CITIZEN PARTICIPATORY SEA WATER MONITORING BY BLUE MUSSEL AS A BIO-MONITOR

Komichi Ikeda[1], Teiichi Aoyama[1,2], Atsushi Takatori[1], Masuo Ueda[3], Hideaki Miyata[4] and Branko Vrzic[5]

1 Environmental Research Institute Inc., Suite 4-1108, 4-5-26, Tokyo 141-0021, Japan
2 Faculty of Environmental and Information Studies, Musashi Institute of Technology, 224-0015, Yokoama City, Kanagawa Pref. Japan
3 Surfrider Foundation Japan, P.O Box 14, Kamogawa , Chiba Pref. 296-8799, Japan
4 Food Hygiene Laboratory, Faculty of Pharmaceutical Sciences, Setsunan University, Hirakata, Osaka Pref. 573-0101, Japan,
5 Environmental Science Division, Maxxam Analytics Inc., 50 Bathurst Drive, Unit 12, Waterloo, Ontario N2V 2C5 Canada

Introduction

Citizens' concerns toward the marine environment contamination by dioxins increased in Japan since the early 2000s when the illegal discharge of wastewater from the major incinerator plant maker was revealed. The surf-rider's group, in particular, was anxious about the human risk caused by water intake from rivers as well as off shore and seas in proximity to the polluted site. This lead the Surfrider Foundation Japan (S.F.J.), one of the NGO groups in Japan, to initiate independent water quality monitoring by using blue mussel in collaboration with the research groups.

Blue mussel is the effective bio-monitor indicator, which can accumulate POPs such as dioxin and PCB congeneric analytes. Miyata et al. had analyzed blue mussel tissue from various bay areas all over Japan since the early 1990s, showing the dioxin concentration level of mussels to be varied more than 50 times depending upon the features of each Bay Area.[1] Based upon this preceding research and data of the mussel samples, Environmental Research Institute (ERI) had planned to start a nation wide citizen participatory dioxin-monitoring project in cooperation with S.F.J. This was the first project in which citizens participated to monitor their local sea areas, were informed of the present situation of the surrounding environment, especially for a neighborhood located by a heavily polluted site of illegal discharge of wastewater from an incinerator plant. The comparative analysis of the same matrix and same parameters at the same time was effective to determine the cumulative impact to the marine environment caused by the human activities such as illegal wastewater discharge which has been brought to light after 7 years. One of the purposes of this project was to stimulate the citizens' concern for the environment as well as to promote their participation for better policy making in the field of hazardous chemical pollution control.

Methods and Materials

Prior to the nation wide monitoring project utilizing blue mussels, ERI and S.F.J. carried out the Pilot Study by collecting mussels from the affected site, the river mouth of Hikichi River and Enoshima Island Marina, the control site, during October 2000. The members of S.F.J. and local citizens conducted the sampling of the shells. The collected mussels were classified by the size of the shell at a length of 3cm with the outer shells being removed cleanly prior to analysis.

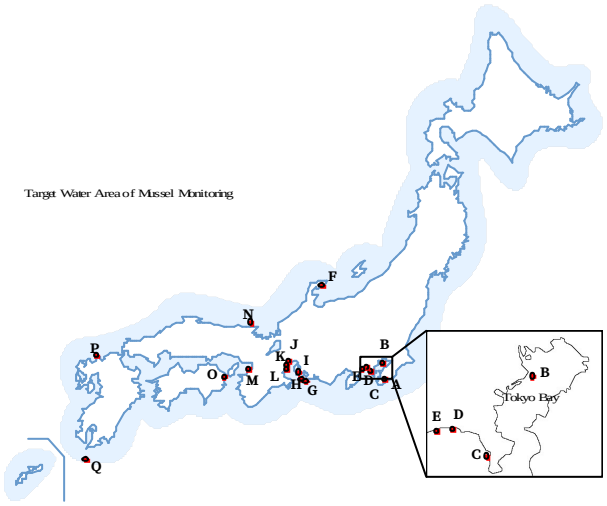
Following are the steps and methodologies of the nation wide blue mussel watch project followed by the Pilot Study.

