**D-2.5** Distribution and Origin of Environmental Pollution in East China Sea

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**Total Budget for FY 1997** ¥3,879,000.

**Abstract** We have developed an information infrastructure for archiving various monitoring data, survey data, and other relevant information on hazardous chemicals in East China Sea and its neighboring areas where pollution is proceeding in very high speed. A geographical information system (GIS) using ArcView3 and digital map data was developed for this purpose. The system is running on our Internet environment. Existing data such as the monitoring data of GEMS or food residue data from prefectural public health laboratory data were mapped onto digital maps and were presented on the WWW pages. A home page called PD Watchers was set up in order to survey plastic debris particularly resin pellets on seashore and to prevent their spills to the environment. We have analyzed some resin pellets and detected some endocrine disruptors such as nonylphenol.

**Key Words** Hazardous Chemicals, East China Sea, GIS, Resin Pellets, Endocrine Disruptors

1. Introduction

South East Asia and Northwest Pacific region is one of the regions where economical development is undergoing in the fastest pace in the World. As its consequence its environment is rapidly getting worse. Various pollutants including hazardous chemicals are flowing into the environment. Their destination is the ocean. Thus East China Sea and its neighboring areas will become increasingly important for environmental concern particularly from marine pollution viewpoint.

One of the important factors which characterize the marine pollution in these areas is the existence of the strong current called Kuroshio. This current flows from east of Philippines and Taiwan, through East China Sea at west of Ryukyu Islands, bifurcate at southern islands, Tokara and Tanegashima, of Kyuushu and flow into both Japanese Ocean and Pacific Ocean. At its northern border East China Sea is facing to Yellow Sea whose coast consists of Mainland China and Korea. Thus international collaborative studies are needed to survey

environmental pollutants in these areas.

We have developed computerized informational platform for such studies which is connected to the Internet. We have begun to archive various data on this system. We have also made a survey of resin pellets which were drifting in the sea and were left at various coasts of Japanese islands.

## 2. Research Objective

The purpose of our research is to find out what kind of hazardous chemicals exist in the East Asia and Northwest Pacific sea areas and how these chemicals were originated and transported into these areas. We are particularly interested in such important pollutants as heavy metals, persistent organic pollutants (POPs) and the so called endocrine disrupting chemicals. One of the difficulties of this kind of study is that there are not yet so much real data, either of monitoring or of surveillance, on these areas. Moreover it is not easy for researchers to access existing data and to cross review them.

It is therefore important to provide some common platform for data repository and information archiving. Thus the primary goal of our research was to develop an informational infrastructure on the Internet on which one can deposit data, archive information, represent the data graphically, and easily cross review various data from different sources. Since many of these data have geographical attribute, it is possible to present them on maps using the so called geographical information system (GIS).

We also wanted to make a survey on plastic debris particularly resin pellets which were drifting in the sea and were left at beaches of islands in the East China Sea and other coastal areas in Japan. We will clarify the possibility that some endocrine disruptors are on or in these resin pellets.

## 3. Research Method

For the information platform we used a computerized system on our local area network environment connected to the outer Internet. The system consists of a WWW server, database servers and a stand alone geographical information system. In order to find hazardous chemicals data in the focused region, we searched relevant information from various sources including publications, the Internet/WWW, and CD-ROMs. In order to collect information from neighbor countries we use the so called GINC Asia network.

GINC (Global Information Network on Chemicals) is a project of IOMC (Inter-Organization Programme for Sound Management of Chemicals) which consists of six international organizations, WHO, ILO, UNEP, FAO, OECD and UNIDOR, and which are formed in order to fulfill targets set in the UNCED's Agenda 21 Chapter 19 for sound management of chemicals. GINC Asia is the pilot study of this project for Asian and West Pacific region.

## 4. Result

### 4.1 Building Informational Platform

#### Computing Environment

We have developed a computerized system by which one can deposit environmental monitoring or survey data and archive related information. The system consists of several servers and client machines on our local area network which are connected to the Internet. We used WWW mechanism for delivering information. Main servers for the network operation and database management are SUN workstations running on UNIX operating system, and there also are several Windows NT machines for in house usage.

#### GIS

One of the important ingredients of the informational platform is geographical information system (GIS). This system consists of three basic components. First is the basic geographical information system (programming package) which generates map image from digital map data. The second component is digital vector data, and the third component is an interface software which converts map images created by the basic geographical information system to some picture files that can be put on the Web server so that the map can be seen by Web browsers.

