4.4.1. Introduction

The second technical training course entitled **"Sampling and analysis of mercury in stack gas"** was organized from September 24 to 27, 2018 at Research Centre for Environmental Technology and Sustainable Development (CETASD). The training course provided the basic knowledge on mercury in the air, sampling method, cold vapor atomic absorption spectroscopy (CVAA), atomic absorption spectrometer (AAS). To assess the capacity of laboratories after the technical training on PAH, the Organizing Committee conducted an Inter-laboratory crosscheck program entitled "Analysis of mercury in stack gas by AAS".

In order to carry out this task, the Organizing Committee conducted preparation of standard samples of PAH including 16 congeners, real samples and delivered to laboratoroes for analysis. This program includes steps:

- ✓ Purchase of certified standard substance, preparation of test samples
- ✓ Delivery of samples and direction to conduct inter-laboratory crosscheck program.
- ✓ Each participating laboratory will use the provided methods and equipment to analyze the sample and report the results.

Participants

All of monitoring centers (12 centers) participating in the technical training course on ***"Sampling and analysis of mercury in stack gas"*** were delivered test samples. Although center for Natural Resources and Environmental Monitoring of Hai Phong could not participate in this course, the organizing committee issued the test sample to them due to their needs.

Table 4.18. Institutions participating in the Inter-laboratory crosscheck program 3

Code	Institution
1	Center for Natural Resources and Environmental Monitoring of Thai Nguyen
2	Center for Natural Resources and Environmental Monitoring of Bac Ninh
3	Center for Natural Resources and Environmental Monitoring of Quang Ninh
4	Center for Natural Resources and Environmental Monitoring of Nghe An
5	Center for Natural Resources and Environmental Monitoring of Ha Tinh
6	Center for Natural Resources and Environmental Monitoring of Da Nang
7	Center for Monitoring and Environmental Engineering of Dong Nai
8	Center for Natural Resources and Environmental Monitoring of Ba Ria - Vung Tau
9	Center for Monitoring and Environmental Engineering of Binh Duong
10	Center for Natural Resources and Environmental Monitoring of Quang Nam

12	Center for Natural Resources and Environmental Monitoring of Bac Ninh
15	Center for Environmental Monitoring of Hai Phong
18	Center for Natural Resources and Environmental Monitoring of Thai Binh

Content of program

Project management board prepared standard samples and real samples to delivery to the participating laboratories including:

- 01 standard of mercury was made from the real sample with concentration of 350 µg/L.
- The testing of standard homogeneous was implemented by CETASD Center before delivery

Standards and test samples were accompanied by a notice of the Inter-laboratory crosscheck program 3, the report form of result and information on the analytical procedure (Annex 3).

Laboratories analyzed mercury in test samples immediately after training for 1 month (from September 28 to October 21, 2018). Laboratories are recommended to fully apply the trained analytical procedure. In case, there are additions or change in the procedure of mercury analysis, they must be clearly reported.

Analytical results of the laboratories were sent to CETASD in order that the experts evaluated data, compared and wrote assessment reports on analytical results

4.4.2. Preparation of mercury standards and homogeneity test

Original standard:

The standard solutions were diluted from the original standard with concentration of 1000 mg/l.

Table 4.19. List of mercury original standard

No.	Substance, concentration, solvent	Origin	Code	Quantity	Unit
1	Hg 1000 µg/ml trong 5% HNO_3	LGC	VHG-PHGN-100	1	100ml

Preparation of standard:

The standard sample was prepared by directly diluting the original standard solution of mercury in a volumetric flask. The standard of mercury had a concentration of about 350 µg/ L.

- Taking 700 µl from the standard of 1000 mg/l into a 2000 ml volumetric flask.
- Filling up to the mark with tap water.
- Ultrasonic vibration of sample for 30 minutes
- Samples were divided into a 20 ml glass jars
- Lab codes were from W-Hg-01 to W-Hg-23
- Lab code: Inter-lab crosscheck program 3

Inter-lab crosscheck program 3
-9/2018-
Code: **W-Hg-xx**

Homogeneity test of mercury standard

Homogeneity test of each standard sample is carried out according to the Hg analysis procedure in stack gas provided by the technical training course 3. The specific procedure was as follows:

Sampling

From each sample set corresponding to different concentrations, 8 vials of sample were randomly selected to test the homogeneity of sample preparation.

Content of each individual vial was homogenized and seven test portions were taken for preparation and analysis by CV-amalgam-AAS in the same conditions and in a random order.

Statistical Analysis

Cochran test:

Duplicated results for 8 sample vials were checked with Cochran test statistic (m=8 at p=95%) to eliminate raw errors in the results. Results shown in table 3.20 indicate that all the Cochran test statistic (C calculated) are less than the critical value C, so there is no

evidence for analytical outlier. Hence the homogeneity test was preceded with the complete data set.

Table 4.20. Cochran results in homogenous test of standard

Substance	Critical value C *(m = 8, p = 95%)*	Cochran test C
Hg	0,3535	0,225

The Analytical variance **San** (the difference between rep 1 and rep 2 in one sample vial) and Sampling variance **Ssam** (difference of between sample variance and Analytical variance) were calculated by using the recommended procedure for homogeneity test given by "The international Harmonized Protocol (1)".

$\mathbf{S_{an}}$ and $\mathbf{S_{sam}}$ were then used to calculate the $\mathbf{S^2_{sam}}$. Results in table 4.20 and 4.21 shows that the Sampling variance $\mathbf{S^2_{sam}}$ are smaller than the Critical Value (m = 7 at p = 95%) (table 4.4 - 4.7). Hence, the prepared samples are sufficiently homogeneous.

Table 4.21. Analytical variance **San** and sampling variance **Ssam** of standard solution

Substance	S_{an} (%)	S_{sam} (%)	S^2_{sam}	Critical value
Hg	1,7	4,3	0,817	350

The testing of sample homogeneous was implemented according to the above procedure, the results showed that the prepared samples are sufficiently homogeneous.

Assigned values and standard deviation used to determine inter-laboratories crosscheck performance on analyzing mercury in test samples

During this program, the organizing committee selected assigned values based on the certificate of that standard corresponding to the concentration of diluted standards. The relative standard deviations of substances corresponding to substances was also calculated according to those of CETASD when testing sample homogeneous. Table 4.22 showed assigned values and standard deviation used to determine inter-laboratories crosscheck performance on analyzing mercury in standard.

