

D-2.2.3 Distribution and Origin of Environmental Pollutants at East China Sea Area

Contact Person Tsuguchika Kaminuma
Head, Division of Chem-Bio Informatics,
National Institute of Health Science
1- 18- 1 Kamiyoga, Setagaya-ku, Tokyo, 158-0098 Japan
Tel: +81-3-3700-9540 Fax: +81-3-3700-7592
E-mail: kaminuma@nihs.go.jp

Total Budget for FY 1998 – FY 1999 13,011,000 Yen (FY 1999; 6,504,000Yen)

Abstract We have developed information infrastructure for archiving data for hazardous chemicals and environmental health in the Northwestern Pacific rim including East China Sea, its neighboring areas, and Japanese Islands. This infrastructure is a computer system which is running on Internet environment consists of a geographic information system (GIS) and databases and Internet WWW servers for information dissemination. The system can store various monitoring and survey data and display them on geographical maps so that researchers can easily compare different data sets from different sources. In addition to literature search a field study was carried out for environmental plastic resin pellets which were spilled into the environment and drifted onto seashores. We have analyzed some of these pellets and found several environmental pollutants including some endocrine disruptors. A home page called PD Watchers was opened in order to exchange information on environmental resin pellets.

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

1. Introduction

South East Asia and Northwestern Pacific rim is one of the regions where economical growth is fastest in the World. As its consequence its environment has been facing sever challenge. Various pollutants including hazardous chemicals are flowing into this area via various media such as air and water. The final destination of these pollutants is the ocean. The pollutants will then be highly concentrated and be transported into human body by food chains. Thus East China Sea and its neighboring area is one of the important portals to Japanese environment from marine pollution viewpoint.

One of the characteristic features of the marine pollution in this area 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 Kyushu and flow into both Japan Sea and Pacific Ocean. At its northern border East China Sea is facing to Yellow Sea whose coast consists of Mainland China and Korean Peninsula. Thus in order to study the origins of pollutants in East China Sea area and their transport pathways one must integrate different kind of data on different regions from different sources. International collaborative studies are ideal for this purpose. However not so many studies have been carried out either internationally or domestically. Moreover archives of these study reports have been very poor, and it is very difficult to search past survey data systematically.

Some data depository or repository systems are indispensable for such studies. We have tried to develop a computerized informational infrastructure. The system which is running on our Internet environment consists of a geographic information system (GIS) and databases and an Internet server for information dissemination. Based on collected literatures we have tried to produce several maps that represents how environmental pollutants distribute over the Northeastern Pacific rim around East China Sea.

In addition to literature search we made field study of plastic resin pellets which were spilled into the environment and were drifted onto seashores. Resin pellets are intermediate materials for wide range of plastic products. Their size ranges approximately from 0.3 mm to 10 mm with various shapes, mainly 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.

We were interested in resin pellets for two reasons. First they are marine contaminants. Second they may be good indicators (tracers) of how hazardous chemicals are transported through the ocean. Except styrene density of most plastics are lower than that of water and thus they buoyant and float in water. They may spill into river from sewage system, drop into water when lifting in to or out of ships. We chose this material because they were suspected to contain some endocrine disrupting chemicals.

2. Research Objective

The purpose of our research is to find out what kind of hazardous chemicals exist in the East Asia and the Northwestern Pacific rim particularly at East China Sea and how these chemicals were generated 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 research is that measurement data, either of monitoring or of surveillance, from these areas are very limited. 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 by 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 some geographical attributes, it is possible to present them on common maps using so called geographic information systems (GISs).

The secondary goal is to make a survey on plastic debris particularly resin pellets which were drifting in the ocean and were left at the beaches of islands around the East China Sea and other neighboring coasts. We also wanted to study whether some endocrine disruptors are on or in these resin pellets.

3. Research Method

Computer System

For developing an information platform we used computers in our local area network environment connected to the Internet via IMnet (Government supporting Inter Ministry Network). The system consists of WWW servers, database servers and stand alone geographic information systems. Main servers for the network operation and database management are SUN workstations running on UNIX operating system, and several Windows NT machines.