There exist several GIS software products on the market among which ArcView and MapInfo are well known. Unfortunately there is no data compatibility between these two systems, namely digital map data for one system can not directly feed into another system and vice versa. Thus one must always chose a GIS software and the digital data formatted for this system as one set. We used ArcView3 from ESRI (Environmental Systems Research Institute Inc.) and digital map data formatted for it. As for digital map data we used Digital World of ESRI for drawing world wide area map and the digital map of 1/25,000 scale from Geographical Survey Institute for domestic area.

One can represent various environmental indicators on maps. These maps can be in color if so needed and will be put on Web pages as clickable maps. If one click some area in a map more detailed information such as detailed map, graphics or pictures associated to that area will be presented. In order to convert the maps generated by ArcView3 (BMP) to standard GIF file which can be handled by the WWW server we used a freeware software LViewPro.

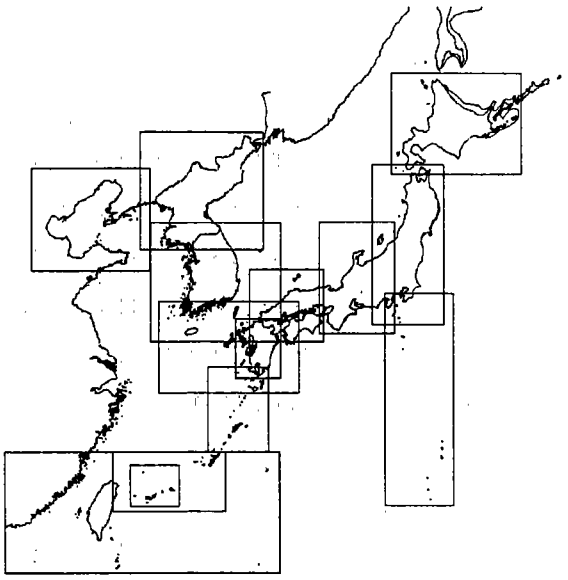

Figure1 Distribution Map of Resin Pellets by GIS

4.2 Data Archiving

We have collected wide range of environmental data related to environment pollutants from various sources. These data may be classified into three categories. First is survey data conducted by some UN organization such as WHO, UNEP and FAO. The second category is survey data focused on (East) Asian region. Third category is Japanese domestic surveillance data carried by the national government or by municipal government. Table 1 gives the list of collected data some of which were already put on Web pages.

Table 1 Collected Monitoring Data which we have generated Maps or Tables on our Web

(1) Monitoring Data of the Environment in Asian Regions from Reports of United Nations and International Organization Projects

① PCB Concentration in Fish and Surface Water in Asian and Pacific Regions
Australia EPA (1996), IFCS Second Meeting of the ISG, 3-8 March

② Data of Water Quality of Rivers and Lakes (in completed) GEMS/Water Monitoring Data
http://cciw.ca/gems/summary/

③ Suspended Particle Maters(SPM) Concentration at Selected Monitoring Sites (1980～1990)
GEMS/Air Urban Air Pollution, UNEP/GEMS Environment Library No.4, Nairobi,36pp.1991

④ Distribution of SPM in 1990(or Latest Year) at Selected Monitoring Sites
GEMS/Air (1991) Urban Air Pollution, UNEP/GEMS Environment Library No.4, Nairobi,36pp.

⑤ GEMS/FOOD, The Contamination of Food, UNEP/GEMS Environment Library No.5, Nairobi, 36pp. (under preparation)

⑥ Life Expectancy, Infant Mortality and Other Indexes of Health, WHO, 1996

(2) Monitoring Data of the Environment in Asian Regions from Small Steady Gropes

① Total DDT Concentration in Green Mussels of Gulf of Thailand
C.Siriwong, Montip S. Tabucanon and et al., Marine Pollution Bulletin,32, 10, 510-516, 1991

② SPM, SO2, NO2 CO Concentration in Air in Selected Asian Cities
T. Okita, Recent Air Pollution and Acid Rain in Asian Regions, Environmental Information Sciences, 126(3), 32-37, 1997

③ Iwata, H. et al. Organochlorines in air, water and sediments from Asia and Oceania, and their implications for global redistribution from lower latitudes, Environmental Pollution, 85, 15-33, 1993 (under preparation)

