UNEP

IMO

NOWPAP MERRAC

Northwest Pacific Action Plan
Marine Environmental Emergency Preparedness and Response
Regional Activity Centre

P.O. Box 23, Yuseong, Daejeon 305-600, Republic of Korea
(c/o MOERI/KORDI)
Tel: (+82-42) 868-7214, FAX: (+82-42) 868-7268
E-mail: nowpap@moeri.re.kr
Website: http://merrac.nowpap.org

Marine Litter Management :

The approach of Incheon City, Republic of Korea

Regional Seas

NOWPAP MERRAC

Northwest Pacific Action Plan
Marine Environmental Emergency Preparedness and Response
Regional Activity Centre

P.O. Box 23, Yuseong, Daejeon 305-600, Republic of Korea
(c/o MOERI/KORDI)
Tel: (+82-42) 868-7214, FAX: (+82-42) 868-7268
E-mail: nowpap@moeri.re.kr
Website: http://merrac.nowpap.org

Marine Litter Management : The approach of Incheon City, Republic of Korea

Regional Seas

The document was prepared by the Marine Environmental Emergency Preparedness and Response Regional Activity Centre of the Northwest Pacific Action Plan (NOWPAP MERRAC) as part of the Northwest Pacific Action Plan (NOWPAP) Marine Litter Activity (MALITA) which has been initiated since its approval at the Tenth NOWPAP Intergovernmental Meeting (Toyama, Japan, November 2005). The following individuals contributed to writing various drafts of the document and to the overall editing of the document: Ms. Hyon-Jeong NOH, Dr. Seong-Gil KANG and Dr. Jeong-Hwan OH of NOWPAP MERRAC. The document was edited by Ms. Nikki Meith, publications and website consultant. The draft document was circulated to the Incheon Metropolitan City, Ministry of Land, Transport and Maritime Affairs (formerly Ministry of Maritime Affairs and Fisheries) of Republic of Korea, NOWPAP Regional Coordinating Unit (RCU), and then revised according to the comments that were received.

ISBN 978-89-959219-2-0 93650

Published in 2008
by NOWPAP MERRAC
P.O.Box 23, Yuseong, Daejeon 305-600, Republic of Korea

For bibliographical purposes, this document may be cited as:
NOWPAP MERRAC 2008: Marine Litter Management:
The approach of Incheon City, Republic of Korea

FOREWORD

Marine litter problem is now recognized by national, regional and global level because it destroys the ecological, economic, cultural, recreational and aesthetic values of the marine and coastal environment. In acknowledging the problems imposed by marine litter in the Northwest Pacific region, the NOWPAP Member states – People's Republic of China, Japan, Republic of Korea, and Russian Federation– have initiated various activities and/or projects related to marine litter issue within the NOWPAP framework.

As a road map to deal with marine litter problems in the NOWPAP region, the project proposal on the Marine Litter Activity (MALITA) was approved by the Tenth NOWPAP Intergovernmental Meeting in November 2005. MERRAC has been designated to cover marine litter from sea-based sources with close cooperation with United Nations Environment Programme (UNEP), International Maritime Organization (IMO), NOWPAP Regional Coordinating Unit (RCU), other NOWPAP Regional Activity Centres (RACs) and NOWPAP Marine Litter Focal Points.

During the implementation of MALITA, it was suggested to share information on marine litter management in the Incheon Metropolitan City, Republic of Korea, with other NOWPAP member states as a case study. It is hoped that this document will serve as an example to other cities, nations, and regions, and thus contribute to improving the global ocean environment.

Seong-Gil Kang
Director of NOWPAP MERRAC

ACKNOWLEDGEMENTS

None of this would have been possible without the generous help of many people, organizations, and governments. The authors would like to thank all the people who have contributed review, comments, and remarks.

The contents of the document based on the reports provided by Incheon Metropolitan City and Ministry of Land, Transport and Maritime Affairs (MLTM), former Ministry of Maritime Affairs and Fisheries (MOMAF) of the Republic of Korea. We are grateful to the Incheon Metropolitan City, MLTM and other organizations and institutes in the Republic of Korea.

This work is supported by Northwest Pacific Action Plan (NOWPAP), part of UNEP Regional Seas Programme, within the framework of NOWPAP Marine Litter Activity (MALITA). Lastly, we would like to express our thanks to KORDI/MOERI for their technical contribution and support.

