The Institute of Nature and Environmental Technology

Kanazawa University

Self-Review/Assessment Report

2017, September

The Institute of Nature and Environmental Technology,

Kanazawa University

Contents

The Institute of Nature and Environmental Technology at Kanazawa University was established in 2002 as a joint research and education facility with the purpose of streamlining existing facilities such as the Low Level Radioactive Laboratory, the Marine Laboratory, the Botanical Garden as well as the Electromagnetic Field Control Laboratory. In 2007, the institute was further integrated with the Japan Sea Research Institute at Kanazawa University in order to promote the 21st Center of Excellence program by the Ministry of Education, Culture, Sports, Science and Technology (MEXT): Environmental Monitoring and Prediction of Long- & Short-Term Dynamics of the Pan-Japan Sea Area. The institute was further reorganized in 2015 to promote environmental research and education in the pursuit of creating sustainable environmental management programs (Figure 1).

Five years has passed since the last assessment of research and educational activities in the Institute held in 2012. This short report introduces our activity during the fiscal year 2012-2016 to help the assessment. In these five years, the Noto Marine Laboratory has been authorised as a joint usage/ education center by MEXT in 2012. The whole institute was then authorised as a joint usage/ research center by MEXT in 2016.

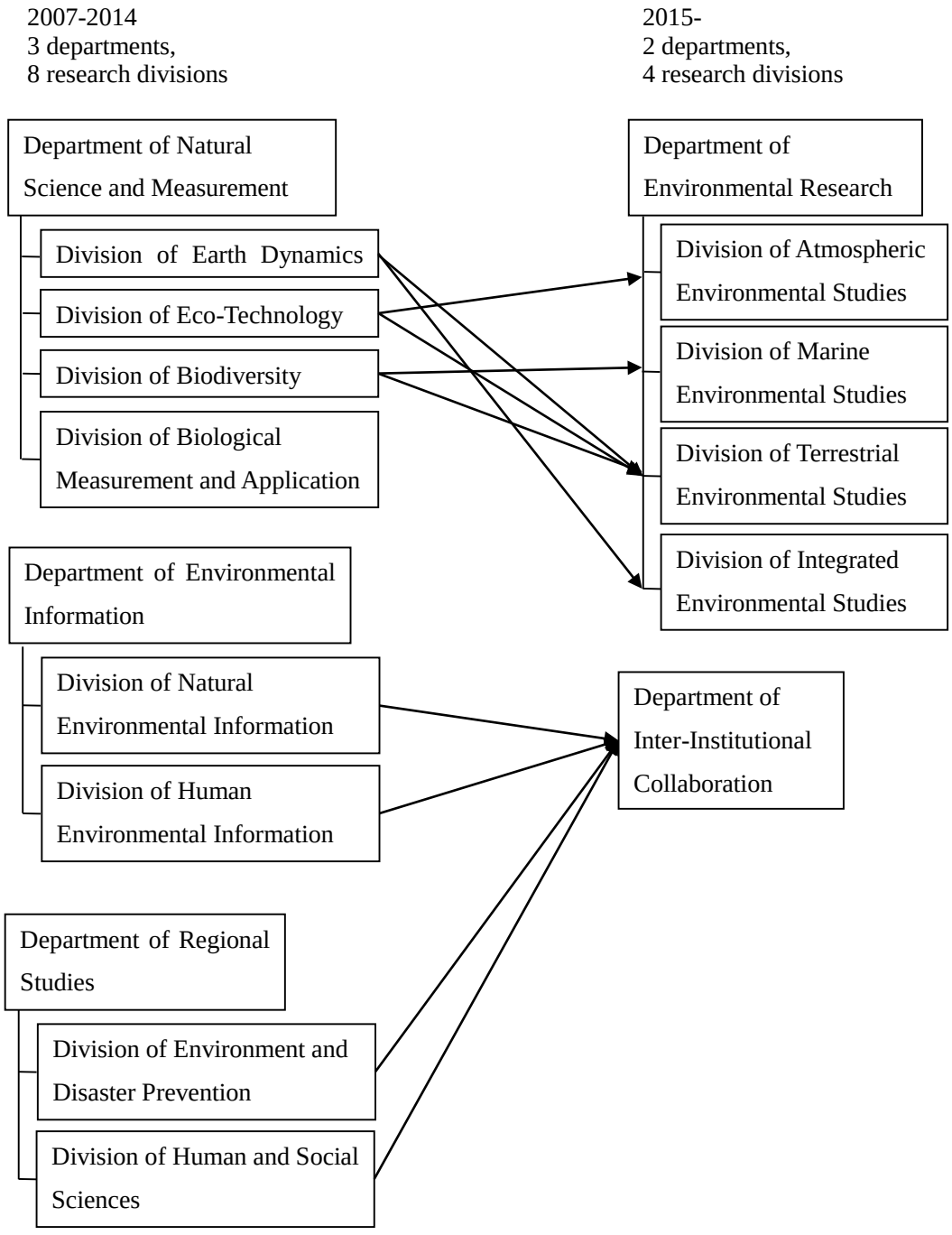


Fig.1 Intraorganization was modified in 2015.

Division of Atmospheric Environmental Studies

This division focuses on the atmospheric environment of the Circum-Sea of Japan area, an area of the world where high concentrations of atmospheric pollutants such as Asian dust (Kosa: yellow dust) and $PM_{2.5}$ have become one of the most prominent environmental issues. The aim of this division is to clarify their mechanisms of generation, transport, reaction, deposition, ecosystem and human consequences, and to better predict future pollution in the area. To this end, this division devises and develops new analytical methods and fosters joint international research networks. These activities and their results will make substantial contributions to the global efforts to mitigate atmospheric contamination.

【Behaviors of Atmospheric Polycyclic Aromatic Hydrocarbons (PAHs) and Nitropolycyclic Aromatic Hydrocarbons (NPAHs) in East Asia】

PAHs are a group of organic compounds consisting of two or more fused benzene rings, and NPAHs are their nitrated derivatives. PAHs and NPAHs are ubiquitous environmental pollutants. Atmospheric PAHs and NPAHs mainly originate from imperfect combustion and pyrolysis of organic matters, although some NPAHs are formed in the atmosphere via reactions of their parent PAHs such as 2-nitropyrene (2-NP) and 2-nitrofluoranthene (2-NFR). PAHs and NPAHs exist in both the gas and particle phases in the atmosphere, and their gas/particulate partition depend on factors such as the vapor pressure, temperature and the concentration and properties of dust. In urban areas, PAHs and NPAHs are mainly emitted from automobiles, power plants, domestic heating and industrial processes. Many PAHs and NPAHs have carcinogenic and/or mutagenic properties. Benzo[*a*]pyrene (BaP) and 1-NP are categorized in groups 1 (*carcinogenic to humans*) and 2A (*probably carcinogenic to humans*), respectively (*International Agency for Research on Cancer*). Several PAHs also exhibit estrogenic, antiestrogenic, antiandrogenic activities or reactive oxygen species producing activity. In addition, prenatal exposure to PAHs could impact cognitive development and learning ability. Therefore, it is necessary to monitor PAHs and NPAHs in the atmosphere because of their health risks to humans

In East Asia, the economics and industrial outputs of Japan, China, Korea and Russia have developed rapidly in recent decades. Together, these countries account for more than a quarter of the world energy consumption. Especially, the primary energy consumption of China increased drastically and has reached to 12% of the total world consumption in 2014. The main energy sources in these countries are oil in Japan and Korea, coal in China and natural gas in Russia (but coal for Far Eastern Russia). The burning of these fuels and biomass releases many pollutants including gases and particulates into the atmosphere.