Table 4.22. Assigned values and standard deviation used to determine inter-laboratories crosscheck performance on analyzing mercury in standard

Analyte	Assigned values - x_a (µg/L)	Relative standard deviation	Standard deviation - σ_p (µg/L)
Hg	**350**	1,98 %	6,84

4.4.3. Result of Inter-laboratory crosscheck program on mercury

The organizing commitee deliveried samples to 13 laboratories. After analysis (3 weeks - 1 month) using the procedure provided at the training course, seven laboratories sent results to the organizing committee. Among six remaining laboratories, some laboratories did not respond, some reported that the results could not be sent due to some broken equipments and lack of technicians. The following table summarizes the results that the laboratories performed in inter-laboratory crosscheck program on mercury.

Table 4.23. Result of Inter-laboratory crosscheck program on mercury

Code	Laboratory/ Center	Hg (µg/L)
	Assigned value	**350**
1	Center for Natural Resources and Environmental Monitoring of Thai Nguyen	496
7	Center for Monitoring and Environmental Engineering of Dong Nai	333
9	Center for Monitoring and Environmental Engineering of Binh Duong	400
10	Center for Environmental Monitoring and Analysis of Quang Nam	404
12	Center for Natural Resources and Environmental Monitoring of Bac Ninh	338
15	Center for Environmental Monitoring of Hai Phong	218
18	Center for Monitoring of Natural Resources and Environment of Thai Binh	513

The following table summarizes the analytical methods that the laboratories performed in the inter-laboratory crosscheck program on mercury.

Table 4.24. Used analytical methods in the inter-laboratory crosscheck program on mercury

Code	Center	Equipment	Calibration of matric e	Calibration of Blank	Calibration of recovery sample/ blank	Dilution factor	Method
1	Center for Natural Resources and Environmental Monitoring of Thai Nguyen	ICP	Yes	Yes	No	50 (5 ml of sample -> 250 ml)	SMEWW 3125B:2012
7	Center for Monitoring and Environmental Engineering of Dong Nai	AAS				50 (2 ml of sample -> 100 ml)	SOP of training course
9	Center for Monitoring and Environmental Engineering of Binh Duong	AAS	Yes	Yes	No	100 (0.5 ml of sample -> 50 ml)	Available SOP of laboratory
10	Center for Environmental Monitoring and Analysis of Quang Nam	AAS	No	No	Yes	250 (1 ml of sample -> 250 ml)	Available SOP of laboratory
12	Center for Natural Resources and Environmental Monitoring of Bac Ninh	DMA-80				1 (0.1 ml of sample)	Available SOP of laboratory
15	Center for Environmental Monitoring of Hai Phong	AAS				100 (1 ml of sample -> 100 ml)	Available SOP of laboratory

18	Center for Monitoring of Natural Resources and Environment of Thai Binh	AAS	Yes	Yes	No	200 (0.5 ml of sample -> 100 ml)	Available SOP of laboratory

4.4.4. Evaluation result of inter-laboratory crosscheck program on mercury

The proficiency of laboratories was assessed by Z-score according to ISO 13258: 2005 that described in Section 4.2 (formula Z, assigned values, standard deviation of substances in Table 4.22, results values of each laboratory in table 4.23). The specific evaluation results (z - score) for each laboratory with each object of analysis were presented in Table 4.25.

Table 4.25. Evaluation result of inter-laboratory crosscheck program on PAH according to Z score

Code	Institution	Z score	Point
		Hg	
1	Center for Natural Resources and Environmental Monitoring of Thai Nguyen	21.3	0
7	Center for Monitoring and Environmental Engineering of Dong Nai	-2.5	5
9	Center for Monitoring and Environmental Engineering of Binh Duong	7.3	0
10	Center for Environmental Monitoring and Analysis of Quang Nam	7.9	0
12	Center for Natural Resources and Environmental Monitoring of Bac Ninh	-1.8	10
15	Center for Environmental Monitoring of Hai Phong	-19.3	0
18	Center for Monitoring of Natural Resources and Environment of Thai Binh	23.8	0

The statistics showed that satisfactory or questionable performance accounts for from 28%, the rest are unsatisfactory or extreme performance.

Table 4.26. Classification of the Z-score - analysis of mercury

Code	Assigned value (µg/l)	Classification of the Z – quantity of result				Classification of the Z – percentage of result			
		IZI ≤ 2	2 <IZI < 3	3 ≤IZI <6	IZI ≥ 6	IZI ≤ 2	2 <IZI < 3	3 ≤IZI <6	IZI ≥ 6
Hg	**350**	1	1	0	5	14%	14%	0%	72%

Table 4.27. Evaluation and ranking of laboratories participating in inter-laboratory crosscheck program on mercury

Code	Laboratory	Z score	Point	Ranking
12	Center for Natural Resources and Environmental Monitoring of Bac Ninh	-1.8	10	1
7	Center for Monitoring and Environmental Engineering of Dong Nai	-2.5	5	2
9	Center for Monitoring and Environmental Engineering of Binh Duong	7.3	0	3
10	Center for Natural Resources and Environmental Monitoring of Quang Nam	7.9	0	4
15	Center for Environmental Monitoring of Hai Phong	-19.3	0	5
1	Center for Natural Resources and Environmental Monitoring Thai Nguyen	21.3	0	6
18	Center for Natural Resources and Environmental Monitoring of Thai Binh	23.8	0	7

4.5. Capacity assessment of laboratories in analyzing POP/PTS

Twenty laboratories were invited to attend 3 technical training courses. Among these registered laboratories, 16 laboratories participated in the training courses on POP/organic

PTS using chromatography method, 12 laboratories attended the training course on mercury, 9 laboratories participated in both training courses.

Among centers under MONRE/DONREs, through initial capacity assessment and needs for monitoring and analysis POP/PTS, these laboratories have been selected due to the group of highest ranking and initial assessment results presented in report No. 2 of the Contract. The capacity assessment criteria inlude (i) human capacity, (ii) technical conditions, (iii) management capacity, (iv) results of inter-laboratory crosscheck program. Regarding management capacity, all laboratories have been certified with VILAS/ISO 17025 and VIMCERTS, some laboratories have been recognized according to VILAS/VIMCERTS for analysis of Hg and organochlorine pesticides, these are factors that need to be maintained. The training courses in this program have the objective of strengthening the capacity of laboratories through a major impact on human resource factors (identifying needs, providing knowledge, practical skills, building network relationships). Evaluation results of laboratories capacity were carried out on the basis of initial assessment points and inter-laboratory crosscheck program points implemented in the program (Section 4.3.4 and 4.4.4). Through this activity, it is possible to evaluate the analysis ability of POP/PTS based on two organic groups/mercury relatively among laboratories as shown in Table 4.28. The results of this assessment were provided in order that the PMU select suitable laboratories for further capacity building to become a leading laboratory in the network.