Korea Ocean Research & Development Institute

Table of Contents

Section 1: Introduction

It is difficult to over-state the importance of the marine and coastal environment to the people of the Northwest Pacific region. It shelters innumerable species of marine organisms, provides economic resources for fisheries and harbour industries, supports local economies through tourism, and is a source of recreation and aesthetic values for local residents.

Throughout the world, there has been an upsurge of marine pollution due to rapid industrialization, uncontrolled development and the continued expansion of human populations in coastal areas. The result is an accelerating flood of pollutants into the marine and coastal environment. Marine litter is considered as one of pollution that destroys the marine environment.

According to the United Nations Environment Programme (UNEP), marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of (1) items that have been made or used by people and deliberately discarded into seas or on beaches; (2) items carried indirectly to the sea by rivers, sewage, storm water or winds; (3) items accidentally lost, including material lost at sea in bad weather such as fishing gear and cargo; or (4) items deliberately left by people on beaches and shores (UNEP, 2005).

Marine litter has many sources, which can be categorized generally as land-based and sea-based (UNEP, 2005).

Marine litter is generated by various **land-based** activities and carried out to sea via rivers and streams. During storms and floods, many items enter the sea; for example, plastic, glass, metal, wood, rubber, and synthetic pellets.

Similarly, **sea-based** marine litter has many sources. Fishing fleets are a major culprit, discarding ropes, fishing nets, buoys, plastics, metal, glass, wood and other items. Abandoned, lost, and derelict fishing gear is a significant and very persistent form of marine litter.

The known sources of marine litter are listed in Table 1.

Table 1. Sources of marine litter (modified from UNEP, 2005)

Sea-based sources of marine litter	Land-based sources of marine litter
• Merchant shipping, ferries and cruise liners • Fishing vessels • Military fleets and research vessels • Pleasure craft • Offshore oil and gas platforms • Aquaculture installations • Waterway recreational activities (diving and marinas)	• Municipal landfills (waste dumps) located on the coast • Riverine transport of waste from landfills or other sources along rivers and other inland waterways (canals) • Discharge of untreated municipal sewage and storm water (including occasional overflows) • Industrial facilities (solid waste from landfills and untreated water) • Tourism (recreational visitors to the coast and beach goers)

Marine litter can cause injury and/or death to humans as well as wildlife. It threatens marine biodiversity, destroys habitats, and helps to disperse invasive species. This results in great economic costs and spoils the beauty of the seas and the coastal zone.

Growing concern about marine litter has led governments and organizations to take action at the local, national, regional and global levels, from passing legislation to launching public awareness campaigns such as beach cleanups.

The Northwest Pacific region has implemented Northwest Pacific Action Plan (NOWPAP) to manage overall issues related to the marine and coastal environment. The Action Plan was adopted in 1994 by the four Member States, namely the People's Republic of China, Japan, the Republic of Korea and the Russian Federation. It is a part of the UNEP Regional Seas Programme, a platform of cooperation and coordination for activities related to the protection and restoration of the marine and coastal environment.

NOWPAP is addressing the problem of marine litter through the formulation and implementation of a Regional Action Plan on Marine Litter (RAP MALI). RAP MALI is the major outcome of the NOWPAP project on marine litter in the Northwest Pacific region, known as Marine Litter Activity (MALITA), which was approved at the Tenth NOWPAP Intergovernmental Meeting held in Toyama, Japan on 24-26 November 2005.

Incheon is a coastal city in the vicinity of Seoul, the capital of the Republic of Korea. Incheon faces serious marine litter problems due to increasing industrial activities and population growth. Enormous amounts of domestic and industrial waste and other pollutants are discharged into the sea, directly or indirectly. A great deal of litter enters the sea via the Han River, which is the main channel to the coast near Incheon.

The resulting degradation of the marine and coastal environment has reached a level where the health of human beings and wildlife is threatened by the accumulation of pollutants, including litter. As a result, Incheon has suffered from economic losses, and decreased tourism and recreational activities due to ecological alterations and marine species decline.

