

ACADEMIC AND RESEARCH PROGRAMS FOR CAPACITY DEVELOPMENT IN ASIA: BUILDING AN ENVIRONMENTAL CHEMISTRY NETWORK AND ITS OUTCOMES ON PERSISTENT ORGANIC POLLUTANTS AND RELATED COMPOUNDS

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Introduction

In recent decades, with rapid economic development in Asia, the effect of various persistent pollutants on human health and the ecosystem have caused increasing concerns among scientists and administrators in the region and beyond. However, for decades research on persistent organic pollutants (POPs) in Asia, particularly in developing countries, has lagged behind those in Europe and North America. Considering such background, various studies have been conducted in our laboratory at Centre for Marine Environmental Studies (CMES), Ehime University over the last three decades on the distribution, sources, transport behavior and fate, pollution trends and toxic impacts of POPs in Asia-Pacific region with a particular emphasis on the developing countries¹. Through these studies and investigations, research networks on POPs monitoring have been developed among scientists and researchers in Asian countries. As an academic evaluation based on our activities, we were fortunate to be selected for Global COE (Center for Excellence) Program of the Ministry of Education, Culture, Sports Science and Technology, Japan (MEXT) in June, 2007. Our concept of the present Global COE program "Interdisciplinary Studies on Environmental Chemistry" is to create an outstanding center for promoting advanced world-class research on chemical pollution by performing various in-depth studies on a wide range of environmental chemistry disciplines at the laboratories of CMES in collaboration with highly talented senior scientists and young researchers especially from the Asian developing countries. This paper introduces our concept for academic and research programs and facilities for capacity building in Asian network of environmental chemistry, and reviews some recent outcomes of collaborative investigations on POPs and related compounds such as brominated flame retardants (BFRs) in Asia-Pacific region.

Outline of Global COE Program in Ehime University

To accomplish the goal of the Global COE Program, we will be utilizing the academic and research oriented programs and facilities such as "Training Program for Young Scientists", "Network for Academic Exchange with Foreign Research Institutes", "Asian Environmental Scientists Network" and "Environmental Specimen Bank for Global Monitoring (*es*-BANK)". Furthermore, the fundamental concept of Global COE Program is to generate interdisciplinary and international research and education systems, and to be a source for developing novel and high ranking research themes. This can concurrently develop and multiply the talents of the young scientists, create ripple effects and form a positive spiral leading to the establishment of world-class Asian intelligence Center of Environmental Chemistry (Figure 1).

Academic Programs

The purpose of the academic program in the present COE is to strengthen the interdisciplinary skills of young researchers to international standards. We are aiming at forming an advanced center that can gather excellent young researchers from Japan and abroad and produce highly competent experts, by fostering the talents of persons who can promote environmental philosophy, contribute to the local, regional and global societies, and manage an organization as a team leader. The concrete programs are planned as follows:

- Program for Fostering Interdisciplinary Scientists: *Cultivation of intellectual interests to challenge pioneering studies*
- Program for Training Ingenious Scientists: *Mastering essential skills to become excellent scientists*
- Program for Contemplating World-class Scientists: *Promoting the ambition to be a world-class scientist*
- Program for Encouraging Leading Scientists: *Fostering the leadership talents*
- Upgrading Program for Overseas Students and Research Fellows: *Strengthening research talents of students from developing countries*

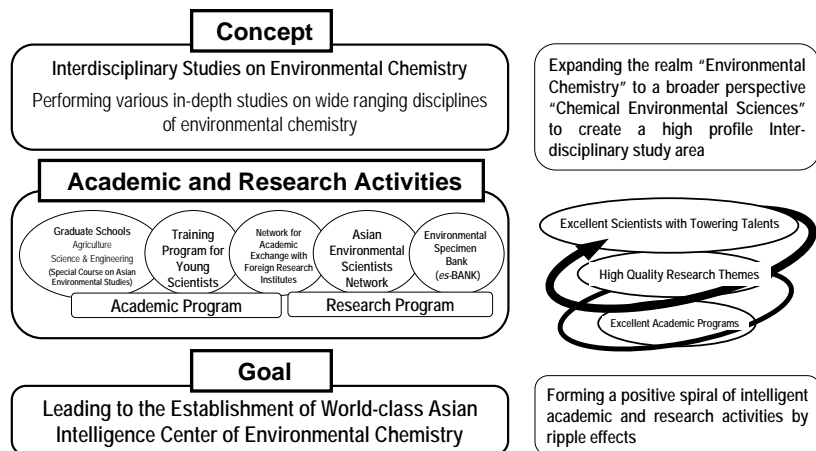


Figure 1. Outline of the Global COE Program in Ehime University

Under these programs we have promoted the academic and research activities of students and young scientists, for instance:

- Participation in field exercises and research surveys (e.g. environmental surveys on e-waste recycling activities in India² and Vietnam, and assessment of human exposure to POPs and BFRs in Indonesia³) and in academic meetings, seminars, conferences (like an excellent international symposium, DIOXIN 2008!), etc.
- Funding support for promoting creative research under competitive application (e.g. a collaborative research conducted by young scientists in Manila Bay, The Philippines)
- Funding support for promoting overseas studies utilizing Network for Academic Exchange with Foreign Research Institutes including 14 universities/institutes in U.S.A., India, Vietnam, U.K., Canada, Portugal, China, Korea
- Planning, organizing and participating in special seminars, international symposia, workshops, etc by doctoral students and post-doctoral fellows (e.g. Global COE Workshop on Development of the Environmental Science and Biological Studies Using es-BANK, Oct., 2007; International Symposium on Biological Responses to Chemical Pollution, Mar., 2008; Global COE Lecture by Prof. Jennifer Field from Oregon State University, Mar., 2008. etc.)
- Conducting special education programs such as academic seminars, exercises, experiments, etc for overseas students by the reputed guest professors from developing countries (e.g. Global COE Lecture Series by Prof. K. Kannan from State University of New York, Jan., 2008, etc.)
- Projecting the internship programs by the industry-university cooperation (Shimadzu Techno-Research Inc. held an internship on high-grade analytical technique of POPs for overseas students in Kyoto, Japan, Jan., 2008)
- Accepting annually some overseas students through Academic Exchange Program from foreign research institutes as Ph. D. students in the Special Course on Asian Environmental Studies in the Graduate Schools, Ehime University (one student from Hanoi National University, Vietnam, was accepted from Oct., 2007)
- Encouraging autonomous and mutual activities of doctoral students and post-doctoral fellows for enhancing their skill and capacity building. At present total 17 post-doctoral fellows and Ph. D. students from overseas such as Korea, China, Vietnam, The Philippines, Thailand, Indonesia, India, Sweden, France, Portugal and U.S.A. with total 26 Japanese post-doctoral fellows and Ph. D. students are working, supporting and studying under the Global COE Program in Ehime University.

Research Programs and Their Outcomes

By utilizing the research facilities and networks such as "Environmental Specimen Bank (es-BANK)", "Network for Academic Exchange among Foreign Research Institutes" and "Asian Environmental Scientists Network", the present

COE program strategically explores international collaborative studies and expedites the outcome of world-class research titled Interdisciplinary Studies on Environmental Chemistry.

We propose the following three major research projects (sub-themes) on environmental pollution and adverse biological effects of persistent toxic substances including classical and emerging POPs, organometallic compounds, trace elements, etc.:

1. Status of Contamination, Temporal and Spatial Distribution and Future Trends
2. Modeling Pollutant Behavior and Dynamics
3. Toxic Effects and Risk Assessment

Research activities by our laboratory, Division of Environmental Chemistry, are mainly related to sub-theme 1, which includes research subjects: 1) developing analytical methods for novel toxic contaminants, 2) elucidating status of contamination and global distribution of classical and emerging POPs and toxic elements, 3) surveying the source areas of pollution such as waste-dumping sites, recycling facilities, etc., and 4) assessing temporal and future trends of contamination using samples in *es*-BANK. The details of some outcomes of collaborative studies on POPs and related compounds in Asia-Pacific region are explained below.

