# EXTRACTABLE ORGANOHALOGENS (EOX) IN BROWN BOOBY (*Sula leucogaster*) FROM NAKANOKAMISHIMA ISLAND, SOUTH RYUKYUS, JAPAN

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**Introduction**

We have described over five million chemical compounds that exist in our daily life and the chemical industry produces about one hundred and fifty million tons of synthetic chemicals annually [1]. Especially large amounts of organohalogen compounds are produced by the industrial activities of man. Anthropogenic organohalogens are responsible for ecological damage associated with their bioaccumulation and biomagnification potentials and their toxic properties. It is well known that covalently bound halogen atoms, such as chlorine, increase persistency and lipophilicity of an organic molecule, and thus enhance bioaccumulation and biomagnification to toxic levels [1]. However, only a limited number of organohalogen compounds which have been produced in industries have been measured and their occurrence and behaviour determined in the environment [1]. It is not easy to investigate all of the individual compounds and their degradation products due to the cost and time required for analysis. On the other hand, it may be true that there are methodological problems with current measurement techniques for complicated residues of man-made compounds.

Instrumental neutron activation analysis (INAA) is a suitable technique to determine the extent of organohalogen residues in the environment. It is possible to get the levels of individual organohalogen compounds as extractable organohalogen (EOX) concentrations. Analysis of EOX will be of help to understand the levels of unidentified organic halogens when EOX and identified man-made organic halogen concentrations are compared [2].

It is well known that determination of the age of wild birds is difficult. Consequently, identification of the age trend of contaminants in wild birds is limited. In the present study, age trend accumulation was investigated for EOX in the seabird samples where age was determined by banding technique.

**Materials and Methods**

The bird samples were collected at Nakanokamishima Island, South Ryukyus, Japan, during the summer of 1993 with permission from the Japanese government. The five individuals were analysed for EOX and organochlorine compounds [PCBs, DDTs, HCHs, HCB and Chlordane compounds(CHLs)]. Approximately 5 to 10 grams of fat tissue from each sample was used for chemical analysis. EOX and organochlorines were extracted using organic solvents. The extract was washed with distilled deionized water, and fractionated with S-X3 (Bio-Lad Laboratories Inc.) gel permeation column chromatography. EOX in the sample solution was measured by instrumental neutron activation technique[2,3]. The analysis was made with the research nuclear reactor JRR-4, Japan Atomic Energy Research Institute (JAERI), Ibaragi, Japan, by using neutron flux at a rate of $3.7 \times 10^{13}$ n/cm$^2$ sec for two minutes. The gamma-rays from $^{38}$Cl, $^{80}$Br and $^{128}$I were measured by gamma-ray spectrometry technique [2,3]. The reproducibility of this method is 11% for chlorine, 5.0% for bromine and 13% for iodine (n=3). Individual organochlorine compounds such as PCBs, DDTs, HCHs, HCB and CHLs were analysed by GC-MS and GC-ECD [4]. The analytical error of this method was less than 5%.

**Results and Discussion**

The results of the EOX analysis are shown in Table 1. The EOX concentrations were 56.2 to 111 μg/g (fat weight basis). The order of EOX concentrations was as follows: extractable organochlorine (EOCl) > extractable organobromine (EOBr) > extractable organoiodine (EOI) (Fig. 1). The highest EOCl concentration was found in sample No.120-03889, which was the youngest (three weeks old) and had the lowest lipid content (24.1%) .

The proportion of known organochlorine compounds in EOCl was analysed to reveal the content of unknown organochlorine compounds. The results showed that a large part of EOCl, more than ninety-five percent, was derived from unidentified compounds. This figure is higer than the figure obtained from grey-tailed tattlers(*Heteroscelus brevipes*)[5]. It is observed that brown boobies banded at Nakanokamishima Island travel 1000 to 2000km southward to the southern Philippines[6]. Consequently, this bird species may ingest the compounds via food such as fish and squid[7] in the regions of southern Japan and the Philippines.

It is already known that some man-made organochlorine compounds, such as PCBs, DDTs, HCHs,

HCB and CHLs, are ubiquitous in the marine environment[4,8,9]. The results strongly indicated that the contamination of the marine environment includes yet unknown/unidentified organochlorine compounds. The EOCl concentration is especially high in the youngest of the individual sample. It is important to investigate whether these unknown/unidentified compounds cause any physiological effects on brown booby or not, and to determine the sources and the extent of the contamination.