The Incheon City, in co-operation with the central Korean Government, Ministry of Land, Transport and Maritime Affairs (MLTM), former Ministry of Maritime Affairs and Fisheries (MOMAF), tried to solve these problems through several efforts. These included applying an advanced ocean cleaning vessel to collect marine litter, encouraging fishermen to bring marine litter to a designated place, and installing a trash boom at the Han River mouth to prevent litter entering the sea.

As one of the MALITA activities, the 1st NOWPAP Workshop on Marine Litter was held in June 2006 (Incheon, Republic of Korea) to exchange information on marine litter management. During a field trip, participants were introduced to several exemplary management techniques employed by Incheon City, including a thermal volume reduction system, a purchasing programme known as the Korean Buyback Programme, and various management practices in Incheon coastal waters.

Consequently, at the 1st MALITA Working Meeting, back-to-back with the 1st NOWPAP Workshop on Marine Litter, it was agreed to publish the document, *Marine Litter Management: The approach of Incheon City, Republic of Korea.*

The document provides several examples of marine litter management in Incheon, i.e., surveying, collecting and handling marine litter, and fundraising for those activities. Also included are public education and awareness-raising campaigns.

The objective of this document is to share a successful example of marine litter management among the NOWPAP member states and with partners outside the region, and to help to create a foundation for further co-operation with the NOWPAP member states for marine litter management in the NOWPAP region.

Section 2: Geography of Incheon coastal waters

Location and climate

Incheon City is located at the western coastal area of Republic of Korea (126°37´E, 37°28´N) abutting on the Yellow Sea (Figure 1), and is situated adjacent to Seoul, the capital of Korea.

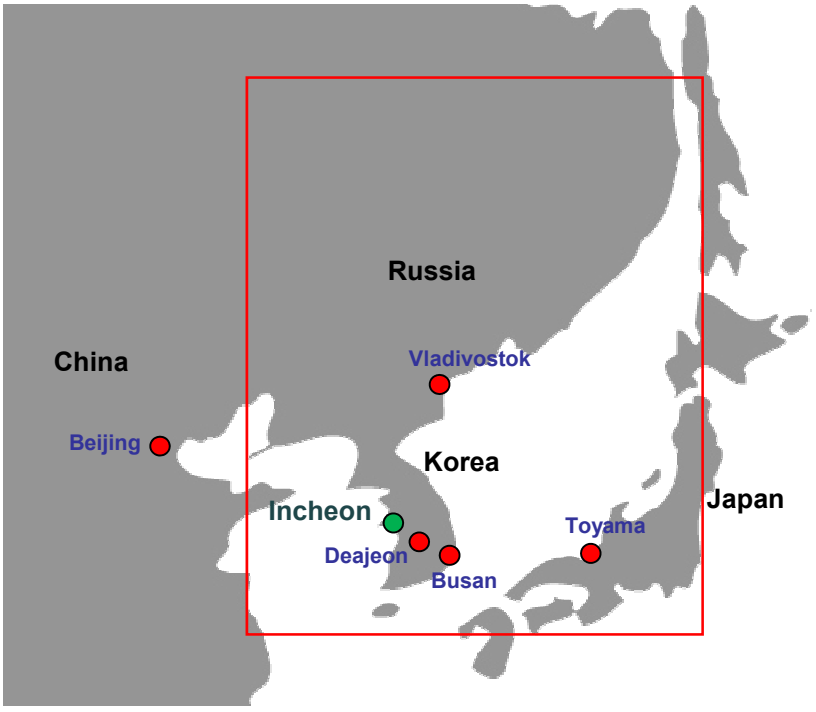


Figure 1. Location of Incheon City, Republic of Korea, where as a red square is the NOWPAP region.

The Incheon area is influenced by a monsoon climate. As a result, there is strong seasonal wind, from the northwest in winter and southwest in summer. According to the Incheon Metropolitan City website (http://www.incheon.go.kr), the average annual temperature is around 11°C, the average minimum for January is around 0°C, and the average maximum temperature for August is around 25°C.

Area, population and local economy

According to the Incheon City, the current administrative unit covers a total area of 986.45 km², or 0.98% of the Republic of Korea. As of September 2005, the city has a total population of 2,628,000, which is 5% of the total population of the Republic of Korea. Incheon coastal waters serve 20 million residents of Incheon, Seoul, and Gyeong-gi Province located in the central part of Korean Peninsular (Figure 2).