We used ArcView3 from ESRI (Environmental Systems Research Institute Inc.) as the GIS. As for the digital map data we used Digital World of ESRI for drawing world wide and Asian area maps and the digital maps of 1/25,000 scale and of 1/2,500 scale from National Geographical Survey Institute for representing Japanese Islands and their coasts.

Data Collection

In order to find hazardous chemicals data in the focused regions, we searched relevant information from various sources including publications, the Internet/WWW, and CD-ROMs. In order to collect information from neighbor countries we relied on 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 stated 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.

Collection of Resin Pellets

For plastic resin pellet studies we visited more than 140 beaches by ourselves. Resin pellets were also collected by other collaborating researchers and by volunteer organizations named Japan Ecological Clean Up Organization. We have opened a home page called, PD Watchers in order to disseminate our research products and to draw attention of researchers

and public on this problem and to get help to collect resin pellet samples from seashores.

Method of Number Estimation

The distribution of pellets may be categorized into three 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, this means that 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 beach. The second mode of distribution is usually found near the waterfront while the third category is more common at the higher tide lines.

It is therefore almost meaningless to try to estimate or to measure number of pellets without taking this paternal difference into consideration. Moreover unless one can measure "all" existing pellets at the beach site including those in the sand, the numbers are unreliable or even misleading. Thus practically speaking it is more reasonable to characterize pellet distributions by the indifference of modes and their rough estimation of densities. If we collect pellets just by simply looking and digging, 10 square cm is a reasonable unit. If one find n pellets from these units as an average, there are $n \times 100$ pellets in one meter square, and $n \times 10,000$ in 10 meter square. If this number n is 1, then the area may be called highly dense, if this number is more than one, 3-4 for example, the area is called anomalously dense.

Analyses of Resin Pellets

Resin pellets were classified and analyzed by human inspection with simple equipment, chemical analysis with Soxhlet's extractors, near infra red spectroscopy, surface heated FT-IR (Fourier Transform-Infra Red) Spectroscopy, and SIMS (Secondary Ion Mass Spectroscopy).

4. Results

4.1 Building the Informational Platform

We have surveyed wide range of environmental data related to environment pollutants from various sources. These sources are classified into three categories; (1) survey data conducted by some international organization such as WHO, UNEP and FAO or by international collaboration, (2) reports of surveys carried out by national governments, and (3) individual researchers study reports published or unpublished. References list some of these documents.

From this survey we found that data categories which are best provided are of aquatic that is such water pollution index as BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), and SS (Suspended Substances). We represented some of these data on a common map. Figure 1 shows BOD concentration over China, Korea, and Japan in the

common map. This map includes national borders, rivers, and administrative sectors. This map indicates that the BOD concentration is the highest at inland of China. Japan already succeeded in improving these pollution problems. Korea is in intermediate state.

For aquatic pollution there are other indicators such as phenols, Total Phosphorus (T-P), Total Nitrogen (T-N), Ammonium Nitrogen, Nitrate Nitrite. These chemicals have been used in fertilizers. However these fertilizers are different for rice fields and for wheat fields. In China rice fields are mostly in south while wheat are in North. It is interesting that these distinction of rice fields and wheat fields are clearly revealed in the differences of concentration of chemicals used in fertilizers for rice fields and that for wheat.

As for heavy metals such as lead, mercury and arsenic, and the so-called persistent organic pollutants (POPs), we found measurement data but many of them are under detection limits. We also found sediment pollutants data and biological monitoring data, but geographic location of the measurements sites of these data are so sparse that it is not so meaningful to represent them on maps.

One interesting finding is the data of DDT and its derivatives DDE and DDD from sediments. The data shows high concentration of DDT in Pearl Delta and its neighboring area and some other areas in China and Korea, while it is rare in Japan. Instead DDE and DDD concentrations are high in Japan. These findings suggest that DDT was once used in Japan but not used anymore so that those we found in the environment are its degraded derivatives, while in China or in Korea DDT are still used. This hypothesis is also supported by resin pellets findings, which is stated in the later part of this report.