④ Main Chemical Pollution in Asia Regions, Edited by DCBI NIHS

(3) Monitoring Data of the Environment in Asian Regions from Government and Local Governments Reports

① TBT/TPT/T-DDT Concentration in Fish and Shellfish
Environment Agency, Chemicals in the Environment 1990, 1995
H. Irie, S. Nakama, T. Nagata and A. Asou, Oita Health and Environmental Laboratory Report No.17 1989, No.18, 1990

② PCB Concentration in Fish, Shellfish and Sediment
Environment Agency, Chemicals in the Environment 1990, 1995
T. Yamaguch, E. Koun H. Sato, H. Takada and N. Ogura, Estimation of sources of PCB, 1996 Proceedings of J. Oceanography, 1996

③ Dioxin Concentration in Sediments of Rivers, Lakes and Seas
Environment Agency, Chemicals in the Environment , 1990, 1995
M. Ando, M. Morita et.al. Human Risk Assessment and Exposure for Chlorinated Dibenzo-p-dioxins in Freshwater, 1996

④ TBT Concentration in Sediments of Rivers, Lakes and Seas
Environment Agency, Chemicals in the Environment , 1990, 1995

⑤ TBT Concentration in Surface Water of Rivers Lakes and Seas
Environment Agency, Chemicals in the Environment, 1990, 1995

⑥ Main Industrial Chemical Pollution in Japan, Edited by DCBI NIHS

⑦ Division of Food, National Institute of Health Sciences (1995) , Monitoring Data of Foods Residues, Report for GEMS/FOOD, 1980-95 (In completed )

4.3 Survey of Endocrine Disruptors

An attempt is made to list up potential endocrine disrupting chemicals. We consider the concept of endocrine disrupting chemicals is still working hypothesis for scientists. We made survey of existing scientific papers and working reports on this subject and listed about 150 different chemicals as potential endocrine disruptors.

This list includes both natural and man-made chemicals including natural sex (estrogen)

hormones, synthetic steroids for therapeutic drugs, pesticides, industrial chemicals and dioxin and related compounds. This list is used to identify environmental endocrine disrupting chemicals in marine environment. Part of information collected for this work is put on the Web.

4.4 Sea Drifting Plastic Debris

Research Objectives

Plastic debris are important marine pollutants. We are particularly interested in resin pellets. Resin pellets are intermediate material for wide range of plastic products. There size ranges approximately from 0.3 mm to 10 mm with various shapes, mainly pressed ball, cylinder, pressed cylinder, ellipsoidal cylinder etc, and either transparent or opaque with and without color. Existence of such pellets on the ocean surface, at some beaches and inside of fishes and birds were reported since early 1970s. In Japan researchers, Maritime Safety Agency, and volunteer organizations made several surveys. Unfortunately some survey results have not yet openly published.

We are interested resin pellets from two reasons. First they are marine contaminants. Second they may be good indicators (tracers) of how hazardous chemicals are transported through ocean. Except styrene density of plastics are lower than that of water and thus buoyant and float in water. They may spill into river from sewage system, drop into water when lifting in to or out of ships. US EPA made a manual for preventing resin pellets spill into the environment, however there still exists large volume of resin pellets in marine environment. If we can collect resin pellets from different geographical location and can analyze their character we may elucidate where they come from.

Field Survey

We made field survey of resin pellets at 80 different beach sites in the western part of Japanese Islands. We also asked outside collaborators mainly Okinawa Deep Sea Water Research Consortium and Japan Ecological Clean Up Organization to make similar field survey. These surveys were carried out from April 1997 to March 1998. As a whole we got data from nearly 150 coastal sites most of which locate in Western Part of Japan Islands.

At each beach site we checked whether there were resin pellets or not, if any how they were distributed, and roughly how many of them were there, etc. Resin pellet samples were also collected. These data were put into data sheets and represented on maps by the GIS. These maps were then converted into clickable maps on the WWW pages.

We also tried to collect floating pellets using neuston (plankton) nets. The survey were carried out at the cost of Itoman City and 40 kilometers south of it in Okinawa in June and July 1997 by the members of Okinawa Deep Sea Water Research Consortium. These samples were sent to us for examination, but we could not find any pellets in these samples.

We also obtained samples found in the birds which were shot down for preventing not crashing to airplanes around Haneda Airport in Tokyo.