Figure 2. The location of Incheon, Seoul and Gyeong-gi Province.

Incheon is now rapidly developing into the third largest city in the Republic of Korea. The local GNP (Gross National Products) for Incheon is about 25,000 billion won (about US$25,000 million), 4.7% of the national GNP. More than 1.2 million people of Incheon City are participating in various economic activities. Incheon displays an urban-type industrial structure, which is characterized by a tertiary industrial sector larger than either the primary or secondary sectors. There are seven industrial complexes in Incheon City, which host more than 7,400 companies.

Incheon coastal waters

Incheon coastal waters cover from 125°50´E to 128°00´E longitude and from 37°00´N to 38°00´N latitude. The area is semi-enclosed, with 155 islands of which 113 are inhabited. The coastal zone is under the jurisdiction of the Incheon City and covers about 500,000 ha influenced by the Han River.

The Han River runs from Seoul and Gyeong-gi Province through Incheon to the Yellow Sea, and is fed by several small tributaries (Figure 2). Due to the narrowness of the waterway and a rapid tidal current, fine sediments transported by the river have accumulated to create an immense shallow tidal flat which offers an excellent habitat for many aquatic species.

According to the Incheon tidal wetland website (http://wetland.incheon.go.kr), the length of the coastline is about 855 km, although it is getting shorter as the coastline is smoothed by landfills and reclamation (Figure 3).

Seawater quality is affected by coastal industrial complexes and other land-based influences. Rapid industrialization and development around Seoul and Gyeong-gi Province have brought serious environmental destruction.

<1990> <1998> <2005>

Figure 3. Topographical changes of the Incheon coastal.

Section 3: Past status of marine litter in Incheon coastal waters

3.1. Background

In 2001 the Incheon City launched an investigation of the status of marine litter in Incheon coastal waters, with a view to litter collection and treatment as part of an integrated management system for marine litter (Incheon Metropolitan City, 2001).

The investigation, “Current status of marine litter for collection and treatment in Incheon Coastal Waters,” was conducted from April 2001 to December 2001 by the Korea Ocean Research & Development Institute (KORDI)/Marine and Ocean Engineering Research Institute (MOERI), as a project of the MOMAF of the Korean Government.

The objectives of this research were to examine marine litter in a coastal area of approximately 500,000 ha, at the sea surface, in the water column and on the seabed; to identify priority areas of highest contamination; and above all, to establish a management programme for collection and treatment of marine litter (Figure 4). The results became the foundation for management of marine litter.

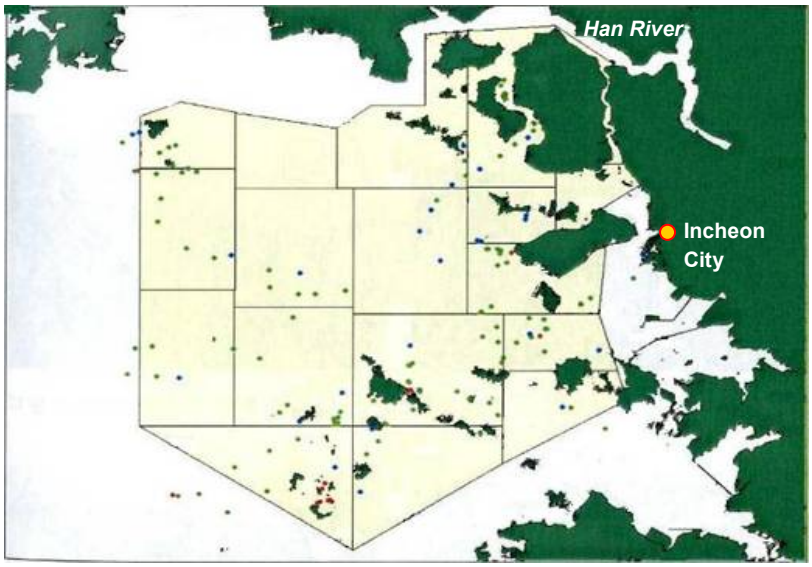


Figure 4. Incheon coastal waters surveyed in 2001 (Incheon Metropolitan City, 2001).