<u>Atmospheric concentrations of PAHs and NPAHs</u>

Airborne particulate matter (PM) has been collected at four cities (Sapporo, Kanazawa, Tokyo and Kitakyushu) in Japan starting in the late 1990s, at five or more major cities in China (Sheyang, Tieling ,Fushun, Beijing and Shanghai), Korea (Seoul and Busan) and Russia (Vladivostok) starting in 2001. Nine particulate-bound PAHs (fluoranthene (FR), pyrene (Pyr), benz[*a*]anthracene (BaA), chrysene (Chr), benzo[*b*]fluoranthene (BbF), benzo[*k*]fluoranthene

(BkF), BaP, benzo[*ghi*]perylene (BgPe) and indeno[1,2,3-*cd*]pyrene (IDP)) and eleven NPAHs (1,3-, 1,6-, 1,8-dinitropyrenes, 9-nitroanthracene, 1-, 2-NPs, 2-NFR, 6-nitrochrysene, 7-nitrobenz[*a*]anthracene, 6-nitro-BaP and 3-nitroperylene) were determined by HPLC with fluorescence and chemiluminescence detections, respectively. Annual concentrations of PAHs and NPAHs were in the order, China > Russia ≫ Korea = Japan, with seasonal change (winter > summer). During the observation period, concentrations of PAHs and NPAHs in Japanese cities significantly decreased but the increases in the PAH concentration were observed in Chinese and Russian cities. Concentrations of PAHs and NPAHs were higher in the Northern China than those in the Southern China. A dramatic change in atmospheric concentrations of PAHs and NPAHs in East Asia suggests the rapid and large change of PM pollution in East Asia. Considering the adverse health effects of PM, especially $PM_{2.5}$, continuous monitoring of atmospheric PAHs and NPAHs is necessary in this area.

Spatial and Temporal Distributions of PAH Concentrations and Deposition

In order to better understand the spatial and temporal distributions of PAH concentrations and deposition, the source-receptor relationship analysis of PAH deposition in Northeast Asia was investigated using an Eulerian regional-scale aerosol chemical transport model. The SRR is an effective analytical method for evaluating the contributions from various source regions to receptor regions. Dry deposition (DD) of PAH was controlled by wind flow patterns, whereas wet deposition (WD) depended on precipitation in addition to wind flow patterns. The contribution of WD was approximately 50-90% of the total deposition, except during winter in Northern China (NCHN) and Eastern Russia (ERUS) because of the low amount of precipitation. The amount of PAH deposition showed clear seasonal variation and was high in winter and low in summer in downwind (South Korea, Japan) and oceanic-receptor regions. In the downwind region, the contributions from NCHN (WD 28-52%; DD 54-55%) and Central China (CCHN) (WD 43-65%; DD 33-38%) were large in winter, whereas self-contributions (WD 20-51%; DD 79-81%) were relatively high in summer. In the oceanic-receptor region, the deposition amount decreased with distance from the Asian continent. The amount of DD was strongly influenced by emissions from neighboring domains. The contributions of WD from NCHN (16-20%) and CCHN (28-35%) were large. The large contributions from China in summer to the downwind region were linked to vertical transport of PAHs over the Asian continent associated with convection.

【Monitoring at Noto Ground-based Research Observatory (NOTOGRO) station, Japan】

Source identification of aerosols transported to central Japan

Atmospheric aerosols are largely responsible for deteriorating the air quality in multiple spatial scales (local and regional), but their source includes variety of both natural and anthropogenic processes. The situation is further complicated by the fact that aerosol composition changes due to secondary gas-to-particle conversion and aging processes along its transport pathway, often hampering the accurate identification and apportionment that can relate them directly to a specific source. Based on the isotopic analysis on the filter samples collected at the Suzu site of the NOTOGRO station, we are investigating on the sources of

atmospheric aerosols transported long-ranges to central Japan.

Results from the stable and radio carbon isotopic analysis revealed large seasonal variation in the relative contribution of fossil and contemporary carbon, which can be highlighted by the sporadic influence of biomass burning in Siberia and North Eastern China. Heavy metal isotopes are also good indicators of the aerosol sources since they can be considered as of primary origin and do not show isotope kinetic effects. Preliminary results showed signs of Asian dust transport taking place not only in Spring but also in Summer, as well as a significant influence from domestic volcanic activities in the western Japan.

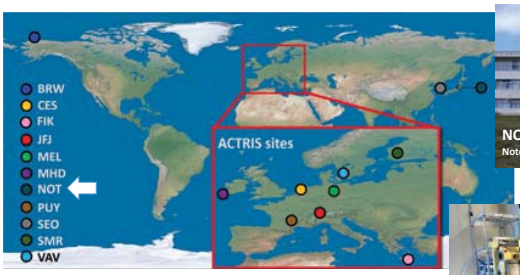
Contribution to the International Observation Network of Atmospheric Aerosols (CCN)

Subset of atmospheric aerosols acts as cloud condensation nuclei (CCN), and therefore affect the microphysical properties of the clouds. This will lead to the changes both in the hydrological cycle and the energy budget of the atmosphere (radiative forcing). In the recent years, the aerosol-cloud interaction is considered to constitute the largest uncertainty in the anthropogenic radiative forcing on the climate. The effort to minimizing such uncertainty requires long-term CCN measurements covering multiple locations and seasons. An unprecedented international campaign was conducted to inter-compare the regional CCN characteristics which involved 70 experts from 23 institutions and 14 countries. Our Suzu site of NOTOGRO station also contributed to this international effort representing a remote site in East Asia. Related works have been published in a data descriptor paper, and another paper submitted as a scientific journal. This dataset is expected to make a significant contribution to the comprehensive aerosol characterization (e.g., closure studies of CCN), model- and satellite retrieval validations.

