Mem. Fac. Fish. Kagoshima Univ.,
Special Issue, pp. 59～62（2010）

Assessment of Residual Petroleum Hydrocarbon Two Years After the M/T Solar I Oil Spill in Southern Guimaras, Central Philippines

Ida G. Pahila[1*], Hilario Taberna Jr[1]., Resurreccion Sadaba Jr[2]., Leandro Gamarcha[1],
Jiro Koyama[3], Seiichi Uno[3]

Key words: oil spill, polycyclic aromatic hydrocarbon, sediment, shellfish, Guimaras, Philippines

Abstract

This study investigated the residual level of polycyclic aromatic hydrocarbons (PAH) in sediments and shellfishes from some heavily impacted areas of Southern Guimaras, Central Philippines two years after the M/T Solar I oil spill. Chemical analysis revealed that the PAH is still within detectable level in some heavily impacted areas of TINMAR and Luzaran in Southern Guimaras, although there was a significant decrease in total PAH of coastal sediments from (3 – 25 ppm) one year after the oil spill to (1 ppb - 17 ppm) two years. However, the total PAH in mangrove surface sediments of TINMAR is relatively lower (<0.16 ppm - 0.8 ppm) and remained almost at the same level two years after the oil spill. On the other hand, the shellfishes recorded a more dramatic decrease in PAH from (9.7- 18.7 ppm) one year after the oil spill to (1 ppb – 2.4 ppm) two years after.

On August 11, 2006, strong winds and big waves caused by a storm that hit central Philippines resulted in the sinking of M/T Solar I and about 2 million liters of bunker oil were spilled. It was reported that when oil becomes entrained in sediments, the contamination can be particularly long lasting.[1,2)] Thus, monitoring the level of petroleum contamination in the sediment was done 1 month after the spill and more than two years thereafter. The PAHs in petroleum have received special attention because its persistence in the environment,[3,4)] toxicity of low molecular weight PAHs and carcinogenicity of some metabolites of high molecular weight PAHs (i.e. benzo[a]pyrene).[5)] It has been documented that PAHs are readily accumulated by shellfishes, particularly by bivalve mollusks.[6,7)]

Spilled oil generally degrades differently under various factors such as evaporation, diffusion, photooxidation, and biodegradation.[8-10)] Petroleum oil degradation is relatively faster in tropical areas than in temperate areas because of high temperature and more frequent storms.[11)] It was reported that the oil spilled from the Exxon Valdez persisted in the environment (temperate area) for a long time[12,13)] and the intertidal community took 3 – 5 years to recover from the impact.[14)]

Hence, a chemical assessment on the level of the persistent polycyclic aromatic hydrocarbon (PAH) in sediment and in some shellfishes shall provide information on the status of petroleum contamination of affected areas.

Materials and Methods

The Sample and Sampling Sites

After the rapid assessment conducted 1 to 3 months after the oil spill incident on August 2006, monitoring was pursued in 2007 and 2008 in some heavily impacted areas in TINMAR (Taklong Island National Marine Reserve) and Luzaran (fig. 1).

Sediment and shellfish samples were collected randomly along the coastline and in some mangrove areas.

Sample Preparation and Extraction

The shellfish samples were thawed, cleaned and washed with distilled water. Two grams (wet weight) each were taken

[1] Department of Chemistry, College of Arts and Sciences, University of the Philippines Visayas, Miagao, 5023 Iloilo, Phils
[2] Division of Biological Sciences, College of Arts and Sciences, University of the Philippines Visayas, Miagao, 5023 Iloilo,Phils
[3] Faculty of Fisheries, 4-50-20 Shimoarata, Kagoshima University 890-0056, Kagoshima, Japan
* corresponding author: E-mail: ida_pahila@upv.edu.ph