Table 4.28. Capacity assessment of laboratories in analyzing POP/PTS

Center	Ranking of analysis capacity		Certificate Number		Recognized parameter by VIMCERTSS/VILAS	
	Organic POP	Hg	VILAS/ISO 17025	VIMCERTSS	Organochlorine pesticide	Hg
Ba Ria	1	6	VILAS 149	VIMCERTSS 011	0	+
Bac Ninh	4	2		VIMCERTSS 049	0	+
Binh Duong	6	8	VILAS 084	VIMCERTSS 002	0	0
Hai Duong	3	9	VILAS 437	VIMCERTSS 017	0	+
Hai Phong	5	5	VILAS 249	VIMCERTSS 008	0	+
Nghe An	2	10	VILAS 651	VIMCERTSS 005	+	+

Quang Nam	10	1	VILAS 541	VIMCERTSS 048	+	+
Thai Binh	9	7	VILAS 568	VIMCERTSS 016	+	+
Thai Nguyen	8	4	VILAS 154	VIMCERTSS 024	+	+
Dong Nai	7	3	VILAS 058	VIMCERTSS 003	+	+

Note:

The evaluation of the ranking according to the points of the following criteria:

- Human capacity, technical conditions, management capacity, POP/Hg analytical needs (according to report No. 2 of the contract)
- Results of interlaboratory crosscheck program on organic POP analysis (2 times), Hg (1 time) (report No.2 (section 3.2.3), report No.4 (section 4.3.4 and 4.4.4))

The results of this assessment are information for the Project Management Unit and the Vietnam Environment Administration to select best laboratories that will be invested further in capacity building to become a key laboratory in the national POP/PTS monitoring network.

5. CONCLUSIONS

Baseline capacity of the laboratories and trainees

Objects of the project are sixty-nine laboratories under MONRE/DONREs. Among them, 39 laboratories participated in basic training course and provided initial information of capacity assessment. Firstly, it can be affirmed that these laboratories have POP/PTS needs to find out information about new pollutants.

The basic training course aimed to provide basic information about the new POP/PTS, discuss directly with the laboratories to identify needs as well as the available capacity related to POP/PTS. After the basic training course, 20 laboratories have been selected to participate in the technical training on experimental skills.

These laboratories were equipped with equipments that can analyze some classical POPs and mercury such as gas chromatography electron capture detector (GC-ECD), gas chromatography mass spectroscopy (GC-MS), high performance liquid chromatography (HPLC), atomic absorption spectrometer (AAS),... However, to analyze POP/PTS objects, it required the synchronization of conditions of chemicals, equipments and ỉnastructure. In terms of human resources, some of technical staffs in these laboratories (trainees of training courses) have little experience in sample preparation and use of GC equipment, AAS... However, they did not have the basic knowledge on POP/PTS as well as in-depth knowledge. In addition, skills in analyzing new objects such as POP/PTS were weak due to lack of time and practice conditions skills.

Content of the capacity building program

Based on baseline capacity of the laboratories, the capacity building program was designed with the contents to improve the human resource capacity of laboratories in analysis and monitoring of POP/PTS. Therefore, the program includes the following contents:

- **Basic information and knowledge on POP/PTS**: this content answered questions about which pollutants are, where they come from, why we are interested in it in the environment. Moreover, this content also provided information about current management regulations, basic technical conditions and methods that need to be invested, studied and trained to be able to perform monitoring and analysis of POP/PTS in the environment. These are the necessary information for the technicians to have an overview of the problem that they will implement.
- **Knowledge and professional skills for analyzing and monitoring specific POP/PTS**: three technical training courses were organized to train on three

POP/PTS namely PBDEs, PAHs and mercury in water, sediment/sludge, plastic and stack gas samples using mass spectrometry GC-MS and AAS. These training courses provided the lectures and theoretical documents so that trainees can grasp in-depth knowledge of objects, equipment and techniques before practice session. Most time of the training courses was spent to practice analysis/monitoring skills under the guidance of lecturers. After the training courses, the laboratories were given a test sample so that trainees can continue to practice in conditions of their laboratory. For each laboratory, this activity was also a training for management requirements, ensurement of the analytical quality.

Results of the capacity building program

For the laboratories under MONRE/DONREs, it can be said that this is the first capacity-building program for the human resources on POP/PTS new pollutants (note: organochlorine pesticides are classified into classic pollution objects), especially including experiment. The program was comprehensively designed from the step of providing basic information and knowledge, identifying the need for technical training to the step of providing knowledge and professional practice skills of specific object for the trainees.

As the technical staffs of the laboratory, the trainees participated enthusiastically and seriously in the process of practice, contributed ideas and discussed effectively. Through the evaluation form, the participants were very satisfied (> 90%) with the training program because the provided knowledge and skills were specific and useful to their current and future work. Because new POP/PTS will continue to be added to the regulations on the environmental monitoring and analysis, trainees especially wish to have the opportunity to participate in similar training courses in the future. Thus, it can be found that the program has achieved good results in improving capacity of human resources for laboratories in order to implement tasks of POP/PTS analysis and monitoring and the national environmental monitoring network.

In addition, through the program, laboratories, technical staffs and experts in the same field have built relationships. Firstly, this facilitates the exchange of information and establish a network in the future. It is considered as the "social capital" factor to enhance cooperation, contribute to improve the capacity of laboratories in analysis and monitoring of POP/PTS.

ANNEX 1. LIST OF PARTICIPANTS IN TRAINING COURSES

1.1. List of participants in basic training courses

No.	Name of participants	Lab	Address	Phone number
List of participants in basic training courses in Hanoi (47 participants)				
1.	Vu Thi Quynh Hoa	Center for Meteorology, Hydrology and Environment, Vietnam Meteorological and Hydrological Center	No. 8, Phao Dai Lang street, Lang Thuong, Dong Da, Ha Noi	0983740619
2.	Tong Thi Van Anh			0982819817
3.	Nguyen Thi Kim Anh	Center for Environmental Research, Vietnam institute of meteorology, hydrology and climate change	Hamlet 62, Nguyen Chi Thanh, Dong Da, Ha Noi	0986117542
4.	Nguyen Truong Giang			0374099644
5.	Trinh Thi Tham	Environmental Laboratory - Faculty of Environment, Hanoi University of Natural Resources and Environment	No 41A, Phu Dien, Phu Dien, Bac Tu Liem, Ha Noi	0983307385
6.	Bui Thi Phuong			
7.	Nguyen Kim Hoan	Institute of Environmental Sciences, Vietnam Environment administration	7th floor, Lot E2, Duong Dinh Nghe, Cau Giay, Ha Noi	0396986411