Long range transposition of PAHs and NPAHs from the Asian continent to Japan

PM was collected at the Wajima site of the NOTOGRO station from September 2004 to June 2014. Nine PAHs (FR, Pyr, BaA, Chr, BbF, BkF, BaP, BgPe and IDP) were determined by HPLC with fluorescence detection. The mean concentrations of the nine PAHs in the cold season (November to May for the years 2004 – 2014) was 670 pg/m^3 (range 37 to 4100 pg/m^3). The mean concentration in the warm season (June to October for the same period) was 170 pg/m^3 (range 31 to 960 pg/m^3). The atmospheric PAH level at the Wajima site decreased in recent years, although no significant change was found in the warm season. An analysis of meteorological conditions showed that the atmospheric PAHs at the Wajima site were long range transported from Northeast China in the cold seasons and were contributed to by Japanese domestic sources in the warm seasons. Activities associated with the Beijing Olympic and Paralympic Games in 2008 and reconstruction after the 2007 Noto Hanto earthquake may have contributed to the yearly variations of atmospheric PAH levels at the Wajima site during the period 2007 – 2009. Source control measures implemented by the Chinese and Japanese governments appear to have been effective in decreasing the atmospheric PAH levels at the Wajima site in recent years. Furthermore, our data showed that most of the atmospheric1-, 2-NPs and 2-NFR at the Wajima site in the cold season were also long range transported from Northeast China.

Contribution to the International Observation Network of Atmospheric Aerosols (CCN)



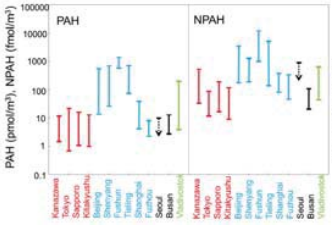
Map showing locations of atmospheric supersites conducting long-term monitoring of CCN.

Schmale et al. (2017), *Scientific Data*

NOTOGRO station participated in the international effort to inter-compare CCN characteristics worldwide.

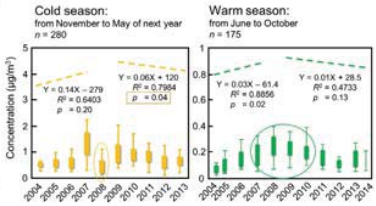
Instrumentations for CCN measurements

Atmospheric concentrations of polycyclic aromatic hydrocarbons and nitropolycyclic aromatic hydrocarbons in East Asia



Both PAH and NPAH levels were in the order:
China > Russia ≫ Korea = Japan
Both PAH and NPAH levels were higher in the Northern China (Beijing, Shenyang, Tieling and Fushun) than those in the Southern China (Shanghai and Fuzhou).

Yearly variations of PAHs at the Wajima site of NOTOGRO station in the cold (L) and warm (R) seasons from 2004 to 2014



The atmospheric PAH level at the Wajima site decreased in recent years, although no significant change was found in the warm season. Source control measures implemented by the Chinese and Japanese governments appear to have been effective in decreasing the atmospheric PAH levels at the Wajima site in recent years.

Source-relationship analysis of the atmospheric deposition of PAHs subject to long-range transport in northeast Asia

Purpose In order to evaluate the contributions of PAH deposition, which is transboundary transported from the Asian continent to Japan, we conducted the **source-receptor analysis** by using **numerical chemical transport model**.

Fig. 1.Source-Receptor domain

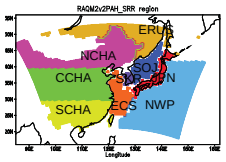
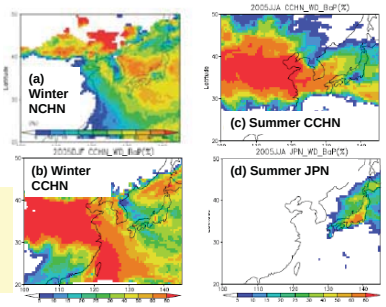


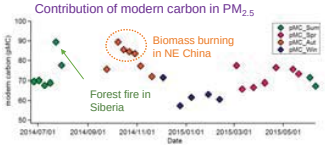
Fig. 2. Contribution (%) from the source to the receptor region



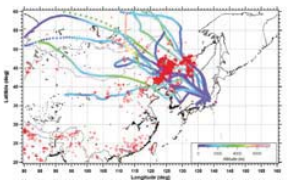
The relative contribution from NCHN and CCHN are large in winter, whereas those from CCHN and JPN are large in summer.

Source identification of aerosols transported to central Japan

Contribution of modern carbon in $PM_{2.5}$

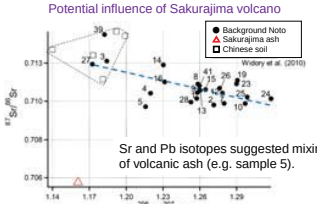


Largest contribution from modern biological activity and/or biomass burning in Autumn.

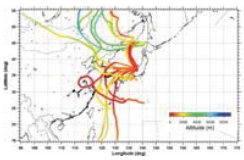


Air-mass trajectories passing over many fire spots in Northeast China (October 2014).

Potential influence of Sakurajima volcano



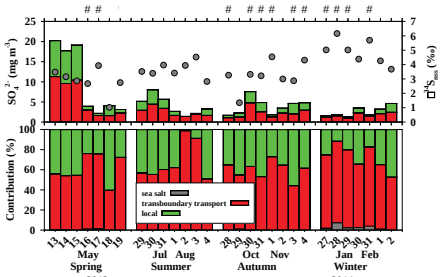
Sr and Pb isotopes suggested mixing of volcanic ash (e.g. sample 5).



Air-mass trajectories passing over western Japan during 23-30 July 2014 (sample 5).

Transboundary transport of anthropogenic sulfur in $PM_{2.5}$ at a coastal site in the Sea of Japan by sulfur isotopic ratio measurement

Niigata Maki (Coastal site of Sea of Japan)



Non-sea salt $d^{34}S$ ($d^{34}Snss$) in $PM_{2.5}$ showed seasonal variations with relatively high values in winter (1.0–3.9‰ in spring, 2.8–4.5‰ in summer, 1.3–4.5‰ in autumn, 3.7–5.7‰ in winter). $d^{34}Snss$ in the air masses which originated in the Asian continent and were transported over the Sea of Japan to the monitoring sites (#) were higher than those values for air masses which were transported over the Japanese islands. The relative contribution of transboundary transport in winter was higher (40–75% in spring, 51–63% in summer, 45–73% in autumn, and 53–81% in winter).

Division of Marine Environmental Studies

This division studies the influence of harmful chemical substances on marine organisms and the dynamics of these substances in the marine environment in the Circum-Sea of Japan area; particularly in coastal areas. This examination of marine biota is performed through the use of biochemical assays. The research performed aids in the development of marine environment evaluation systems and for this purpose involves international collaborations.