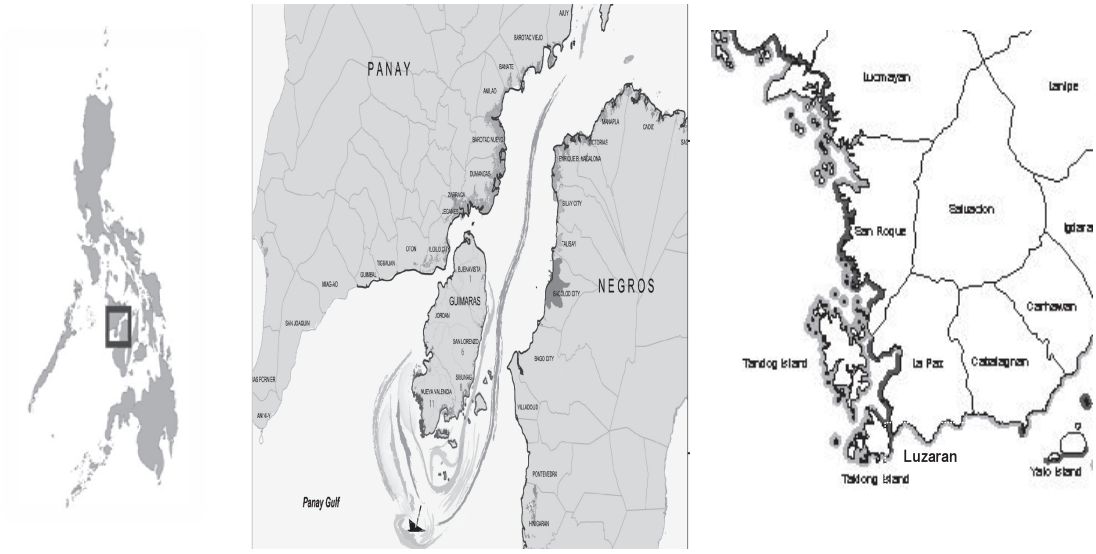

Fig 1. The sampling sites in Southern Guimaras, Central Philippines.
(http://www.wwf and http://www.upv.edu.ph)

(one gram for smaller samples) for n-hexane extraction using Sohxlet method. A portion of the sample was taken for dry matter determination (quantitative result is reported on dry weight basis).

Likewise, five grams each (wet weight) of the homogeneously ground sediment samples was extracted with n-hexane using Soxhlet method. Extraction was done for 16 hours, after which, it was concentrated in vacuo using a rotary evaporator at reduced pressure. The concentrated extract was then redissolved in 10-mL chrom-grade hexane and was passed through a silica-gel column for clean-up prior to injection in a Gas chromatograph-Mass spectrometer (Perkin Elmer Clarus 600 model) for determination of PAH.

The chromatogram and spectra of the samples were then compared to the 16 PAH standards [naphthalene, acenaphthylene, acenaphthene, fluorene, dibenzothiophene, phenanthrene, anthracene, fluoranthene, benz(*a*)anthracene, chrysene, benzo(*b*)fluoranthene, benzo(*a*)pyrene, perylene, dibenzo(*a,h*) anthracene, indeno(1,2,3-*cd*)pyrene, and benzo(*g,h,i*)perylene] previously run under the same condition for quantization. Since the level of some PAHs were below the detection limit of the machine and the method, the authors decided to report the total PAH as the sum of 16 PAHs determined.

Results and Discussion

Chemical analysis revealed that the PAH is still within detectable level in some heavily impacted areas of TINMAR and Luzaran in Southern Guimaras. In 2007, 1 year after the oil spill, the sum of 16 PAHs in the surface sediment was 3 mg/kg, 23 mg/kg and 25 mg/kg (ppm) in Lusaran and 2 sites in Taklong Island (near UPV Biological Station), respectively. In 2008, 2 years after the oil spill, there was a dramatic decrease in total PAH in the same areas, with Lusaran having 1 µg/kg (ppb) PAH, and Taklong with 13.2 mg/kg and 17 mg/kg (ppm) (Fig. 2).

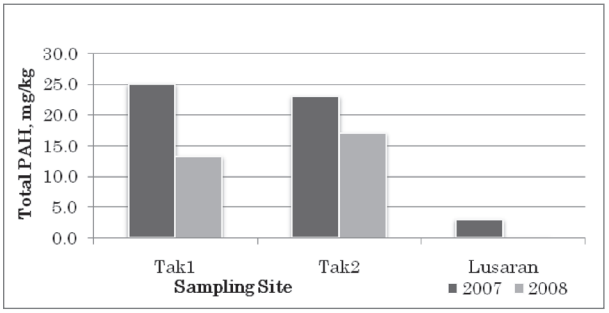

Fig 2. Total (16) PAH in sediments.

One year after the oil spill (2007), the total PAH in the surface sediments of TINMAR mangrove areas are relatively lower (<0.16 mg/kg - 0.8 mg/kg) than the total PAH in surface sediments of Taklong Island near UPV Biological Station and the PAH remained almost at the same level two years after the oil spill (Fig. 3). The low concentration of the persistent polycyclic aromatic hydrocarbon may primarily be due to the location of the mangrove areas especially Tandog and Tuguisan. These areas are within the intertidal zones and are more exposed to wave action / water exchange.