We have also investigated data sets and information from Vietnam and Thailand. Several maps that represent environmental pollution were produced. These maps were put on our Web sites so that they can be retrieved by over sea researchers too.

4.2 Geographical Distribution of Resin Pellets

Environmental resin pellets were found in almost all coasts we have surveyed. Based on our own field survey and surveys and reports from our collaborators we concluded that almost all Nansei Islands where Kuroshio current flow from Taiwan to Kyushu are highly polluted by resin pellets. Highly concentrated sites were found in Yonaguni, Iriomote, Miyako, Mainland Okinawa, Amami Honto and Tanegashima. Resin pellets were also found in beaches of other islands such as Yoron, Okinoerabu and Yakushima. They are also found in Kagoshima and Goto Islands in Kyushu, and many other coasts in Japanese Islands. We also found them in northern Taiwan, Macau, Hong Kong, Xamen. Cheju Islands.

We called 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 and Amami Ohshima of

Kagoshima Prefecture, and highly accumulated sites in Motobu Peninsula in Okinawa Main Island and Miyako Island and in a beach in Shimane Prefecture. There are many accumulated sites all over Western Japan including isolated islands like Ogasawara.

Comparing to these high concentration Taiwan, Macau and Hong Kong, and Cheju Island concentration is relatively low. Their distribution is in lines not areal. We also surveyed Xiao Mei Sha (east of Shenzhen), Shanghai, Qing Dao, Pusan, Yosu, Mopo and islands near Inchon, but could find almost no pellets. Nevertheless we could find one or several pellets at some site of these places. This fact suggests that there are some possibilities that pellets are drifted onto these sites time by time. Our data were put into a simple table based database, by which detailed maps of distribution of resin pellets were made for each beach. The data and the maps can be seen at our Web Pages, PD Watchers.

4.3 Classification and Chemical Analysis of Pellets

Resin pellets can be classified according to their colors, claritys, sizes, shapes, material qualities, elasticities, and so on. If necessary one can put them into water or measure specific gravity using a gravimeter. Such rather subjective analysis can be checked by more reliable chemical component analysis. Resin pellets are classified first by their main chemical components which would be polyethylene (PE), polypropylene (PP), and EVA. These classifications were confirmed further by more detailed spectroscopy analysis by Opt Scan. These analyses however can not identify finer ingredients such as fine additives or surface contaminants. The analysis using GC/MS detected more fine ingredients and surface contaminants. Some environmental contaminants such as DDT, DDE, DDD, PCBs, HCHs, BHT (Butylhydroxytoluene), nonylphenol were thus identified. Na, Cl, and Ca ions were also identified by ion bombarding spectroscopy.

5. Discussion

Usefulness of Digital Map Systems

The information platform we have developed were used to represent various environmental pollutants in East Asia and Japan onto representation maps. These maps help researchers to cross view same contaminates over different countries and correlation among different pollutants with other environmental attributes. Since our system was developed on the Internet it can be accessed not only by domestic researchers and public but also by foreign researchers.

One important problem that should be resolved in the near future is to provide a standard digital map less than 1 to 1,000,000 scale 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. Unfortunately maps are sensitive matters

where political and regional conflicts exist. East Asia is such a region.

Resin Pellets can be used as Environmental Markers

The fact that we could identify some environment pollutants from surface of resin pellets suggests that we can consider these pellets as new environmental markers. Our analysis suggest that these contaminates seem to be identical to contaminates found neighboring sediments or water. Yet resin pellets are easier to handle and to analyze as environmental samples. Our study also suggests that if we can identify subfamilies of these pollutants we can get some hints on where the pellets come from. These may be considered as "finger printing" of resin pellets. Further studies are needed towards such research.

Origins and Pathways of Resin Pellets

Our study suggests that origin and transport roots of these pellets are classified into the following three cases; (1) pellets were spilled from some plastic user factories, transported via near rivers and drifted onto the neighboring beaches, (2) pellets were spilled from ships in the ocean or spilled during shipping or unloading at some harbor and drifted to some beaches in a mass, sometimes as a floating belt, and (3) pellets went into outer ocean and drifted long distance and reached remote islands. In the third category pellets often grow bryozoans on their surface that suggests they had been in the ocean for a long time.