To achieve the purpose, we recently focus on the toxicity of polycyclic aromatic hydrocarbons (PAHs). PAHs are widespread environmental contaminants derived from petroleum and generated through the incomplete combustion of fossil fuel, wood, and other organic materials. In the aquatic environment, PAH contamination occurs through storm water runoff. Atmospheric deposition of PAHs is now the largest source of aquatic PAH contamination. Furthermore, oil tankers are another anthropogenic source of PAHs and oil spills are correlated with the major shipping routes in marine environments. Moreover, accidental oil spills, such as those from the Deepwater Horizon, the Exxon Valdez, and the Nakhodka, have caused direct PAH pollution in the marine environment. PAH contamination is thus prevalent throughout the global marine system and directly affect marine organisms. In this division, thus, we recently studied the toxicity of PAHs and their metabolites in aquatic animals such as fish and sea urchin. We describe below.

【Fish scales as a suitable model for the analysis of pollutants including PAHs on bone metabolism】

A teleost scale is a bone-like tissue in which coexist osteoblasts (Fig. 1A), osteoclasts (Fig. 1B), and calcified bone matrix. The bone matrix, which includes type I collagen, osteocalcin, osteonectin, and hydroxyapatite, is present in scales as well as in mammalian bone. Teleost scales have an important function in regulating blood calcium levels because teleost scales, which have both osteoblasts and osteoclasts, are known to function as potential internal calcium reservoirs similar to those in the endoskeletons of mammals. Using a functional calcium-regulating organ (teleost scales), we have developed a novel assay system (Suzuki et al., Endocrine, 2016). This system can simultaneously detect the activities of both scale osteoblasts and osteoclasts with alkaline phosphatase (ALP) and tartrate-resistant acid phosphatase (TRAP) as markers.

Using an assay system, we investigated the influence of PAHs on calcium metabolism. For example, goldfish were intraperitoneally injected with benz[*a*]anthracene (BaA) (5μg/g body weight) (around 10^{-5} M). BaA induced hypocalcemia at 24 and 48 h (Fig. 2A) resulting from inhibition of osteoclastic activity in the scales of goldfish (Fig. 2B) (Suzuki et al., Internat. J. Zool. Invest., 2017).

【The influence of OHPAHs on fish embryogenesis】

Monohydroxylated polycyclic aromatic hydrocarbons (OHPAHs) with four aromatic rings, such as 3-hydroxybenz[*a*]anthracene (3-OHBaA) and 4-hydroxybenz[*a*]anthracene (4-OHBaA), showed the toxicity for osteoblasts and osteoclasts in the scales of goldfish and wrasse (Suzuki et al., Life Sci., 2009). Therefore, using medaka embryos, we examined the toxicity of OHPAHs on embryogenesis. Nanoinjecting 3-hydroxybenzo[*c*]phenanthrene (3-OHBcP) (1 nM) in ovo accelerated the development of medaka embryos on the 1st, 4th, and 6th days post fertilization (dpf) (Fig. 3A). On the 5th dpf, the heart rates of embryos in the 1-nM 3-OHBcP exposure group were significantly higher than those in

the control and solvent control groups (Fig. 3B). Furthermore, the expression of genes related to eye development, muscle development, energy supply, and stress-response proteins significantly changed during early development in medaka. Thus, 3-OHBcP acts on several organs and is toxic to fish embryogenesis (Chen et al., Aquatic Toxicol., 2017).

【Influences of seawater highly contaminated with PAHs on fish bone metabolism】

The Suez Canal in Egypt links the Mediterranean Sea to the Red Sea. Since its inauguration in November 1869, many ships and oil tankers have used the canal. Furthermore, Alexandria, located at the mouth of the Nile, is an important port of the Mediterranean Sea route and fishing port with several kinds of marine resources. However, both crude oil and heavy oil are often included in the ballast water discarded by ships, and the marine pollution of the Mediterranean Sea coast and the Suez Canal worsens even if a ship accident does not happen. It was found that the concentration of PAHs (approximately 1,000 ng/l) in both the seawater of the Red Sea side of the Suez Canal and of the Alexandria port was remarkably high at around 100 times that of the Sea of Japan (Table) (Suzuki et al., Zool. Sci., 2016). Furthermore, we indicated that ALP activity in the scales was significantly suppressed by both polluted seawater samples, even if seawater was diluted up to 500 times, although TRAP activity did not change, at least in present conditions (Fig. 4) (Suzuki et al., Zool. Sci., 2016).

【Toxicity of PAHs and OHPAHs to sea urchins】

Furthermore, we examined the effect of both PAHs and OHPAHs on the embryogenesis of sea urchins (*Hemicentrotus pulcherrimus*) (Suzuki et al., Comp. Biochem. Physiol., 2015). Prior to fertilization, the eggs were washed twice with FSW. Eggs used in the present study reached at least 95% fertilization within 10 min postinsemination. The eggs were divided into control and experimental groups. After fertilization, BaA and 4-OHBaA were added to seawater at concentrations of 10^{-8} and 10^{-7} M and kept at 18ºC while mixing lightly. Embryos treated with BaA and 4-OHBaA were compared to control embryos. In the blastula and prism stages, there was no difference regarding external features between the control and experimental groups. In the pluteus stage, morphological differences were observed. Spicule length (arrows in Fig. 5) was measured using embryos crushed by a cover glass. Spicule length was significantly inhibited by 4-OHBaA (10^{-8} and 10^{-7} M). BaA (10^{-7} M) suppressed the length of the spicule significantly, while the length did not change with BaA (10^{-8} M).

【Conclusions】

In aquatic animals, we discovered the toxicity of OHPAHs, metabolites of PAHs. Judging from the obtained data, the toxicity of OHPAHs is stronger than that of PAHs, at least in fish and sea urchins. To analyze the toxicity of PAHs and OHPAHs on bone metabolism, furthermore, we developed an original bioassay with fish scales, which have osteoblasts (bone formation cells) and osteoclasts (bone resorption cells). Using our original bioassay, we indicated that seawater polluted with highly concentrated PAHs inhibited osteoblastic activity, even if polluted seawater was added into the culture medium at dilution rates of 500 times. OHPAHs that occurred with accumulated PAHs may have toxic influences on aquatic animals, even if the PAH levels in the aquatic environments are low. Thus, we should emphasize the prevention of aquatic PAH pollution because of the toxicity of OHPAHs.