Analytical methods for novel toxic contaminants

We developed the analytical methods for emerging POPs such as polybrominated diphenyl ethers (PBDEs), hexabromocyclododecanes (HBCDs) which can be extracted simultaneously from the same sample and quantified by GC-MS and LC-MS together with classical POPs such as PCBs and DDT⁴. This method facilitated our monitoring of emerging POPs in the Asia-Pacific region. Recently, a cell-based bioassay, DR-CALUX, was also applied to sediment and soil samples from Asian countries for a quantitative screening of dioxin-like POPs in a collaborative study with National Institute of Environmental Studies (NIES), Japan⁵. The data obtained from the bioassay were significantly correlated with WHO-TEQs determined in chemical analysis by HRGC-HRMS. Such a screening method is expected to become a useful and cost-effective tool for environmental monitoring and risk assessment of dioxin-like POPs in developing countries. Training for mastering these analytical methods by young scientists from Asian countries is one of our aims in the activity of "Network for Academic Exchange among Foreign Research Institutes".

Status of contamination and global distribution

Our research center has 35 collaborative Asian scientists who graduated from our center/university and work in Russia, Korea, China, Vietnam, The Philippines, Cambodia, Thailand, Indonesia, India, Sri Lanka, etc. They play a key role in the activities of Asian Environmental Scientists Network. Through this activity the global-scale monitoring on POPs and BFRs in Asia-Pacific region has been conducted using various kind of 'bioindicators' such as mussels, human breast milk, marine mammals and skipjack tunas. The hot spots of POPs and BFRs pollution were found in the areas where they have been heavily used, e.g., elevated hexachlorocyclohexane (HCH) residue levels were found in samples from India and South China, while pollution by DDTs was found to be high in China and Vietnam. PBDE exhibited higher concentrations in coastal waters of Korea and Hong Kong and areas around East China Sea, suggesting the presence of PBDE sources in highly industrialized zones¹. Our recent studies on mussels from Korea⁶ and cetaceans from Asian-Pacific⁷ noted different trends of spatial distribution between PBDEs and HBCDs, indicating the differences in the application of these BFRs among the locations and regions.

Waste-dumping sites and recycling facilities as sources of pollution

Asian Environmental Scientists Network was also utilized for researches to elucidate pollution sources of dioxins and related compounds (DRCs) in Asian developing countries. Significant levels of DRCs were detected in human breast milk from developing countries, indicating considerable contamination in some developing countries¹. Our earlier studies on DRCs revealed critical emission sources in the open dumping sites of municipal wastes and higher concentrations in human milk samples collected from residents around dumping sites in some Asian developing

countries such as Vietnam, Cambodia and India^{8,9}. In addition to chlorinated DRCs (i.e. PCDD/DFs and coplanar-PCBs), our recent investigations found significantly higher levels of BFRs and brominated (PBDD/DFs) and mix-halogenated dioxins (PBCDD/DFs) in soils from dumping sites in Vietnam, Cambodia and India¹⁰ and e-waste backyard recycling units in India² than in reference locations. Monitoring researches on POPs and BFRs using floor and air dusts, passive air samplers and human blood samples from Asian developing countries are being conducted to elucidate their sources and pathways of human exposure^{2,3}.

Temporal and future trends of contamination

Utilizing samples archived in *es*-BANK enables to conduct retrospective monitoring studies on emerging POPs such as PBDEs and HBCDs and other potential compounds of concern. To our knowledge, our studies on PBDEs and HBCDs were first to reveal their drastic increase in Asian waters^{7,11}. In general, the results indicate that environmental levels of PBDEs and HBCDs have risen significantly during the last 30 years. In the samples from Japan, where usage of some commercial PBDE products was voluntary discontinued in the 1990s, environmental PBDE levels seem to be steady or slightly decreasing since then. However, in the same samples, concentrations of HBCDs exhibited continuous increasing trend and, in recent years, the contaminant levels appear to exceed those of PBDEs, reflecting increasing usage of HBCDs over PBDEs in Japan. Increasing environmental contamination by PBDEs and HBCDs was also noticed in Chinese coastal waters, indicating that the contamination by BFRs has already become evident even in developing countries. In view of the rising environmental levels and high consumption volume of BFRs in Asia, further efforts should be made to monitor environmental contamination by these chemicals in order to identify sources and reduce emissions.

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