Prevention of Spills

Though some environment pollutants were identified from resin pellets they can not yet be considered as hazardous materials for human health. Birds who have tendency to swallow pellets may be effected by these pollutants, but we could not proved this theory. Yet it is obvious that environmental resin pellets should be cleaned up from environment. Prevention is the most important and perhaps the only solution for this problem, and public awareness is the key for that. US EPA made a manual for preventing resin pellets spill into the environment. Essential part of this manual was translated into Japanese and disseminated by Japanese Plastic Association. Our study showed that prevention action was no yet so effective in Japan. However our study has evoked public interests in this problem. Already number of researchers, administrative sectors, and volunteers were interested in this problem and mass media often reported state of the art of our research and related topics

It should also be stressed that resin pellet problem is a borderless matter too, and public awareness should be cross-country and of international. The Internet/ WWW approach would be suitable for this purpose.

The Internet Home Page is a Useful Research Tool

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, students, and mass media, and thus greatly contributed to publicize the resin pellet problem. Unfortunately these pages are in Japanese. English version of these pages must be provided.

6. Conclusion

We have developed an informational platform by which data and information on environmental pollutants and hazardous chemicals in East China Sea and Northeastern Pacific rim are archived. The system consists of databases, WWW servers and geographic information systems. Based on the data sets collected from Japan, Korea, China, Vietnam, and Thailand we produced several maps that enable cross viewing pesticides and environmental pollutants over these countries. These maps clearly show some characteristic feature of hazardous chemicals distribution in the Northeastern Pacific rim including East China Sea. We made field survey for resin pellets at nearly 140 beaches and found that resin pellets can be found almost all of these seashores. This means that Resin pellets can be found almost all Japanese Island beaches and Northern Coast of Taiwan and Hong Kong and Macau area. Origin and transport roots of these pellets are suspected into the three categories. We have also identified several environment pollutants such as DDT, PCBs, and HCHs from the surface of these resin pellets. This means that they are good markers of environment pollutants. It was also proved that the Internet is a very useful tool for disseminating and collecting environmental data.

Acknowledgements

This research was carried out with close collaboration with Prof. H. Kanehiro of Tokyo Maine Production University, Prof. H. Takada, and Dr. N. Itoh of Asahi Chemicals Co. Resin pellets samples were collected with the help of many other collaborators including a volunteer organization, Japan Ecological Clean Up Organization and other individuals. We got resin pellet samples swallowed in birds from Prof. N. Hayama of Japan Veterinarian and Stock Breeding University. The analyses of pellets were carried out at Japan Frozen Foods Inc. Co. and Ulvac-Phi. Inc. We deeply thank for these collaborators. We also deeply thank to foreign researchers who kindly helped our field surveys, Dr. Manping Zhang of Graduate School of Ocean University of Qingdao, Dr. Kang Hun of Suwon University, Dr. Jin-Ae Lee, of INJE University and Dr. Pu Young Kim of KFDA.

References

1. H. Hong, W. Chen, L. Xu, X. Wang and L. Zhang, Distribution and Fate of Organochlorine Pollutants in the Pearl River Estuary, *Marine Pollution Bulletin* 39(1-12), 376-382, 1999
2. M. Kunugi, et al., Report of Studies on Movements of Hazardous Chemicals, *Global Environment Research Fund*, 60-64, 1999
3. Japan Plastics Industry Federation, *A Manual on Preventing Resin Pellet Spills*, 1993

6. Japan Environment Agency, Water Quality Monitoring data,1997, MO version.
7. M. Matsuda et. al., Environ. Chem., 4(2),576-577,1994
8. M. Matsuda et al., Environ. Chem., 5(2),420-4217,1995
9. Environmental Health and Safety Division, Environment Agency, Chemicals and The Environment, 1989-1997
<http://www.eic.or.jp/eanet/kurohon/>
10. Wu, Y., Zhang, J., and Zhou, Q., Persistent organochlorine residues in sediments from Chinese river/estuary systems, Environmental Pollution, 100,1-8,1998
11. PD Watchers Home Page
<http://www.nihs.go.jp/pdw/index.html>