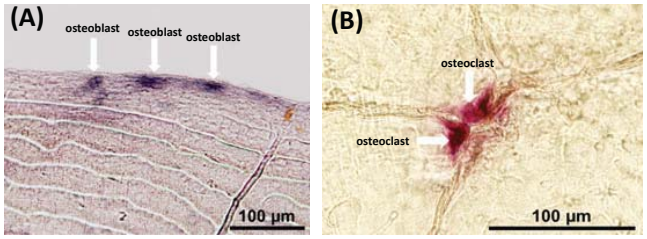


Fig.1 Teleost scales have an important function in regulating blood calcium levels because teleost scales, which have both osteoblasts (A) and osteoclasts (B), are known to function as potential internal calcium reservoirs similar to those in the endoskeletons of mammals (Suzuki et al., Endocrine, 2016).

Table PAH concentrations in the seawater of both Alexanderia and Suez Canal sites (Suzuki et al., Zool. Sci., 2016).

Ring no.	Name of PAH	Alexanderia site (ng/l)	Suis Canal site (ng/l)	Tsukumo bay (Noto Peninsula) (ng/l)
2-ring	Nap	420	303.91	
3-ring	Ace	369.7	277.32	0.05
	Fle	133.2	105.51	0.32
	Phe	218.4	162.9	
	Ant	16.2	4.86	0.09
4-ring	Frt	22	16.14	0.23
	Pyr	37.8	39.42	0.17
	BaA	21.4	6.75	0.03
	Chr	13.6	7.36	0.07
5-ring	BbF	18.7	12.11	0.09
	BkF	10.1	4.34	0.02
	BaP	49.3	26.41	0.03
	DBA	0	0	0.01
6-ring	BghiPe	33.5	25.53	0.02
	IDP	0.69	0	0.04
	Total	1364.59 ng/L	992.56 ng/L	1.16 ng/L

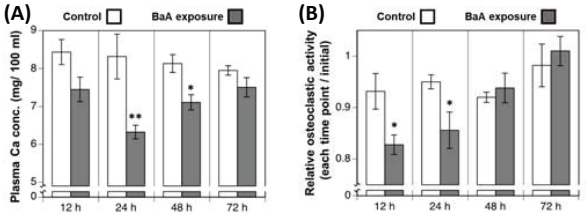


Fig.2 In the present study, the effects of polycyclic aromatic hydrocarbons (PAHs) on calcium metabolism (A: Plasma Ca; B:Osteoclastic activity) were investigated. Goldfish were intraperitoneally injected with benz[*a*]anthracene (BaA) (5μg/g body weight) (around 10^{-5} M). BaA induced hypocalcemia at 24 and 48 h resulting from inhibition of osteoclastic activity in the scales of goldfish (Suzuki et al., Internat. J. Zool. Invest., 2017).

Seawater polluted with highly concentrated PAHs influenced bone metabolism in teleosts.

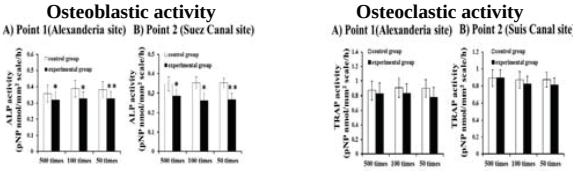


Fig. 4 Each sample of polluted seawater was added into culture medium at dilution rates of 50, 100, and 500 and incubated with the goldfish scales for 6 hrs. Thereafter, ALP and TRAP activities were measured. As a result, ALP activity was significantly suppressed by both polluted seawater samples diluted at least 500 times, although TRAP activity did not change as did 3-OHBcP and 4-OHBcP.(Suzuki et al., Zool. Sci., 2016).

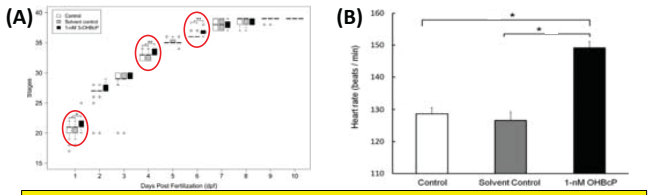


Fig.3 Using medaka embryos, we examined the toxicity of OHPAHs on embryogenesis. As a result, nanoinjecting 3-OHBcP (1 nM) in ovo accelerated the development of medaka embryos on the 1st, 4th, and 6th days post fertilization (A). Also, an abnormal development of the heart in the 3-OHBcP-exposed medaka embryo had occurred (B). Furthermore, the expression of genes related to eye development, muscle development, energy supply, and stress-response proteins significantly changed during early development in medaka. Thus, 3-OHBcP acts on several organs and is toxic to fish embryogenesis. (Chen et al., Aquatic Toxicol., 2017) *: P <0.05; **: P <0.01

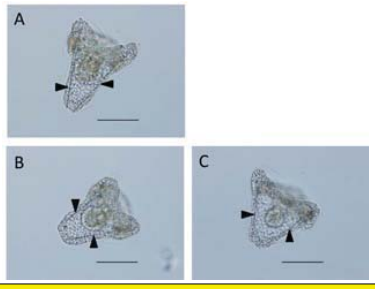


Fig. 5 Influences on spicule formation in control (A), BaA (10^{-7} M)(B)-, and 4-OHBaA (10^{-7} M)(C)-treated embryos. (Suzuki et al., Comp. Biochem. Physiol., 2015) Each Bar: 100 μm.

Division of Terrestrial Environmental Studies

【Outline】

The area of the Circum-Sea of Japan is characterised by existence of various and diverse terrestrial environments. Aiming to understand their temporal and spatial changes and to define clearly the current situation of the environments, the Division of Terrestrial Environmental Studies has been carrying out palaeoenvironmental, biological and geological researches in the area in order to evaluate influence of human activities and natural phenomena.

【Freshwater Conservation and Restoration】

With focus on biodiversity, we perform risk assessment and scrutinise management strategies of natural and human-altered freshwater habitats in Japan and overseas.

1) Farm pond conservation and management (Japan)

Farm ponds are among the most biodiverse anthropogenic freshwater habitats. Land-use changes are assumed to be major factors that change such ecosystems from a clear-water state to a turbid state, leading to deterioration of water quality and biodiversity in such ponds. We evaluated the effects of surrounding land use, fish abundance, and other environmental variables on total phosphorus concentration and taxonomic richness patterns of six biological indicators associated with changes in the trophic state. Based on these results, we propose potential landscape and pond management strategies for conserving and/or restoring the water quality and biodiversity of farm ponds through maintenance of a clear-water state.

2) Phylogeographic insights into the invasion history and secondary spread of the signal crayfish (Japan, United States and Canada)

In recent decades, invasive signal crayfish (*Pacifastacus leniusculus*) have expanded their distribution range in Japan. To infer the history and explore the success of this invasive crayfish, we combined detailed phylogeographical and morphological analyses conducted in both their introduced and native ranges. As a result, introduced signal crayfish populations in Japan originate from multiple source populations from a wide geographic range in the native range of western North America. A combination of high genetic diversity, especially for older populations in the invasive range, and rapid adaptation to colonisation, manifested as larger chela in recent invasions, likely contribute to invasion success of signal crayfish in Japan.