On the other hand, the shellfishes recorded a more dramatic

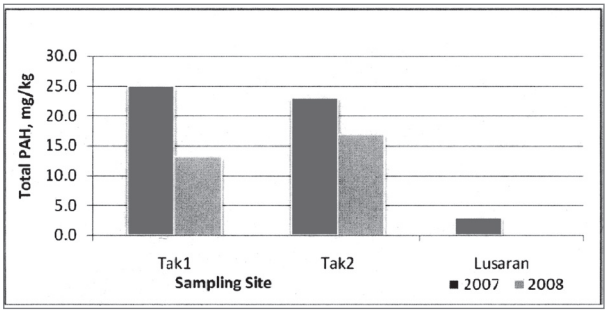

Fig 3. Total (16) PAH in TINMAR Mangrove surface sediment.

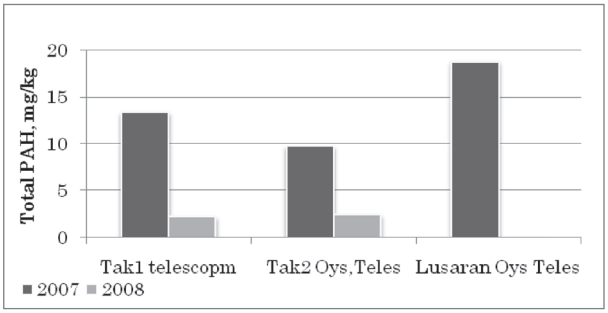

Fig 4. Total (16) PAHs of shellfish samples collected from Southern Guimaras

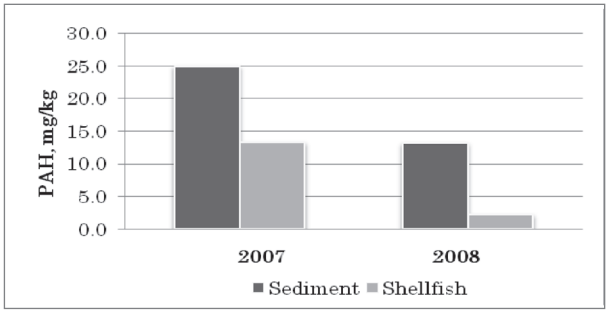

Fig 5. Total (16) PAH in Taklong 1 sediment and shellfishes.

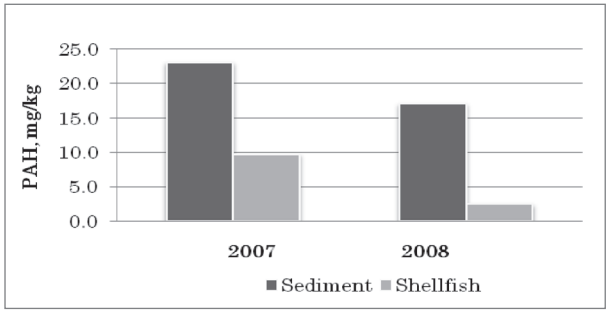

Fig 6. Total (16) PAH in Taklong 2 sediment and shellfishes.

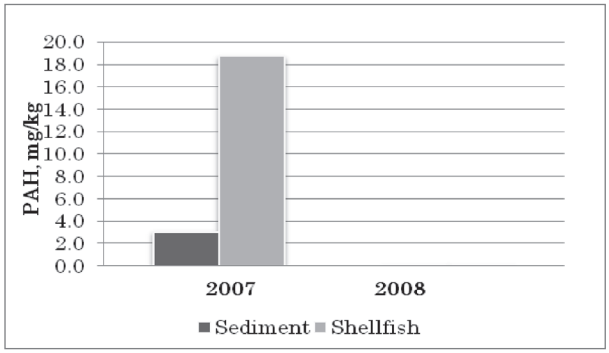

Fig 7. Total (16) PAH in Luzaran sediment and shellfishes.

decrease in PAH from (9.7- 18.7 mg/kg) in 2007, one year after the oil spill to (1 ppb – 2.4 mg/kg) two years after. Oyster samples collected from Lusaran one year after the spill recorded about 18.7 mg/kg total PAH compared to the oyster sample collected from Taklong 2 (9.7 mg/kg) and *Telescopium* samples (13.3 mg/kg) from Taklong 1. However, in 2008, only *Telescopium* samples were collected from the 3 areas for analysis and the total PAH level was very low in samples collected from Lusaran (1 µg/kg) and in samples taken from Taklong 1 and Taklong 2 (2.4 mg/kg) (Fig. 4).

Figure 5, 6 and 7 show the relative level of total PAH in sediment and shellfish samples. In Taklong 1 (fig. 5) and Taklong 2 (fig. 6), a uniform decreasing trend in total PAH in sediment and shellfish samples was evident. However, the oyster sample collected from Lusaran in 2007 (fig. 7) was found to have accumulated higher level of PAH (18.7 mg/kg) compared to the recorded total PAH in surface sediment (3 mg/kg), while in 2008, two years after the spill, the total PAH concentration in the *Telescopium* sample and surface sediment in Lusaran was only 0.001 mg/kg (0.001 ppm equiv to 1 ppb). The sudden decrease in the PAH level could probably be the effect of water exchange and big waves resulting from several storms that hit western visayas from 2007 to 2008.