8.	Do Duc Thu	Center for Natural Resources and Environmental Monitoring of Hanoi	No. 36A Pham Van Dong, Hanoi	0915798499
9.	Le Van Duc			0915528930
10.	Do Duy Khanh			0946684222
11.	Le Cao The			0396557586
12.	Dang Thi Lien			0982002826
13.	Nguyen Thi Anh	Center for Natural Resources and Environmental Monitoring of Ha Tinh	No 1, Vo Liem Son, Ha Tinh City, Ha Tinh	0916636099
14.	Tran Thi Thanh			09179051568
15.	Nguyen Van Khuyen	Center for Natural Resources and Environmental Monitoring of Lai Chau	Residential No.5, Tan Phong, Lai Chau City, Lai Chau	0912789396
16.	Hoang Van Vien			0974837127
17.	Lu Thi Hoan	Center for Environmental Monitoring and Analysis of Ha Nam	Lam Ha Ward, Phu Ly City, Ha Nam	0948863836
18.	Truong Dinh Duong			0389967059
19.	Dinh Thi Huyen	Center for Environmental Monitoring and Analysis of Nam Dinh	No. 192, Cu Chinh Lan street, Nam Dinh City, Nam Dinh	0989260405
20.	Dinh Thi Thom			0984945871
21.	Dao Thi Thu	Center for Resources & Environmental Protection of Vinh Phuc	Khai Quang Ward, Vinh Yen City, Vinh Phuc	0974360814
22.	Le Thanh Nam			0985342775

23.	Le Phu Dong	Center for Environmental Monitoring and Analysis of Hai Duong	159 Ngo Quyen str., Hai Duong City, Hai Duong	0983705628
24.	Tran Xuan Toan			0934467789
25.	Nguyen Van Tuan			0904063272
26.	Nguyen Van Tiep	Center for Environmental Monitoring of Hai Phong	275 Lach Tray, Ngo Quyen, Hai Phong City	0868080684
27.	Tran Thi Minh Huyen			0934365288
28.	Nguyen Van Trong	Center for Environmental Monitoring of Bac Giang	No. 158, Xuong Giang str., Bac Giang City, Bac Giang	0976322458
29.	Nguyen Thi Dong			01682296826
30.	Pham Huong Luu			01223272502
31.	Nguyen Thi Ha An	Center for Natural Resources and Environmental Monitoring of Bac Ninh	No. 11, Hai Ba Trung str., Suoi Hoa ward, Bac Ninh City	0912348590
32.	Dinh Thi Thanh Tam			0868896823
33.	Nguyen Thanh Son			0943313233
34.	Vu Thanh Hai	Center for Environmental Monitoring of Bac Kan	Residential No. 1A, phuong Phung Chi Kien, thanh pho Bac Kan, tinh Bac Kan	0388433688
35.	Vu Nguyen Cuong			0964382362
40.	Bui Ngoc Trang	Center for Monitoring of Natural Resources and Environment of Thai Binh	No 12, Quang Trung ward, Thai Binh City	0904443622
41.	Ha Manh Dung			0987821084
42.	Pham Truong Giang			0904490496
43.	Pham Thi Nga	Center for Natural Resources and Environmental Monitoring of Thai Nguyen	No 425A, Phan Dinh Phung, Thai Nguyen City	0949374295
44.	Pham Thi Thanh Thuy			0987849225
45.	Phung Thi Thuy			0974425589

46.	Nguyen Huu Chuc	Center for Environmental Monitoring and Analysis of Hung Yen	No 437 Nguyen Van Linh, Hung Yen City, Tinh Hung Yen	
47.	Nguyen Thi Thuy			
List of participants in basic training courses in Hochiminh City (24 participants)				
48.	Pham Van Sinh	Southern Division of Water Resources Planning and Investigation	59, street No.2, Binh An ward, District 2, Hochiminh City	0939142848
49.	Nguyen Van Sinh			09362773535
50.	Le Xuan Hoa	Sub-institute of Hydrology and Climate Change, Institute of Meteorology, Hydrology and Environment	19, Nguyen Thi Minh Khai street, Ben Nghe ward, dist No.1, Hochiminh City	0972067785
51.	Tran Minh Son			0938850836
52.	Le Ngoc Quy	Southern Natural Resources and Environment Company	30, street No. 3, Binh An ward, District 2, Hochiminh City	
53.	Van Huu Tai			
54.	Bui Phuong Linh	Environmental Laboratory, University of Natural Resources and Environment of Ho Chi Minh City	236B Le Van Sy, Ward 1, Tan Binh dist., Hochiminh City	
55.	Dam Thi Minh Tam			

56.	Vu Cong Thanh	Center for Environmental Monitoring of Tay Ninh	No 606, 30/4 str., ward 3, Tay Ninh town	0989767101
57.	Dang Thai Hieu			0935529625
58.	Le Thi Thanh Lieu	Center for Environmental Monitoring and Analysis of Ba Ria - Vung Tau	28B Thi Sach, Thang Tam, Vung Tau City, Ba Ria-Vung Tau	090962072
59.	Pham Van Canh			0987743716
60.	Tran Van Thom	Center for Natural Resources and Environmental Monitoring of Hau Giang	No 19, Vo Van Kiet str., ward 5, Vi Thanh, Hau Giang	0906904374
61.	Nguyen Duong Mai Thy	Center for Monitoring and Environmental Engineering of Tra Vinh	478A Mau Than, ward 6, Tra Vinh town	038 617 9690
62.	Ngo Van Linh			0383688665
63.	Huynh Thao Vy	Center for Natural Resources and Environmental Monitoring of Soc Trang	No. 18 Hung Vuong, ward 6, Soc Trang	0939270212
64.	Nguyen Thi Hong Tham			0942135400
65.	Doan Thi Truc Man	Southern regional Hydro-Meterological center	No. 8 Mac Dinh Chi, dist. 1, Ho Chi Minh City	0906732709
66.	Luong Lam Tuan Phi			
67.	Huynh Tan Luc	Center for Natural Resources and Environmental Monitoring of Kien Giang	No. 1226A Nguyen Trung Truc, An Binh ward, Rach Gia City, Kien Giang	0944599191
68.	Nguyen Van Dat			0944253020