3) Latrine-site use of small-clawed otters in Indonesian rice fields (Indonesia)

The small-clawed otter (*Aonyx cinereus*) inhabits both natural and rice field landscapes in Southeast Asia. However, the latrine-site use by small-clawed otters in rice-field landscapes is largely unknown. Based on a 53-week field survey and landscape analyses, we investigated latrine-site use by small-clawed otters in rice-field landscapes in West Sumatra. Generalized linear model analyses revealed that the latrine site preferences of small-clawed otters in rice field landscapes are strongly associated with intermediate levels of rice farming activities. Indonesian rice fields are being degraded or disappearing at an accelerated rate because of land

conversion and modernisation of agriculture. We emphasize an urgent need for design and implementation of otter-friendly rice farming to conserve small-clawed otters.

【Palaeoenvironmental and Geological Studies】

1) we investigated the tsunami disaster and environmental change using sediment cores from lake Kitagata, Fukui Prefecture. Lake Kitagata is a brackish lake connected to the sea. Several cores were collected by the Fukui Prefectural Satoyama-Satoumi Research Institute, and three of them were analyzed. Age constraints are given by 137Cs radioactivity and 14C ages. The oyster farming was known in the Edo era (17-19 centuries) and layer with a lots of oyster shell remains is a deposit in the Edo era. A tuff layer was found in three cores, which is characterized by the low water content, and attributed to Hakusan volcanic event in 1659AD. Possible tsunami sediment layer was found in the layer between ~1450AD and ~1650AD. This layer includes the shell of sea origin which live on the sand bed as deep as ~30 m, while sediment in Lake Kitagata is silt size with the deepest lake depth is <5m. The layer shows grading in mineral particle size. A diatom assemblage shows that marine and brackish species were about 70% of the total diatom, while that of a sample 30 cm beneath this layer exhibit freshwater species with about 60 percent of the total diatom species. These lines of observation indicate that this layer may be a tsunami deposit. The age of this layer is more or less equivalent to the age of Tensho tsunami. Before the ~1450AD, the significant drop in water content is observed in the x-ray CT diagram. This may be corresponding to the start of little ice age after the medieval worm period. Based on the age estimate, the Taiho tsunami (701AD) must have left some evidence in one of the cores, though it is not clear with the present data set.

2) We also worked on the environmental research in the arid area of Mongolia. Paleo environmental research in Mongolia has two advantages: (1) It locates in the middle of continent with high elevation of ~1500m, sensitive to the solar incision fluctuation and (2) human activity is less intense due to its low population and natural geographical environment is more or less preserved in the country side. There are many lakes and rivers which have been lost following the increase in the air temperature and decrease in the precipitation especially in arid area. We studied change in lake level and water chemistory by analysing sediment cores from lakes, paleo-lake sediments at outcrops, and lake, river, and sprong water. The behaviour of toxic elements probably from mining activity was also studied.

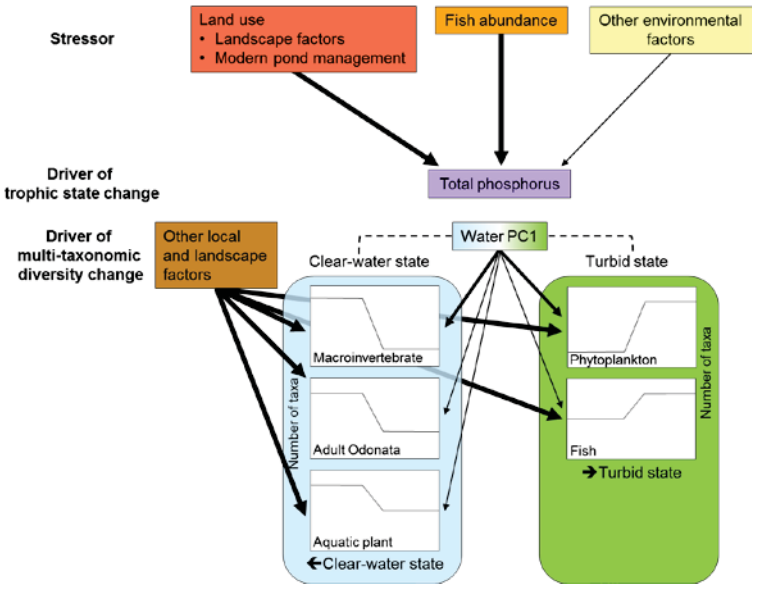
3) In order to clarify stratigraphical horizon and to describe general lithofacies of the Miocene tuffaceous sandstone, so called “Green Tuff”, widely distributed in Hokuriku District, preliminary lithostratigraphical survey and petrographical examination were made in the area of Komatsu City south of Kanazawa City in cooperation with Komatsu City Office. It is well known that the tuffaceous sandstone in Komatsu yields green jasper known to have been a favourite gemstone in the Yayoi Period of Japan

【Social and Cultural Contributions】

The Angkor World Heritage in Cambodia, one of the most famous and outstanding cultural heritage in the world, has been confronted by serious environmental pollution and destruction owing to rapid development of tourism. As an ad hoc expert for sustainable development of ICC-Angkor (International Co-ordinating Committee for the Safeguarding and Development of the Historic Site of Angkor), field examination and inspection were carried out in several urgent sites such as Phnom Kulen National Park north of the heritage in order to protect and conserve pollution free natural environment, cultural heritage and local society of these sites.

【Ecosystem in Inland Waters】

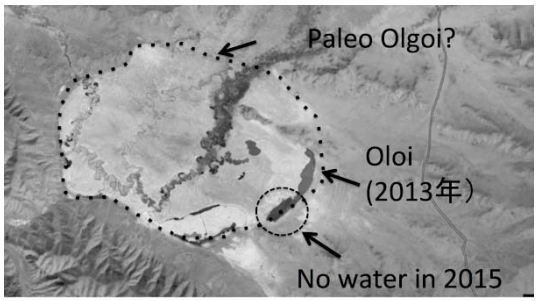
Right: Conceptual model summarising the results of the study on farm pond conservation and management.
Below: A farm pond in a clear water state.