3.2. Floating litter

Floating litter in Incheon coastal waters

As one of investigation in 2001, floating litter was collected from 41 sites using a rectangular net (3m x 20m x 1m) for 30 minutes at a speed of 1.5 knots from 30 October 2001 to 4 November 2001.

The amount of litter collected decreased with distance from the Han River mouth, suggesting that most floating litter in Incheon coastal waters is carried by the river.

Most of floating litter was wood (more than 50%), vinyl (40%), and plastics (4%). A great deal of domestic litter – primarily household items – was collected at the sites, most of which originated from the Han River (Figures 5, 6, 7, 8, 9 and 10).

Floating litter from the Han River

According to the survey, about 26,310 tonnes of floating litter entered Incheon coastal waters in 2001. Assuming that the density of litter was 7.27 m^3/ton and homogenous, the estimated amount of floating litter transported by the Han River was about 191,273 m^3. The annual input of floating litter into Incheon coastal waters from the Han River is summarized in Table 2 (Incheon Metropolitan City, 2001).

In Table 3, the data is divided into three periods, based on the report in 1998-2000 from the Korea Meteorological Administration (KMA) i.e., normal season, rainy season (July and August) and flood season (14 days among the rainy season).

During the normal season, the composition of collected floating litter was, in order of abundance: 46,508 m^3 of vinyl and plastics (63.6%), 10,050 m^3 of wood (13.7%), 5,848 m^3 of styrofoam (8.0%), 4,674 m^3 of rubber (6.4%), and 3,739 m^3 of fishing nets (5.1%).

During the rainy season, the order changed to 42,372 m^3 of wood (76.2%), followed by 5,068 m^3 of vinyl and plastics (9.1%) and 3,308 m^3 of fishing nets (5.9%).

Table 2. Annual input of floating litter into Incheon coastal waters from the Han River (Incheon Metropolitan City, 2001)

Composition	Total	Vinyl and plastics	Fishing nets	Bottles	Rubber	Styrofoam	Wood	Others
Volume (m^3)	191,273	52,059	7,047	3,375	6,633	8,001	106,059	8,099
Percentage (%)	100.0	27.2	3.7	1.8	3.5	4.2	55.4	4.2

Table 3. Types and amounts of land-based marine litter carried to the sea by the Han River depending on seasons (Incheon Metropolitan City, 2001)

Season / Type	Normal season (305 days)		Rainy season (46 days)		Flood season (14 days)		Total	
	Volume (m^3)	Percentage (%)	Volume (m^3)	Percentage (%)	Volume (m^3)	Percentage (%)	Volume (m^3)	Percentage (%)
Vinyl and plastics	46,508	63.6	5,068	9.1	483	0.8	52.059	27.2
Fishing nets	3,739	5.1	3,308	5.9	-	-	7,047	3.7
Bottles	2,337	3.2	1,038	1.9	-	-	3,375	1.8
Rubber	4,674	6.4	1,669	3.0	290	0.5	6,633	3.5
Styrofoam	5,843	8.0	2,158	3.9	-	-	8,001	4.2
Wood	10,050	13.7	42,372	76.2	53,637	85.8	106,059	55.4
Others		-	-	-	8,099	12.9	8,099	4.2
Total	73,151	100	55,613	100	62,509	100	191,273	100

Figure 5. Marine litter on the beach at Gyodong, Gangwha Island, Inchen City (1999).

Figure 6. Marine litter on the beach at Sudo, Gangwha Island, Incheon City (1999).

Figure 7. Land-based marine litter from the river at Gilsang, Gangwha Island, Incheon City (2001).

Figure 8. Construction debris at the 2nd Gangwha Bridge, Incheon City (2001).

Figure 9. Marine litter at the 2nd Gangwha Bridge, Incheon City (1997).

Figure 10. A 30-year-old plastic bag collected from the Incheon coastal water (2003).

3.3. Deposited Litter

Survey using Side Scan Sonar (SSS)

The survey employed trawls and Side Scan Sonar to examine the seabed of the Incheon coastal waters (Figures 11, 12 and 13). It found an estimated 97,000 tonnes, or 194,000 m^3 of marine litter (Kang, 2004).