69.	Le Quoc Hieu	Center for Natural Resources and Environmental Monitoring of Ca Mau	No. 17, 1/5 str., ward 5, Ca Mau City	0913988177
70.	Nguyen Hoang Viet			0948185195
71.	Tran Long Phi			0944454878
72.	Nguyen Chi Cuong	Center for Monitoring and Environmental Engineering of Binh Duong	26 Huynh Van Nghe, Phu Loi ward, Thu Dau Mot, Binh Duong	0937249047
73.	To Thi Hong Chuyen			01639751416
74.	Duong Thi Thanh Phuong	Center for Monitoring and Environmental Engineering of Dong Nai	520 Duong Dong Khoi, Tan Hiep ward, Bien Hoa, Dong Nai	0907207292
75.	Nguyen Thanh Hoa			0983770584
List of participants in basic training courses in Danang (24 participants)				
76.	Ho Thi Kim Lam	Center for Environmental Monitoring and Analysis of Quang Nam	No. 84, Phan Boi Chau str., Tam Ky City, Quang Nam	0935 089 760
77.	Tran Thua The			0934 749 772
78.	Le Minh Ngoc	Center for Environmental Monitoring and Analysis of Dak Lak	No. 38, Nguyen Chi Thanh str., Buon Ma Thuot City, Dak Lak	0978 897 017
79.	Nguyen Minh Tuan			0937 072 772
80.	Nguyen Cong Tuan	Center for Natural Resources and Environmental Monitoring of Lam Dong	No. 35B Pasteur, ward 4, Da Lat City, Lam Dong	0937.948.005
81.	Dang Nguyen Tran Huy			01684138834

82.	Quach Thanh Thuy	Center for Natural Resources and Environmental Monitoring of Khanh Hoa	No. 35 Yet Kieu, Nha Trang City	0975 436 487
83.	Do Anh Van			0905 757 100
84.	Dang Thi Le Thuong	Center for Natural Resources and Environmental Monitoring of Dak Nong	Cao Thang, Nghia Duc ward, Gia Nghia town, Dak Nong	0908 610008
85.	Pham Dinh Thach			0919 531 424
86.	Huynh Van Tinh	Mid-central regional Hydro-Meterological center	660 Trung Nu Vuong, Hoa Thuan Nam, Hai Chau dist., Da Nang	0905 191 595
87.	Nguyen Anh Tuan			0905 667 081
88.	Hoang Thi Xuyen	Center for Environmental Engineering of Da Nang	24 Ho Nguyen Trung, Hoa Cuong Nam ward, Hai Chau dist., Da Nang City	0901123103
89.	Nguyen Dinh Phuoc	Center for Natural Resources and Environmental Monitoring of Thua Thien Hue	173 Pham Van Dong str., Vy Da ward, Hue City, Thua Thien Hue	0982 729 579
90.	Duong Trong Anh			01214498893
91.	Nguyen Van Chung			0905 227 113
92.	Phan Minh Hoa			0978 016 195
93.	Nguyen Hai Minh	Center for Environmental Monitoring of Phu Yen	547 Hung Vuong, ward 9, Tuy Hoa City, Phu Yen	01222 525 357
94.	Nguyen Ngoc Nhu Son			0987 214 612
95.	Nguyen Thi Thanh Thuy			0985 590 422

98.	Tran Thi Thanh	Center for Environmental Monitoring and Engineering of Nghe An	No. 2, hamlet 248, Ha Huy Tap str., Vinh City, Nghe An	0982 159 981
99.	Pham Thi Hong Thuy			0971 053 892
100.	Doan Thi Ngoc Linh	Center for Environmental Monitoring of Binh Thuan	A41 Hung Vuong, Phan Thiet City, Binh Thuan	0908 70 511
101.	Truong Thi Kim Linh	Center for Environmental Monitoring of Binh Thuan	A41 Hung Vuong, Phan Thiet City, Binh Thuan	1278 445

1.2. List of participants in PAH training course

No.	Name of participants	Lab	Address	Phone number
1.	Tran Quoc Viet	Center for Environmental Engineering of Da Nang	24 Ho Nguyen Trung, Hoa Cuong Nam ward, Hai Chau dist., Da Nang City	01224195383
2.	Pham Van Canh	Center for Environmental Monitoring and Analysis of Ba Ria - Vung Tau	28B Thi Sach, Thang Tam, Vung Tau City, Ba Ria-Vung Tau	0987743716
3.	Le Dinh Hai			0978489526
4.	Le Phu Dong	Center for Environmental Monitoring and Analysis of Hai Duong	159 Ngo Quyen str., Hai Duong City, Hai Duong	0983705628
5.	Nguyen Van Tuan			0904063272

6.	Nguyen Thi Anh	Center for Natural Resources and Environmental Monitoring of Ha Tinh	No 1, Vo Liem Son, Ha Tinh City, Ha Tinh	091.6636099
7.	Tran Thi Thanh			0917.9051568
8.	Dinh Thi Thanh Tam	Center for Natural Resources and Environmental Monitoring of Bac Ninh	No. 11, Hai Ba Trung str., Suoi Hoa ward, Bac Ninh City	0868896923
9.	Mai Hung	Center for Environmental Monitoring and Analysis of Hung Yen	No 437 Nguyen Van Linh, Hung Yen City, Tinh Hung Yen	0914913175
10.	Nguyen Khanh Luan	Center for Natural Resources and Environmental Monitoring of Can Tho	No. 8, Nguyen Van Cu, An Hoa, Ninh Kieu, Can Tho	0986.020.694
11.	Nguyen Minh Tam	Center for Monitoring and Environmental Engineering of Binh Duong	26 Huynh Van Nghe, Phu Loi ward, Thu Dau Mot, Binh Duong	0907 195 670
12.	To Thi Hong Chuyen			0163 975 1416
13.	Nguyen Van Tiep	Center for Environmental Monitoring of Hai Phong	275 Lach Tray, Ngo Quyen, Hai Phong City	0868080684
14.	Luu Thi Hoi	Center for Monitoring and Environmental Engineering of Dong Nai	520 Duong Dong Khoi, Tan Hiep ward, Bien Hoa, Dong Nai	0983770584
15.	Nguyen Thanh Hoa			01686866511