Method of Number Estimation

Roughly there are two ways to estimate number of resin pellets on beach. One is to count all pellets taken from several preset areas. For example take an one meter square area and collect all pellets up to 5 to 10 cm depth and repeat this process until to cover all areas which have pellets. However this method has two difficulties. First it is laborious to collect all samples including other wastes from predetermined space. Selection process is particularly tedious and takes time. Second it is very difficult to cover all areas where pellets are suspected to exists or embedded in the sand. Thus even if this measurement is exact in selected area, it may not give any information for neighboring or other areas. It only gives the information that how many pellets were there in the picked up square.

Another method is to characterize global distribution of pellets on beaches by simple sampling. The distribution of pellets may be categorized into two types: sparse, (wave like) linear distributions parallel to shore line or area distribution. In sparse mode one can only pick up pellets here and there, and or continuous sampling along lines or within-some area are meaningless. In linear distribution mode pellets are distributed along a line of wastes drifted from the sea. The waste usually placed along the shore parallel to the waterfront. Thus one can estimate number of pellets in the waste belts along the line. Problem is how many such clear belts can be identified. In area distribution mode pellets distribute in a rather homogeneous manner over the sand. The second mode of distribution is usually found near the waterfront while the third category is more common at the higher tide line.

It is almost meaningless to try to estimate or to measure number of pellets without taking this paternal difference into consideration unless one can measure "all" existing pellets at the beach site. Thus practically it is more reasonable to characterize pellet distribution by the difference of mode and rough estimation of density. If we collect pellets just by simple looking and digging, 10 square cm is a reasonable unit. If one find n pellets from the unit as an average, there are n x 100 pellets in one meter square, and n x 10,000 in 10 meter square.

The beach site where resin pellets were most highly accumulated was in Kugenuma beach. This area is located west of Hikiji River. Pellets were distributed in 30-50 meters belt which is located 30 meter off from the wave front for nearly one kilo meters along the sandy beach. In this case the number n in the above estimation is 3-4, which gives 9-16 million pellets as a whole. Similarly at Kumano beach of Tanegashima Island we found an area which consists of 5 meters times 50 meters square with 3-4. This means there were approximately 100,000 pellets in this square.

Coastal Distribution

From our survey we concluded that although resin pellets were found from almost all beaches we have surveyed it is rare to find the site where there are more than several hundreds pellets in one square meters. In another words pellets were usually more sparsely distributed than this mode. Thus we can call the beach sites which has at least one square meter area of more than several hundred pellets as highly concentrated point, and called abnormally highly accumulated sites for those which has an area of 10 square meters with more than several ten thousand pellets.

According to this definition we found abnormally highly accumulated sites in Kugenuma and Chigasaki beach in Kanagawa Prefecture and in Tanegashima Island of Kagoshima Prefecture, and highly accumulated sites in Motobu Peninsula in Okinawa Main Island and in a beach in Shimane Prefecture. There are many accumulated sites all over Western Japan including isolated islands like Ogasawara.

Classification and Chemical Analysis of Pellets

Resin pellets can be classified according to their color, clarity, size , shape, material quality, elasticity, and so on. If necessary one can put them into water or measure specific gravity using gravimeter. Such rather subjective categorization can be checked by more reliable chemical component analysis. Resin pellets are classified first by their main chemical components which would be polyethylene, polypropylene, and EVA. Another well used plastic is vinyl chloride, but vinyl chloride is usually used as powder and not in resin pellet form. Polystyrene is used in a large amount as containers whose waste debris are another common beach waste but not in pellet form. Thus most resin pellets are classified into either polyethylene (PE) or polyploylene (PP) from their main ingredients. They may further subclassified into different groups by their additives.

We have also tried to analyze samples chemically. Several FT-IR(Fast Fourier Transform Infrared Spectroscopy) measurements were applied to the samples. These measurement can identify main ingredients of the samples namely PP, PE, or EVA. However these analysis can not identify finer ingredients such as fine additives or surface contaminants. For this purpose we tried several analysis using GC/MS. By these analysis we identified some environmental contaminants such as nonylphenol or BHT (Butylhydroxytoluene). Such chemical analysis is still on going.

Building Networks for Watch and Prevention

Already number of researchers, administrative sectors, and volunteers are interested in environmental resin pellets. Resin pellet problem is a borderless matter. Their spill to environment should be prevented at factories when they are sent, received or wasted. Care should be paid during transportation and shipping at harbors. Beach watcher or beachcombers have most concerned resin pellets spills, because it is very difficult to clean them up at

beaches due to their size. Once in river, they go down the stream, go into the ocean, cross national borders to other nations'coast, accumulate there, and drift away to other place. Thus prevention is most effective to cut this circular process, and public awareness for this problem is the key.