**Table 1. Concentrations (μg/g on fat weight basis) of extractable organohalogens (EOX) in five brown boobies (*Sula leucogaster*) from Nakanokamishima Island, South Ryukyus, Japan.**

| Sample No. | Age (Years) | Fat Content (%) | EOCl | EOBr | EOI |
|---|---|---|---|---|---|
| 120-03889 | 0.06 | 24.1 | 88 | 18 | 5.0 |
| 930505-D2 | 0.06 | 34.8 | 40 | 12 | 4.6 |
| 12A-01132 | 0.27 | 58.7 | 42 | 12 | 2.2 |
| 120-02366 | 5.0 | 55.2 | 45 | 11 | 4.7 |
| 120-01785 | 7.0 | 52.2 | 46 | 12 | 5.2 |

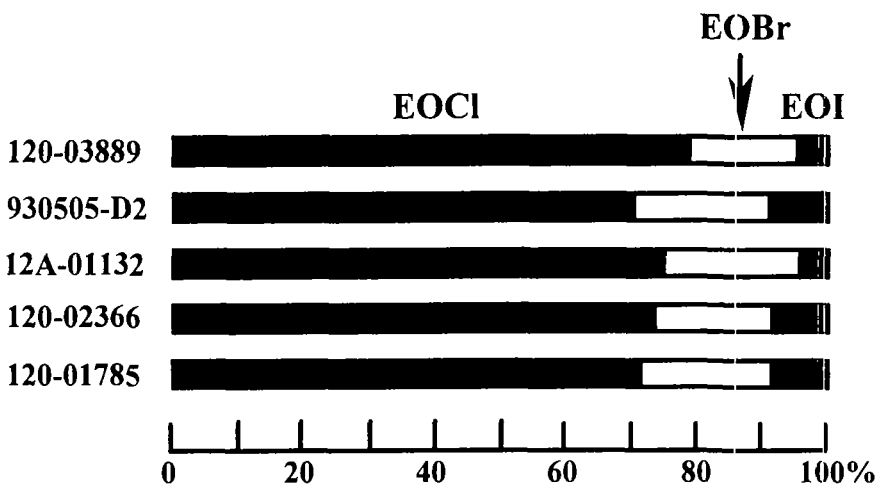


**Fig. 1. EOX compositions in adipose tissue of the brown booby samples.**

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**References**

1. Beek, B., Bioaccumulation -New Aspects and Developments-, The Handbook of Environmental Chemistry Volumn 2, Springer-Velag, Berlin (1994).

2. Kawano, M. and Tatsukawa, R., Neutron Activation Analysis (NAA) 3. NAA in Environmental Sciences: 1. Total organic halogens in the environment., Radioisotopes, 43, 228-232 (1994) (in japanese)

3. Kawano, M., Yoshioka, H., Tejima, Y. and Tatsukawa, R., Occurrence of organic halogens in marine mammals. pp333-337. in "Naturally-Produced Organohalogens" Edited by Grimvall, A. and De Leer, Ed W. D., Kluwer Academic Publishers, Dordrecht, The Netherlands (1995).

4. Kawano, M., Inoue, T., Wada, T., Hidaka, H. and Tatsukawa, R.: Bioconcentration and residue patterns of chlordane compounds in marine animals: invertebrates, fisf, mammals, and sea birds. Environ. Sci. Technol., 22, 792-797 (1988).

5. Kawano, M., Yamamoto, K., Shigeta, Y., Tatsukawa, R. and Wakimoto, T., Accumulation of extractable organic halogens (EOX) and persistent man-made organochlorines by grey-tailed tattler (*Heteroscelus brevipes*). Organohalogen Compounds, 43, 67-71 (1999).

6. Kohno, H., Visits of immature Blue-faced and Red-footed Boobies to Nakanokamishima, South Ryukyus, Japan. Bull. Inst. Oceanic Res. & Develop., Tokai Univ., 21 111-117 (2000).

7. Kohno, H., The prey of seabirds breeding Nakanokamishima, South Ryukyus, Japan. Bull. Inst. Oceanic Res. & Develop., Tokai Univ., 10, 43-64 (1989) (in Japanese)

8. Sladen, W.J.L., Menzie, C.M. and Rechel, W.L., DDT residues in Adelie penguines and a crabeater seal from Antarctic. Nature, 210, 670-673 (1966).

9. Muir, D., Braune, B., DeMarch, B., Norstrom, R., Wagemann, R., Lockhart, L., Hargrave, B., Bright, D., Addison, R., Payne, J. and Reimer, K., Spatial and temporal trends and effects of contaminants in the Canadian Arctic marine ecosystem: a review. The Science of the Total Environment, 230, 83-144 (1999).