16.	Pham Thi Hong Thuy	Center for Environmental Monitoring and Engineering of Nghe An	No. 2, hamlet 248, Ha Huy Tap str., Vinh City, Nghe An	0971053892
17.	Nguyen Mai Hanh	Center for Resources & Environmental Protection of Vinh Phuc	Khai Quang Ward, Vinh Yen City, Vinh Phuc	0984079176
18.	Nguyen Nhat Truong	Center for Environmental Monitoring and Analysis of Quang Nam	No. 84, Phan Boi Chau str., Tam Ky City, Quang Nam	0911379089
19.	Cao Tan Le			0935021204
20.	Nguyen Thi Thu Trang	Center for Environmental Monitoring and Analysis of Nam Dinh	No. 192, Cu Chinh Lan street, Nam Dinh City, Nam Dinh	01258450047
21.	Dinh Thi Huyen			0989260405
22.	Pham Thi Thanh Thuy	Center for Natural Resources and Environmental Monitoring of Thai Nguyen	No 425A, Phan Dinh Phung, Thai Nguyen City	0987849225

1.3. List of participants in mercury training course

No.	Name of participants	Lab	Address	Phone number
1.	Nguyen Van Hung	Center for Natural Resources and Environmental Monitoring of Bac Ninh	No. 11, Hai Ba Trung str., Suoi Hoa ward, Bac Ninh City	0913913165

2.	Ta Thi Quy	Center for Natural Resources and Environmental Monitoring of Thai Nguyen	No 425A, Phan Dinh Phung, Thai Nguyen City	01685148627
3.	Dang Thi Huyen Hue			0978548993
4.	Nguyen Duc Toan	Center for environmental monitoring, MONRE	No. 556, Nguyen Van Cu, Gia Thuy ward, Long Bien dist., Hanoi	
5.	Pham Truong Giang	Center for Monitoring of Natural Resources and Environment of Thai Binh	No 12, Quang Trung ward, Thai Binh City	0904 490 496
6.	Hoang Minh Thao			0378 345 083
7.	Bui Ngoc Trang			
8.	Phung Van Hung	Center for Monitoring of Natural Resources and Environment of Quang Ninh	Hong Ha, Ha Long City, Quang Ninh	0349696120
9.	Nguyen Truong Sung	Center for Environmental Monitoring and Engineering of Nghe An	No. 2, hamlet 248, Ha Huy Tap str., Vinh City, Nghe An	0947078586
10.	Nguyen Tuan	Center for Natural Resources and Environmental Monitoring of Ha Tinh	No 1, Vo Liem Son, Ha Tinh City, Ha Tinh	0916435568
11.	Nguyen Tong Ty			0947 895915
12.	Tran Quoc Viet	Center for Environmental Engineering of Da Nang	24 Ho Nguyen Trung, Hoa Cuong Nam ward, Hai Chau dist., Da Nang City	01224195383

13.	Le Van Hao	Center for Environmental Monitoring and Analysis of Quang Nam	No. 84, Phan Boi Chau str., Tam Ky City, Quang Nam	0389819264
14.	Tran Thua The			934749772
15.	Pham Van Canh	Center for Environmental Monitoring and Analysis of Ba Ria - Vung Tau	28B Thi Sach, Thang Tam, Vung Tau City, Ba Ria-Vung Tau	087743716
16.	Do Thanh Tuyen	Center for Monitoring and Environmental Engineering of Dong Nai	520 Duong Dong Khoi, Tan Hiep ward, Bien Hoa, Dong Nai	0918075724
17.	Le Thanh Phong			0979413939
18.	Dang Thai Nguyen			0984062032
19.	Dang Thi Lan	Center for Monitoring and Environmental Engineering of Binh Duong	26 Huynh Van Nghe, Phu Loi ward, Thu Dau Mot, Binh Duong	0383.315.513 0936.036.893

1.4. List of participants in PBDE training course

No.	Name of participants	Lab	Address	Phone number
1.	Le Phu Dong	Center for Environmental Monitoring and Analysis of Hai Duong	159 Ngo Quyen str., Hai Duong City, Hai Duong	0983705628
2.	Nguyen Van Tuan			0904063272

3.	Nguyen Thi Anh	Center for Natural Resources and Environmental Monitoring of Ha Tinh	No 1, Vo Liem Son, Ha Tinh City, Ha Tinh	091.6636099
4.	Nguyen Tong Ty			0945798389
5.	Mai Hung	Center for Environmental Monitoring and Analysis of Hung Yen	No 437 Nguyen Van Linh, Hung Yen City, Tinh Hung Yen	0914913175
6.	Ha Manh Dung	Center for Monitoring of Natural Resources and Environment of Thai Binh	No 12, Quang Trung ward, Thai Binh City	0987281084
7.	To Thi Hong Chuyen	Center for Monitoring and Environmental Engineering of Binh Duong	26 Huynh Van Nghe, Phu Loi ward, Thu Dau Mot, Binh Duong	0837 000 416
8.	Nguyen Mai Hanh	Center for Resources & Environmental Protection of Vinh Phuc	Khai Quang Ward, Vinh Yen City, Vinh Phuc	0984079176
9.	Pham Thi Thanh Thuy	Center for Natural Resources and Environmental Monitoring of Thai Nguyen	No 425A, Phan Dinh Phung, Thai Nguyen City	0987849225
10.	Nguyen Ngoc Thuy			0989463388
11.	Luu Thi Hoi	Center for Monitoring and Environmental Engineering of Dong Nai	520 Duong Dong Khoi, Tan Hiep ward, Bien Hoa, Dong Nai	0386866511

12.	Nguyen Van Tiep	Center for Environmental Monitoring of Hai Phong	275 Lach Tray, Ngo Quyen, Hai Phong City	0868080684
13.	Pham Thi Ly	Center for Environmental Monitoring and Analysis of Nam Dinh	No. 192, Cu Chinh Lan street, Nam Dinh City, Nam Dinh	0988230190
14.	Dinh Thi Thanh Tam	Center for Natural Resources and Environmental Monitoring of Bac Ninh	No. 11, Hai Ba Trung str., Suoi Hoa ward, Bac Ninh City	0868896823

ANNEX 2. PARTICIPANT TRAINING EVALUATION FORM

2.1. Participant training evaluation form for basic training course

It is valuable for our training program to be more and more successful, we highly appreciate your comments, please answer the following questions:

Please circle on your options:

1. Evaluation of the content:

A. Easy to understand □ B. Difficult to understand □ C. Very difficult to understand □

2. Evaluation of the lecturer:

A. Very interesting □ B. Interesting □ C. Normal □ D. Not interesting □

3. Through the content of lectures and presentations, how well do you know the following basic knowledge about POP/PTS?

a/ Classification, characteristics, origin

A. Very good □ B. Good □ C. Ordinary □ D. Bad □

b/ Regulations on management related to POP/PTS in the environment

A. Very good □ B. Good □ C. Ordinary □ D. Bad □

c/ Basic technical conditions for monitoring and analysis of POP/PTS

A. Very good □ B. Good □ C. Ordinary □ D. Bad □

4. After discussion session, could you please let us know the needs of your lab for monitoring and analysis of POP/PTS?

□ We do not have the needs for monitoring and analysis of POP/PTS

□ We have the needs for monitoring and analysis of POP/PTS

□ We have the needs for training on analytical method of GC

For example:

□ We have the needs for training on mercury analytical method

□ We have the needs for training on sampling methods

Kinds of samples:

5. If you score the training course, how much will be on the below scale?

1. Very bad □ 2. Bad □ 3. Normal □ 4. Interesting □ 5. Very interesting □

6. Other comments:

After you finish the above questions, please kindly submit this form for trainers.