It was observed[11] that petroleum oil degradation is relatively faster in tropical areas than in temperate areas because of high temperature and more frequent storms and big waves which resulted in the flushing out of oil from surface sediments. It was also documented that the oil spilled in temperate areas persisted in the environment longer and it took 3 - 5 years for the community to recover from the impact[14] compared to that in tropical areas. This common observation is based on the fact that spilled oil degrades differently under various factors such as evaporation, diffusion, photooxidation, and biodegradation.[8-10]

Acknowledgement

The authors would like to thank the University of the Philippines Visayas for the research support, Kagoshima Universi-

ty and Japan Society for the Promotion of Science for the travel grant.

References

1) Rice, S. D. R.B.Spies, D.A.Wolf, B.A.wright Edo.1996. Proceedings of the "Exxon Valdez" Oil Spill Symposium (American Fisheries Society), Bethesda, MD., 18, 286.
2) Shigenaka, G., D.A. Coats, A.K. Fukuyama, and P.O. Roberts (1999). Beyond 2000–Balancing Perspectives, Paper #326, in "Proceedings of the 1999 International Oil Spill Conference". March 8-11, 1999, Seattle, USA. American Petroleum Institute, Washington DC, Publication no. 4686A/B. ISSN 75-4161, p. 349.
3) Malins, Dc, B.B. McCain, J.T. Landahl, M.S. Myers, M.M. Krahn, D.W. Brown, S.L. Chan, and W.T. Roubal (1988). Neoplastic and other diseases in fish in relation to toxic chemicals: an overview. *Aquat. Toxicol.,* **11**:43-67.
4) Wang, Z., M. Fingas, E.H. Owens, L. Sigouin, and C.E. Brown (2001). Long-term fate and persistence of the spilled Metula oil in a marine salt marsh environment degradation of petroleum biomarkers. *J. Chromatogr. A,* **926**:275–290.
5) Law, R.J., C. Kelly, K. Baker, J. Jones, A. McIntosh, and C.F. Moffat (2002). Toxic equivalency factors for PAH and their applicability in shellfish pollution monitoring studies. *J. Environ. Monit.,* **4**:383-388
6) Yender, R., J. Michel, and C. Lord (2002). Managing Seafood Safety after an Oil Spill. Seattle: Hazardous Materials Response Division, Office of Response and Restoration, National Oceanic and Atmospheric Administration, p. 72
7) Koyama, J., S. Uno, and K. Kohno (2004). Polycyclic aromatic hydrocarbon contamination and recovery characteristics in some organisms after the Nakhodka oil spill. *Mar. Pollut. Bull.,* **49**:1054-1061.
8) Laffon, B., T. Rábade, E. Pásaro, and J. Méndez (2006). Monitoring of the impact of Prestige oil spill on *Mytilus galloprovincialis* from Galician coast. *Environ. Int.,* **32**:342–348.
9) Owens, E.H., E. Taylor, and B. Humphrey (2008). The persistence and character of stranded oil on coarse sediment beaches. *Mar. Pollut. Bull.,* **56**:14–26.
10) Taylor, E. and D. Reimer (2008).Oil persistence on beaches in Prince William Sound—A review of SCAT surveys conducted from 1989 to 2002. *Mar. Pollut. Bull.,* **56**:458–474.
11) Uno, S., J. Koyama, E. Kokushi, H. Monteclaro, S. Santander, J.O. Cheikyula, S. Miki, N. Añasco, I.G. Pahila, H.S. Taberna, Jr., T. Matsuoka (2009). Monitoring of PAHs and alkylated PAHs in aquatic organisms after 1 month from the *Solar I* oil spill off the coast of Guimaras Island, Philippines. *Environ. Monit. Assess.,* DOI 10.1007/s10661-009-0962-1.
12) Wolfe, D.A., M.J. Hameedi, J.A. Galt, G. Watabayashi, J. Short, C. O' claire, S. Rice, J. Michel, J.R. Payne, J. Bradock, S. Hanne, and D. Sale (1994(. The fate of the oil spilled from the Exxon Valdez. *Environ. Sci. Technol.,* **28**:561A-568A.
13) Hayes, M.O. and J. Michel (1999). Factors determining the long-term persistence of Exxon Valdez oil in gravel beaches. *Mar. Pollut. Bull.,* **38**:92–101.
14) Skalski J.R., D.A. Coats, and A.K. Fukuyama (2001). Criteria for oil spill recovery: A case study of the intertidal community of Prince William Sound, Alaska, following the Exxon Valdez oil spill. *Environmental Management,* **28**:9-18.