(1) Sample Matrix: Approximately 100 pieces of mussels with 5cm of outer shell length were sampled, shucked and soft tissue was homogenized so that 80-100g per sample was obtained. The Laboratory of Organic Geochemistry, Faculty of Agriculture, Tokyo University of Agriculture &Technology performed the homogenizing procedure.

(2) Target Areas: Among those major marine leisure areas including important bay areas of Japan, the local citizens and surf-rider groups reviewed the sampling points. Finally, 16 target areas were selected as shown in Figure 1.

(3) Sampling: Sampling was conducted through the cooperation of the local NGO groups and S.F.J. members from October to November of 2001, 18 months following the shut down of the incineration plant at Fujisawa City, Kanagawa Pref., that had caused the serious pollution to the lower river and sea.

(4) Analytical methodology: The analytical methodology was suggested by H.Miyata, Setsunan Universtiy, and was closely followed by the in-house protocol of Maxxam Analytics Inc.



Name of the Water area (Prefecure)

A: Maehara Beach (Chiba)
B: Tokyo Bay Haneda Off shore
C: Sashima Marina (Kanagawa)
D: Hikichi R. Mouth (Kanagawa)
E: Sagami R. Estuary (Kanagawa)
F: Tsukumo Bay (Ishikawa)
G: Akabane Fishing Port (Aichi)
H: AFP Off shore (Aichi)
I : Mikawa Bay (Aichi)
J : Takamatsu Beach (Mie)
K: Kasumigaura Canal (Mie)
L: Suzuka R. Estuary (Mie)
M: Izumiotsu Marina (Osaka)
N: Amino Town Beach (Kyoto)
O: Komatsu Beach (Tokushima)
P: Futami Ura Beach (Fukuoka)
Q: Tanegashima Island (Kagoshima)

Figure 1. Map of Target Areas

(5) Parameters analyzed: Dioxin like PCBs from the WHO list (Coplanar-PCBs) were analyzed for all samples with PCDD/PCDF analogues only analyzed for 4 samples. Three from Kanagawa Prefecture (Sagami Bay) and 1 sample from Toyo Bay were used to examine the effects of the

dioxin accumulation caused by illegal wastewater discharge from an incinerator plant.

The analytical method for Dioxin Analogues in Blue Mussel was established at Maxxam Analytics Inc. The samples were homogenized and weighed into an extraction jar, then fortified with surrogates compounds. HCl was employed for the overnight digestion. A 25% DCM/Hexane solution was added to the tissue, shaken for 5 minutes for settling, and the solvent layer was collected after passing through sodium sulphate. This extraction was repeated 2 more times and the extract was concentrated to determine the lipid content. After reconstituting the extract with dichloromethane followed by methanol, cleaning or "washing" was performed with sulphuric acid. The cleaned extract was eluted through an acid/base silica column, then concentrated and split extract for D/F and Co-PCB analysis. Both the D/F and Co-PCB portions were cleaned through basic alumina columns, collecting the cleanup and concentrate fractions separately. The fractions were transferred to vials, taken just to dryness and fotified with internal standard prior to analysis by HR GC/MS for PCDD/PCDF and Co-PCBs.

Results and Discussion

Table 1 Co-PCBs concentration in the mussels of target areas

ID	Target Water Area	Co-PCBs	
		pg/g	pg-TEQ/g
A	Maehara Beach	650	0.39
B	Tokyo Bay Haneda Off shore	3,400	0.99
C	Sashima Marina	1,300	0.86
D	Hikichi R. Mouth	3,300	1.8
E	Sagami R. Estuary	2,000	1.0
F	Tsukumo Bay	1,900	0.72
G	Akabane Fishing Port	170	0.15
H	Akabane Fishing Port Off	180	0.19
I	Mikawa Bay	200	0.20
J	Takamatsu Beach	1,200	0.19
K	Kasumigaura Canal	3,800	0.43
L	Suzuka R. Estuary	1,800	0.58
M	Izumiotsu Marina	4,300	1.5
N	Amino Town Beach	220	0.23
O	Komatsu Beach	670	0.66
P	Futami Ura Beach	160	0.08
Q	Tanegashima Island	110	0.77