We thus set up a home page called PD (Plastic Debris) on the Web for this purpose. The Web page gives basic information on resin pellets, how to watch them, and how to prevent them spilling into the environment. In these pages we put data recording sheets for pellet inspection. One can down load these form in order to report us his or her findings.

4.5 Obtaining Information from Overseas

In order to analyze marine data one might need land data both from domestic and overseas. It is worthwhile to know what kind of chemicals are formally regulated and what kind of chemicals and how much of them were or are really used in other Asian Pacific countries. Information collection for this purpose is still on going.

5. Discussion

5.1 Environmental Geographical Information Platform

Due to strong current, Kuroshio, East China Sea is the entrance of marine pollutants to Japan. Once pollutants get into this area, chances are that they would be transported into either Japan Sea, Japan Inside Sea called Setonaikai, or Pacific Coast of Japan Islands. It is thus reasonable to set many sentinel sites in this area. However the islands in this area, Nanseishoto (South West Islands) consists of sparse arch of islands each of which has only limited population except the central Island Okinawa. There are not many institutions for environmental health. Moreover not so much surveillance projects are on going. It is therefore important to archive all available data readily usable among researchers.

The information platform we developed will become a good stepping stone for building more comprehensive data archive system. Since it was developed on Internet it can be accessed not only by domestic researchers but also by foreign researchers interested in this area. Though contents were all in Japanese right now we are planning to provide English version too in the near future so that foreign researchers will show interests.

One important problem that should be resolved in the near future is to provide a standard digital map for entire Asian Pacific region. Such a map should cover Far East Russia, North and South Korea, Coastal China, Taiwan, Philippines, Vietnam, Thailand, Malaysia, Singapore, Indonesia, and their marginal sea. We may make this kind of map combining national land maps and ocean maps. Information from satellites will also be merged onto this map.

At present data and information collected by our group was very limited. We are planning to collect more data and information in the future.

5.2 Resin Pellet As New Marker And Carrier For Marine Pollutants

Our Internet home page for resin pellets, PD Watchers, was linked to the Internet on February 1998. Since then these pages have been browsed by many researchers, volunteers, school teachers and students, and mass media, and thus greatly contributed to publicize the resin pellet problem. We are planning to provide English version of PD Watchers so that our project attracts international concern. It was proved that the Internet/Web is useful for building surveillance network.

The distribution of resin pellets suggest that there are at least two typical cases for accumulation mechanism. One is Kugenuma beach where pellets seem to be supplied from the two nearby rivers. It was highly suspected that abnormally large amount of pellets flow through the rivers into the sea and drifted back to the nearby beaches. In April 1998, it was observed that cherry flowers blossomed and dropped in short period flew through the rivers and drifted back to the shore where pellets were distributed densely. We also found one site in Arakawa River in Tokyo which is not far from the mouth of the river and at which there were large volume of waste pellets.

This and other findings suggest that rivers are the source of waste pellets of some highly accumulated sites. Contrary beaches like that of Tanegashima, of Kumejima in Okinawa, or of Ogasawara do not have any such nearby inland sources of pellets. It is therefore reasonable to elucidate that pellets at these beaches came from remote place by ocean currents. One indirect evidence for this elucidation is the fact that some of these resin pellets were damaged on their surfaces. Moreover only at these beaches we could find pellets whose surface were partly or completely covered by some organisms which form some net pattern. Later these organisms were identified as bryozoans.

Thus it is highly probable that at some beaches part of the pellet may be supplied from nearby in land sources via rivers and part of them from remote sources via long ocean current. We expect that further chemical analysis may give some positive information for such classification.

6. Conclusion

We have developed informational platform by which data and information on environmental pollutants and hazardous chemicals in East China Sea will be archived. The system consists of WWW servers and a map handling GIS. From collected data clickable maps on WWW pages were generated. Original survey was made for resin pellets on nearly 150 beach sites, and distribution map was generated. There exist highly accumulated sites. At some of these sites pellets seemed to be supplied from nearby rivers, while other sites they were supplied from remote place by long ocean currents. The collected samples were classified and chemically analyzed. Some endocrine disrupting chemicals were identified from them.