Publications

1. T. Kaminuma and C. Ohtake, Environmental Monitoring Data in Global Information Network on Chemicals, GINC, Papers on Environmental Information of Science, 10, 85-90,1996
2. T. Kaminuma, C. Ohtake and N. Ito, Building Surveillance Network System of Plastic Debris as Marine Polluants, Papers on Environmental Information Science, 11,165-170,1997
3. C. Ohtake, T. Kaminuma et al., Classification and Analysis of compound of plastic resin pellets washed up on the beaches, Proceedings of The 7th Japan Society for Environmental Chemistry, 316-317,1998
4. T. Kaminuma , C. Ohtake et al., Distribution and Characteristic of Resin Pellets as Marine Pollutants, Proceedings of Society of Environmental Science, Japan,4-5,1998
5. C. Ohtake, T. Kaminuma et al., Classification and Analysis of compound of plastic resin pellets washed up on the beaches 2, Proceedings of Society of Environmental Science, Japan, 2-3 ,1998
6. T. Kaminuma, A Global Information Network for Chemical Safety and GIS、 International Workshop of Lake Baykal, Shinyokohama Nov. 1998
7. C. Ohtake, T. Kaminuma et al., Classification and analysis of compound of plastic resin pellets washed up on the beaches and found in the birds, 3, Proceedings of Society of Environmental Science, Japan,40-41, 1999
8. C. Ohtake, N. Kabuyama and T. Kaminuma, Map Representation Aquatic Pollution In East Asia, Proceedings of 25th Symposium on Toxicology and Environmental Health/3rd Forum on Pharmaceutical Health Science,58,1999
9. Y. Mato, H. Takada C. Ohtake et al. Resin Pellets as Transport Media of Pollutants in the Marine Environment 1, Proceedings of The 8th Japan Society for Environmental Chemistry, 46-57,1999
10. C. Ohtake, T. Kaminuma et al., Classification and analysis of compound of plastic resin pellets washed up on the beaches 4, Proceedings of The 9th Japan Society for Environmental Chemistry, in printing,2000

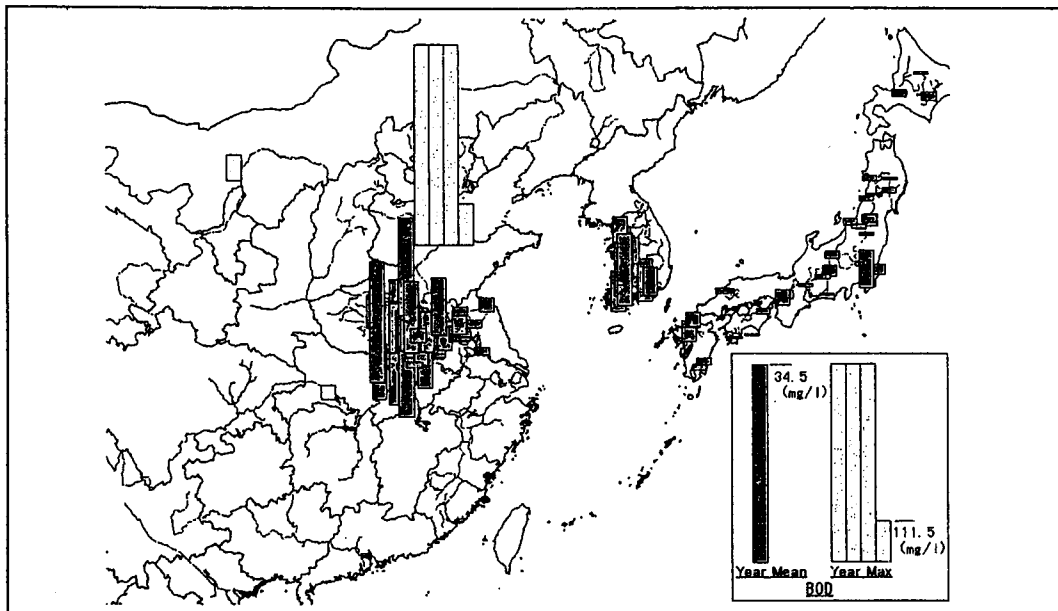


Fig.1. BOD Concentration of Rivers in China, Korea and Japan
 China: reference 4. Korea: reference 5. Japan: reference 6.