As indicated in Table 1, the contamination levels of Co-PCBs in the mussels from 16 target areas were quite diverse, with the greatest variance being approximately 22.5 times. The highest was Hikichi R. mouth in Sagami Bay, Kanagawa Pref. where high concentration effluents with about 8000pg-TEQ/L dioxins had been discharged from the Incinerator plant industry located 5km above. Among those 16 samples, Sagami Bay, Tokyo Bay and Osaka Bay were the most polluted areas with over 1.0pg-TEQ/g of Co-PCBs. On the other hand, non-industrial fishery areas and harbors were respectively low levels compared to urban areas. Focusing on the Sagami Bay area, the concentration levels of Co-PCBs of the Pilot Study performed 1 year prior to the nation wide survey (October-November 2001), were 1.3pg-TEQ/g at Hikichi R. mouth and 1.5pg-TEQ/g at Enoshima Island, located about 2km east from the river mouth of Hikichi.[2] This indicates that with respect to Co-PCBs, the concentrations in the mussels at Hikichi R. were still increasing, even 18 months after the pollution source was stopped. Figure 2 shows the

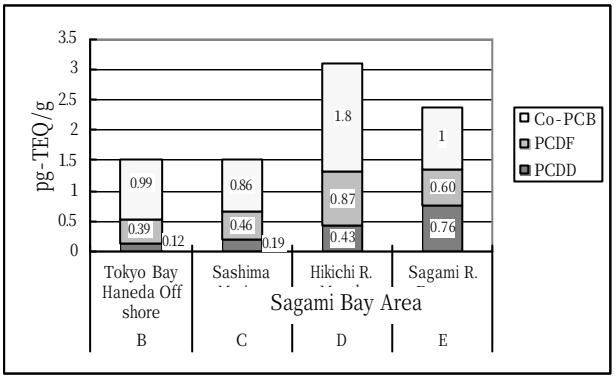


Figure 2 Concentration of Dioxin analogues

Table 2 Ratios of Co-PCBs in Mussels

Sampling	Area	%
FY 1998	Ave. of 15 samples	68
2000.10	PS:Hikichi R. Mouth	32
2000.10	PS:Enoshima Island	48
2001.10	B:Tokyo Bay Haneda	66
2001.10	C:Sashima Marina	57
2001.10	D:Hikichi R. Mouth	58
2001.10	E: Sagami R. Estuary	42

Note: PS means Pilot Study in 2000

comparison of total dioxin analogue TEQ levels of Sagami Bay area and Tokyo Bay Haneda Off shore. Looking at the percentage of the 3-dioxin analogue components shown in Table 2, Co-PCBs are relatively low (42-58%) compared to the monitoring survey done by the Japan Environment Agency, which was 68% on average in 15 blue mussel samples collected throughout Japan[3].

This suggests that the mussels of Hikichi River mouth (D) are still highly affected by the wastewater discharge in comparison with other areas of Japan. Especially, the Co-PCB ratio of Sagami R. Estuary (E) is the lowest of the 4 samples. It could be assumed that the west of Hikichi R. mouth is more affected than the eastern area like Sashima Marina of Miura Pen. This nation wide citizen participatory environmental monitoring project was conducted 18 months after the detection of the serious pollution by the illegal discharge of dioxins. Although the dioxin concentration of the river and seawater had been improved greatly[4], the mussel tissue was accumulating and concentrating the dioxin analogues caused by the wastewater discharge from the plant. Thus, it is possible to say that the mussels are an effective bio-monitor index for citizens and NGOs who are living in the neighborhood of heavily polluted river basins. As well, the analytical data became an important means for citizens to be informed of the situation in their environment, supported by the knowledge of the research group.

Acknowledgments

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References

1. Hideaki Miyata, (1999) Dioxin, Iwanami Paperbacks (Iwanami Shinsho) 605, Iwanami Shoten
2. Komichi Ikeda, Teiichi Aoyama and Atsushi Takatori, (2001), Research on Environmental Monitoring Methodology of Seawater Using Mussels as Bio-monitor, The 4th Annual Meeting of Japan Society of Endocrine Disrupters Research Abstracts.
3. Nationwide Dioxin Monitoring Survey In FY1998, Environment Agency Japan.
4. Environmental Survey Report, (2000 and 2001), Fujisawa City and Kanagawa Pref. Japan