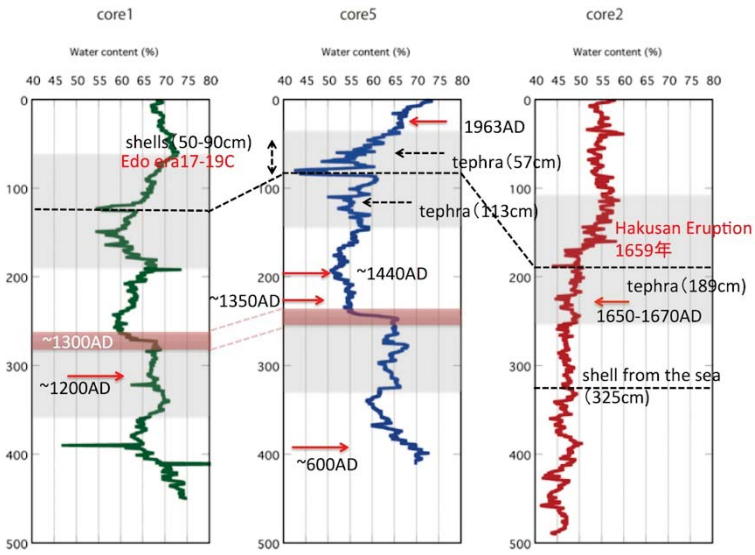


【Paleoenvironment and Geology 】

Right : Water content of Lake Kitagata shows event layers

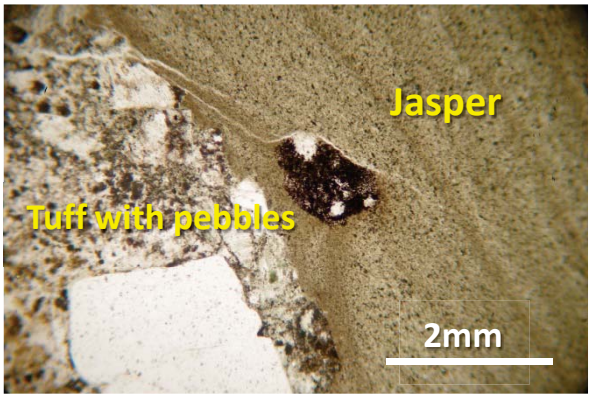
Below : Lake shrink found in Lake Olgoy, Mongolia





【Contribution to community and traditional culture】

Stratigraphy and petrology of Miocene Green Tuff in Hokuriku district



Conservation of world heritage: example on Angkor Wat, Cambodia

Division of Integrated Environmental Studies
(The Low Level Radioactivity Laboratory; LLRL)

【Outline of this division (and laboratory)】

This division is located in Nomi City, Ishikawa Prefecture, and extension and structural alteration of building was finished in March 2014. This division is composed of five research staff members, and the hands-on training of Kanazawa University students and collaborative research activities with other universities and research institutes are carried out using radioactivity measurement systems. This is aided by the extremely low background system constructed in the Ogoya Underground Laboratory (OUL; 270 m meter water equivalent). In the OUL, the use of 17 HP-Ge detectors is exceptional for underground laboratories and all detectors at the OUL provide excellent background conditions, stability and counting efficiency.

【Outline of Research】

In order to understand the migration behavior of chemical substances in the Earth's surface environment, it is necessary to study the transport processes within terrestrial, atmospheric and marine environments, as well as their boundary zones. For this purpose, this division (and laboratory) uses environmental tracers (particularly for various stable and radio isotopes), involving each of the department's research divisions. Through the use of environmental tracers and model simulations, this division carries out the integrated analysis of substance dynamics in the Circum-Sea of Japan area in order to better predict future circumstances. By the Fukushima Dai-ichi Nuclear Power Plant accident (in March 2011), large amounts of radiocesium spread wide area and various environments, particularly in eastern Japan. The investigation of distribution and migration patterns of the accident-derived radiocesium is our important work, which is the subject of a project that we are currently engaged in.

In final goal, we predict future circumstances by wide-range observations and model simulations, using integrated analyses of substance dynamics in terrestrial-atmospheric-marine environments, and follows researches are ongoing:

1) Development of low-background γ-spectrometry method using Ogoya Underground Laboratory and applications to various environmental samples (Fig. 1)

2) Dating of lake sediment and paleoenvironmental analysis (Fig. 2)

3) Study of geochemical cycles within the Sea of Japan from distributions of multi-radionuclides (Fig. 3)

4) Study on geochemical dynamics in terrestrial and coastal marine environments by using radionuclides (Fig. 4)

5) Study of distribution of Fukushima Dai-ichi Nuclear Power Plant accident-derived radiocesium in marine and riverine environments and their implications (Fig. 5 and Fig. 6)

Ogoya Underground Laboratory

Fig. 1: Low-background γ-spectrometry using Ge-detectors in Ogoya Underground Laboratory was conducted in seawater, riverine particle, and sediment samples.

Dynamics of riverine particulate organic matter in the Kumaki River, Japan

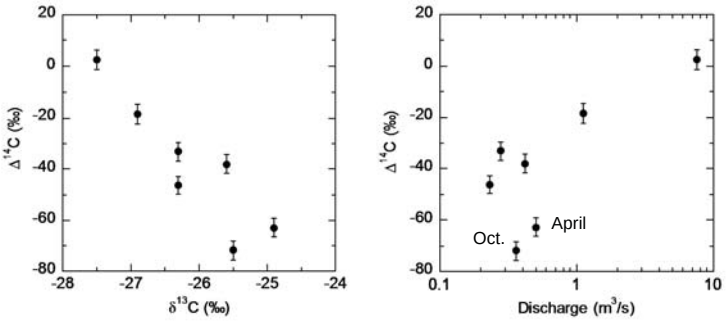


Fig. 4: Monitoring results at the middle observation site of the Kumaki River are shown. Variation in carbon isotope composition in riverine POC during April-October 2016 is controlled by water discharge.

Effects of deforestation on the material transport in the catchment inferred from reservoir sediments in the Noto Peninsula, Japan

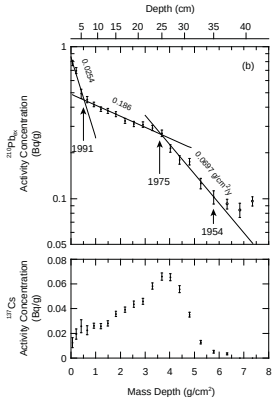


Fig. 2a: Vertical changes in excess ^{210}Pb and ^{137}Cs concentration of the sediment core.

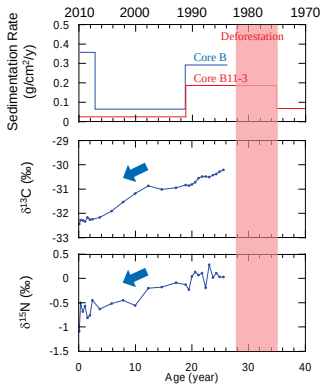


Fig. 2b: Temporal changes in sedimentation rate, δ^{13}C, and δ^{15}N of the sediment core.

These results indicate that deforestation had large impact on the transport of organic matter and it continued for several years after the deforestation.