Thank you very much for your attending this training course.

2.2. Participant training evaluation form for technical training course

Sample Participant Training Evaluation Form

Project code and title: ……..…….
National Implementing Partner: .....…….....
Co-Implementing Partner (if relevant): .....…….....

PARTICIPANT TRAINING EVALUATION FORM

Name of Training Activity: .....”
Training venue: .....
Date: ....

	Strongly Disagree (1)	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**
TRAINING CONTENT				
1. Contents of the training activity were useful to my work	☐	☐	☐	☐
2. The duration of the training activity was appropriate to cover the planned content	☐	☐	☐	☐
3. The training activity provided me with new knowledge	☐	☐	☐	☐
4. The steps of the training activity were appropriate	☐	☐	☐	☐
5. The time I spent on the training activity was worthwhile	☐	☐	☐	☐
6. My expectations from the training activity were met	☐	☐	☐	☐
7. I am interested to introduce this training activity to other people	☐	☐	☐	☐
TRAINING MATERIALS				
22. The training materials helped me understand the training contents.	☐	☐	☐	☐
23. The training materials were very useful to my work	☐	☐	☐	☐

General remarks: .....

.....

.....

TRAINING METHODOLOGY

24. The methodology to conduct the training activity was ☐ ☐ ☐ ☐ appropriate to deliver the contents.

25. The examples used were relevant to and helped illustrate the subject matters. ☐ ☐ ☐ ☐

26. The timing for practices/ exercises was appropriate. ☐ ☐ ☐ ☐

General remarks: .....

.....

.....

.....

LOGISTICAL SUPPORT

27. I was happy with the training venue. ☐ ☐ ☐ ☐

28. I was happy with other support services (refreshment, etc...). ☐ ☐ ☐ ☐

29. The training facilities were adequate. ☐ ☐ ☐ ☐

General remarks: .....

.....

.....

RESOURCE PERSONS

16. The resource person(s) was/were knowledgeable about the subject matters. ☐ ☐ ☐ ☐

17. The resource person(s) was/were dedicated to the training activity. ☐ ☐ ☐ ☐

18. The resource person(s) gave satisfactory answers to my questions. ☐ ☐ ☐ ☐

19. The resource person(s) made satisfactory presentation(s) on their topics. ☐ ☐ ☐ ☐

20. The resource person(s) made proper preparations for the training activity. ☐ ☐ ☐ ☐

21. The resource person(s) had good skills to engage trainees in discussions. ☐ ☐ ☐ ☐

General remarks: .....

.....

.....

22. I wish to add the following comments on the training activity:

.....

.....

.....

23. Overall assessment on the training activity (including suggestions for improvement):

.....

.....

.....

.....

.....

Many thanks for your contributions

ANNEX 3: FORM OF INTER-LABORATORY CROSSCHECK PROGRAM

3.1. Form of inter-laboratory crosscheck program on PAH

RESEARCH CENTRE FOR ENVIRONMENTAL TECHNOLOGY AND SUSTAINABLE DEVELOPEMENT
334 Nguyen Trai, Thanh Xuan, Ha Noi, Viet Nam
Tel: *+84-4-3858 7964*, Fax: *+84-4-3858 8152*

Hanoi, 30 August 2018

To:

- ***Participants in the second inter-laboratory crosscheck program within the framework of program entitled "strengthen monitoring capacity of POP/PTS for labs under MONREs/DONREs";***
- ***All laboratories/line agency***

Within the framework of the Project "Viet Nam POPs and Sound Harmful Chemicals Management" organized by Vietnam Environment Administration, Research Centre from Environmental Technology and Sustainable Development (CESTAD) has the honor to cooperate with the Project Management Unit of the second inter-laboratory crosscheck on poly aromatic hydrocarbons (PAH).

The inter-laboratory crosscheck program which was carried out from August 27 to 31, 2018 aimed to evaluate and strengthen laboratories capacity on the network of proficient POP analysis by gas chromatography method. In order to create favorable conditions for the participated laboratories, we would like to give all the laboratories details as following:

1. Attached samples and standard chemicals

- 01 vial of PAH standard, 1ml, concentration of 1 µg/ml in xylohexane, (code of sample: STD-PAH)
- 01 vial of PAH surrogate, 1ml, concentration of 1 µg/ml in xylohexan, (code of sample: SR Mix-PAH)
- 01 vial of PAH internal standard, 1ml, concentration of 1 µg/ml in xylohexan, (code of sample: IS-PAH)
- 01 vial of sediment sample, 12 g, dried and grinded sample.

2. Contents

- The deadline for the laboratories started analyzing and sending results to CETASD is on 15 September 2018. The results are sent to:

  Assoc.Prof.Dr. Duong Hong Anh: 0912 380 373

  Email: duonghonganh@hus.edu.com
- The laboratories can use their available analytical procedure or others analytical procedure introduced in training course on PAH.
- Experimental content is about determining total PAH in blind sample.
- Result report is represented according to report form and sent to CETASD:
  1. Result report form
  2. Addition information about PAH analysis in test samples

3. The following files and relevant documents will be sent to the laboratories via registered email address

- ***Annoucement-CESTAD.doc:*** includes work content and name list of attached chemicals

- ***Form of result.doc:*** is used to fill the analyzed result and sent to CETASD
- ***Form of addition information.xsl:*** is used to fill addition information about analysis process which will be sent to CETASD.

During the participatory process, if you have any questions or professional contributions to the organization and workflow, please contact the following address:

1. **Research Centre for Environmental Technology and Sustainable Development (CETASD)**

   T3 Building, 334 Nguyen Trai, Thanh Xuan District, Hanoi

   Contact:

   Assoc.Prof.Dr. Duong Hong Anh: 024. 3858 7964/ 0912 380 373

   Email: duonghonganh@hus.edu.com

Wish you all success!

Thank you very much for your participation.