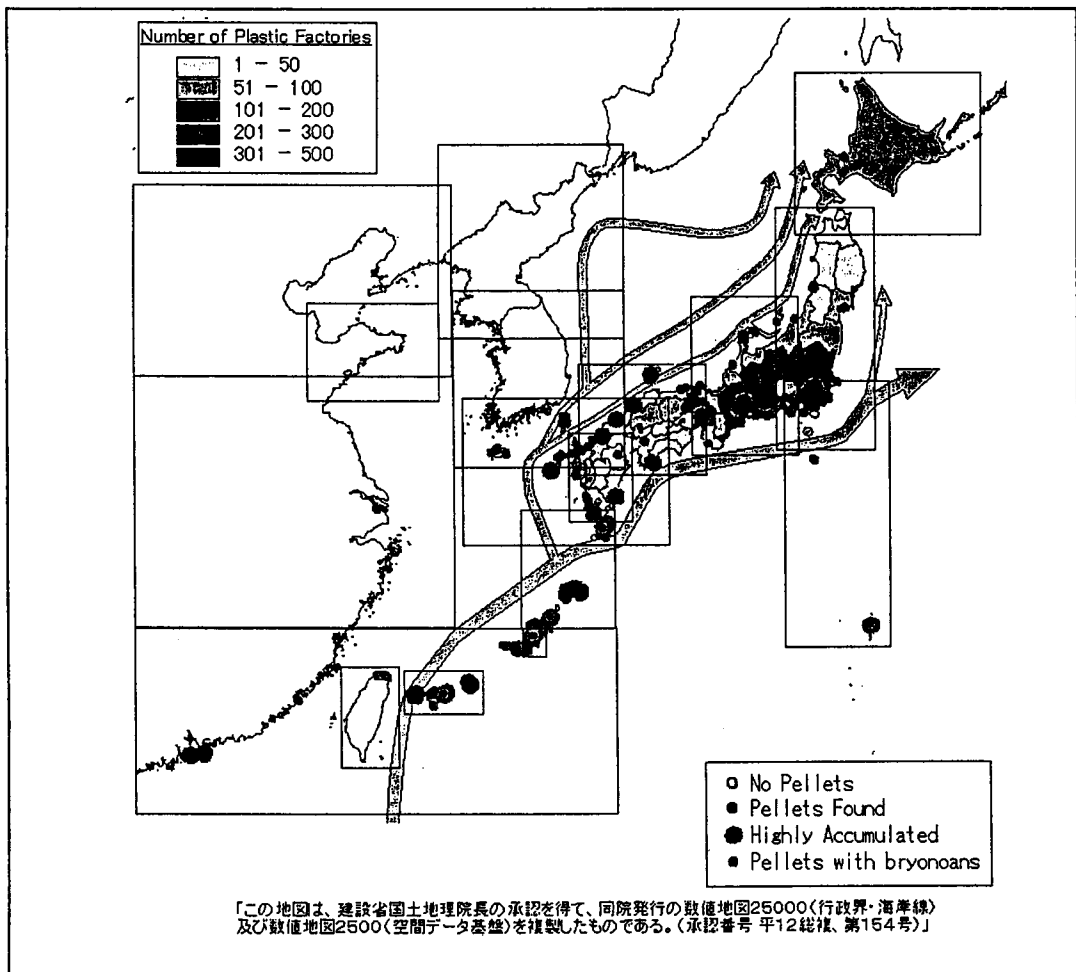


Fig.2. 1 Distribution map of pellets at the beaches of Japan and neighboring countries coasts
 Pellets were found on most beaches in Japan and neighboring countries.
 The number of pellets was more than 1000 per m² on the highest beach with the concentration of pellets in Japan. Only a few beaches have no pellets. ●: Abundant, ∙: Found, ○: Not found