^{134}Cs at surface in the Sea of Japan

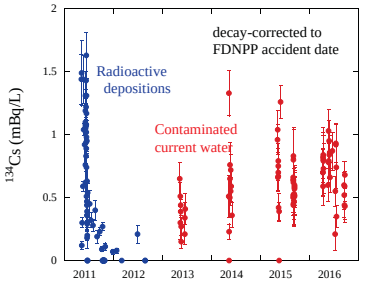


Fig. 5: Effect of radioactive deposition from FDNPP in 2011 and mixing of ^{134}Cs-contaminated current water from the Pacific Ocean during 2013-2016

Lateral profile of ^{228}Ra/^{226}Ra ratio

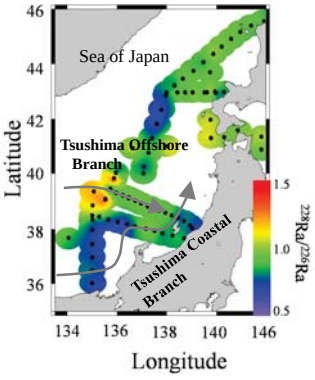


Fig. 3: Lateral profile of the ^{228}Ra/^{226}Ra ratio (range 0.5–1.5) in July within the Sea of Japan. This indicates the mixing pattern of ^{228}Ra-rich continental shelf water and ^{228}Ra-poor Kuroshio Current water

Spatial distribution of ^{137}Cs radioactivity of river waters in Kanto and Tohoku region

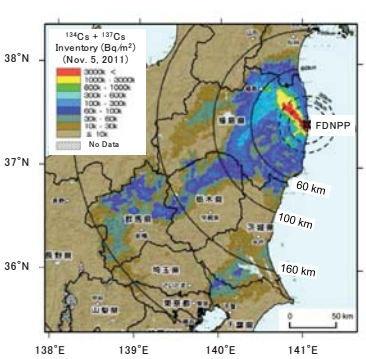


Fig. 6a: Inventory of ^{134}Cs + ^{137}Cs on ground surface by aircraft monitoring survey in November 2011 (MEXT, 2011)

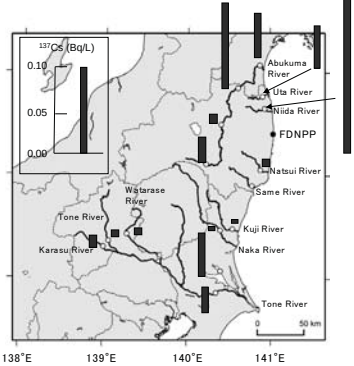


Fig. 6b: ^{137}Cs radioactivity of river waters from Fukushima, Miyagi, Chiba and Gunma Prefecture, Japan during 24-26 August in 2012

Department of Inter-Institutional Collaboration

The Japan Sea Research Institute of Kanazawa University established in 1963 became the Department of Regional Studies at the Institute of Nature and Environmental Technology in 2007. Over again, the department was reorganised into the Department of Inter-Institutional Collaboration as a part of a reorganisation programme of the institute in 2016.

The Department of Inter-Institutional Collaboration manages the collection, exchange and maintenance of environmental information in the area of the entire East Asia while centred on the Circum-Sea of Japan, and it constructs and sustains international research networks in the area to disseminate information to all over the world (Figs. 1 and 2). The department promotes interdisciplinary researches in the area where is geopolitically important region in the world. It also supports students' internationalisation education.

Fig. 1: Geographical and geopolitical situation of the Circum-Sea of Japan region.

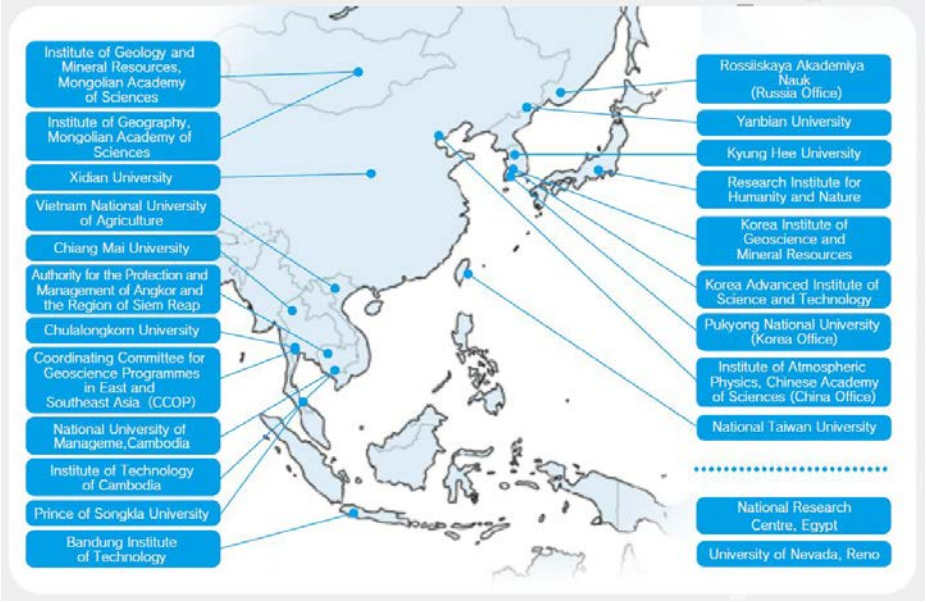


Fig. 2: International and domestic network of the Institute of Nature and Environmental Technology.

The Circum-Sea of Japan region in which industrised countries are located can be recognised as a core of East Asia in various settings, environmental issues in particular. The department has been trying to expand its interdisciplinary activities to whole East Asian region and to coordinate them. As a part of the activities, the department publishes a scientific journal named "*Japan Sea Research* ("*Bulletin of the Japan Sea Research Institute, Kanazawa University*" before 2017)" which contains original articles, short articles and so forth on in various research fields such as natural, human and social sciences related only in the region (Fig. 3).

Fig. 3: Covers of the journal "*Bulletin of the Japan Sea Research Institute, Kanazawa University*" volume 1 in 1969 and "*Japan Sea Research*" volume 48 in 2017.

The department supports students' internationalisation education of Kanazawa University. Since 2010. It has been coordinating a students' international internship programme which sent ten undergraduate students belonging to various schools and colleges of the university to the APSARA National Authority of Cambodia which manages conservation and maintenance of the Angkor World Heritage site as one of most famous world heritage of UNESCO. The students have been engaged in the routines of the authority to learn environmental management such as monitoring of groundwater level, water quality survey in local rivers and afforestation in the areas of the site (Fig. 4).

Fig. 4: International internship programme at the APSARA National Authority of Cambodia in 2017.