Prof. Dr. Pham Hung Viet

Director

Project 00091381

Viet Nam POPs and Sound Harmful Chemicals Management

STRENGTHEN MONITORING CAPACITY OF POP/PTS FOR LABS UNDER MONREs/DONREs

RESULT FORM OF THE SECOND INTER-LABORATORY CROSSCHECK PROGRAM

Code (the PMU issued):	
Representative:	
Participating laboratory:	
Address:	

Type of sample:	Sediment
Code of sample:	
Issued date:	/ /2018
Analyzed date:	
Sample intake (mg)	
Final volume (ml)	
Injected volume (ml)	

Result of analysis

No.	Congener	Concentration	Unit	Note

Analyst: **Fullname** **Signature**

Additional information for the analyis of PAH

1. Preparation of sample

- The laboratory applied completely according to the training procedure:

  □ Completely □ Incompletely

- If you did not apply completely according to the training procedure or change the procedure, please let us know more information:

	Content	Change/used method
1.	Surrogate	
2.	Extraction solvent(s)/volume	
3.	Extraction method:	
4.	Clean up	
5	Other:	

2. Quatitative method of PAH

Analysis equipment: Type of GCMS equipment and analytical columns to quantify and quantify the PAH in the test sample.

	Information	Note
GC/MS : High res/low res: Type		 (Quadrup., Ion Trap, TOF,...)
GC column:		
Type:		(DB-5, BP-5MS,…)
Specifications (length x o. ID x i. ID):		(30 m x 0.25 mm x 0.25 µm, ...)

Analysis conditions of GCMS:

- The laboratory applied completely according to the training procedure:

  □ Completely □ Incompletely

- If you did not apply completely according to the training procedure or change the procedure, please let us know more information:

	Content	
1.	Laboratory changed SIM mode for PAH congeners	
2.	IS: (Yes/ No, which substance did the laboratory use?)	
3.	Range of calibration curve for 16 PAH, correlation coefficient	

4	Calibration of surrogate (Yes/ No), efficiency?	
5	Recovery sample (Yes/ No), efficiency?	
6	Calibration of blank (Yes/ No)	
7	Others:	

3.2. Form of inter-laboratory crosscheck program on mercury

RESEARCH CENTRE FOR ENVIRONMENTAL TECHNOLOGY AND SUSTAINABLE DEVELOPEMENT
334 Nguyen Trai, Thanh Xuan, Ha Noi, Viet Nam
Tel: *+84-4-3858 7964*, Fax: *+84-4-3858 8152*

Hanoi, 20 September 2018

To:

- ***Participants in the third inter-laboratory crosscheck program within the framework of program entitled "strengthen monitoring capacity of POP/PTS for labs under MONREs/DONREs";***
- ***All laboratories/line agency***

Within the framework of the Project "Viet Nam POPs and Sound Harmful Chemicals Management" organized by Vietnam Environment Administration, Research Centre from Environmental Technology and Sustainable Development (CESTAD) has the honor to cooperate with the Project Management Unit of the third inter-laboratory crosscheck on mercury.

The inter-laboratory crosscheck program which was carried out from September 28 to October 21, 2018 aimed to evaluate and strengthen laboratories capacity on the network of proficient mercury analysis by AAS. In order to create favorable conditions for the participated laboratories, we would like to give all the laboratories details as following:

1. Attached samples and standard chemicals

- 01 vial containing mercury in water, sample in 44ml colorless glass vial, black cap with septum.

2. Contents

- The deadline for the laboratories started analyzing and sending results to CETASD is on 21 October 2018. The results are sent to:

  Assoc.Prof.Dr. Duong Hong Anh: 0912 380 373

  Email: duonghonganh@hus.edu.com

- The laboratories can use their available analytical procedure or others analytical procedure introduced in training course on mercury.

- Experimental content is about determining mercury in blind sample.
- Result report is represented according to report form and sent to CETASD:
    1. Result report form
    2. Addition information about mercury analysis in test samples

3. The following files and relevant documents will be sent to the laboratories via registered email address

- ***Annoucement-CESTAD.doc:*** includes work content and name list of attached chemicals
- ***Form of result.doc:*** is used to fill the analyzed result and sent to CETASD
- ***Form of addition information.xsl:*** is used to fill addition information about analysis process which will be sent to CETASD.

During the participatory process, if you have any questions or professional contributions to the organization and workflow, please contact the following address:

2. **Research Centre for Environmental Technology and Sustainable Development (CETASD)**

   T3 Building, 334 Nguyen Trai, Thanh Xuan District, Hanoi

   Contact:

   Assoc.Prof.Dr. Duong Hong Anh: 024. 3858 7964/ 0912 380 373

   Email: duonghonganh@hus.edu.com

Wish you all success!

Thank you very much for your participation.

Prof. Dr. Pham Hung Viet

Director

Project 00091381

Viet Nam POPs and Sound Harmful Chemicals Management

STRENGTHEN MONITORING CAPACITY OF POP/PTS FOR LABS UNDER MONREs/DONREs

RESULT FORM OF THE THIRD INTER-LABORATORY CROSSCHECK PROGRAM

Code (the PMU issued):	
Representative:	
Participating laboratory:	
Address:	

Type of sample:	Standard was mixed with water
Code of sample:	
Issued date:	/ /2018
Analyzed date:	
Sample intake (ml)	
Final volume (ml)	
Injected volume (ml)	

Result of analysis

No.	Measurement	Concentration	Unit	Note
	1st			
	2nd			
	…			

Analyst: **Fullname** **Signature**

Additional information for the analyis of mercury

3. Preparation of sample

- The laboratory applied completely according to the training procedure:

  □ Completely □ Incompletely

- If you did not apply completely according to the training procedure or change the procedure, please let us know more information:

	Content	Change/used method
1.	Preparation method	
2.	Used chemicals	
3.	Other:	

4. Quatitative method of mercury

Analysis equipment: Type of equipment to quantify and quantify the mercury in the test sample.

	Information	Note
Elution of sample: Solvent: Factor of elution:		
Reference sample: CRM, RMs		
Reductant		$SnCl_2$, $NaBH_4$,…

Analysis conditions of mercury:

- The laboratory applied completely according to the training procedure:

  □ Completely □ Incompletely

- If you did not apply completely according to the training procedure or change the procedure, please let us know more information:

	Content	
1.	Construction method of calibration curve	
2	Calibration of surrogate (Yes/ No), efficiency?	
3	Recovery sample (Yes/ No), efficiency?	
4	Calibration of blank (Yes/ No)	
5	Others:	