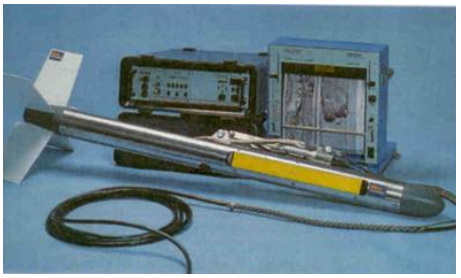


Figure 11. Picture of Side Scan Sonar.

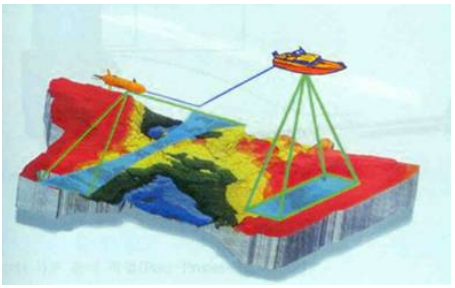


Figure 12. Diagram of survey using Side Scan Sonar.

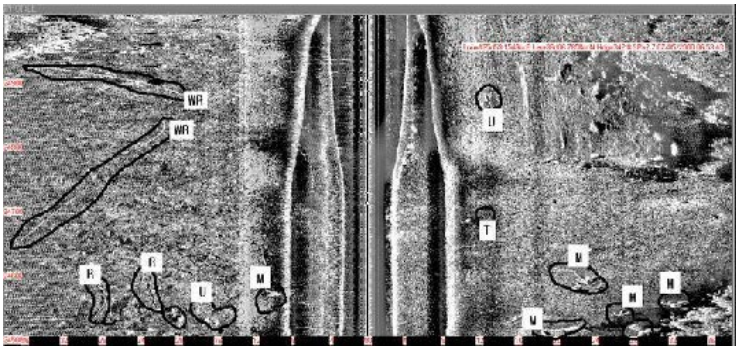


Figure 13. Diagram of the seabed scan using Side Scan Sonar, where WR is wire ropes, R is rope, M is metal, T is tire and others (U).

Distribution of deposited litter

Trawl surveys were carried out over the Incheon coastal area in July 2001 (Figure 14). A total of 726,638 m^2 and 7,049 kg of deposited marine litter was collected. The amount of deposited marine litter varied widely among the study sites.

The trawls collected 190 kg of land-based litter. Wood represented highest percentage of land-based litter (31.0%), followed by vinyl (16.9%), fiber (16.7%), rubber (10.5%), etc. Much of the wood was collected at the site nearest the Han River, and seemed to be associated with the flood season (Table 4).

On the other hand, 6,859 kg of sea-based marine litter were collected which consisted of fishing nets (57.7%), wire (35.5%), miscellaneous materials (2.9%), and ropes (2.0%) shown in Table 5 (Figure 15).

Figure 14. Collecting marine litter from the seabed.

Figure 15. Marine litter collected from the seabed.

Table 4. Amount and type of marine litter from land-based sources in Incheon coastal waters, based on trawl sampling (Kang, 2004)

Type	Weight (kg)	Percentage (%)
Plastic	11.03	5.8
Vinyl	32.05	16.9
Styrofoam	0.0	0.0
Glass	12.42	6.6
Metal	4.83	2.5
Wood	58.74	31.0
Paper	0.10	0.1
Fiber	31.72	16.7
Leather	0.15	0.1
Refuse rubber	19.96	10.5
Others	18.59	9.8
Total	189.59	100

Table 5. Amount and type of marine litter from sea-based sources in Incheon coastal waters, based on trawl sampling (Kang, 2004)

Type	Weight (kg)	Percentage (%)
Refuse nets	3956.41	57.7
Ropes	136.30	2.0
Wire	2431.42	35.5
Refuse rubber	17.93	0.3
Refuse tire	65.0	0.9
Styrofoam	30.0	0.4
Wood	9.31	0.1
Metal	14.52	0.2
Others	198.14	2.9
Total	6859.03	100

Section 4: Cost-sharing programme for Han River Basin Marine Litter Management

4.1. Background

The Han River serves the populations of Incheon City, Seoul and Gyeong-gi Province (Figure 2). Incheon coastal waters have been exposed to marine pollution for many years, resulting in environmental, ecological and economic problems. The Han River is regarded as a major source of this pollution. From 1997 to 2000, discussions and negotiations between three local governments were held to determine financial arrangements for long-term marine litter management in Incheon coastal waters.

In 2001, the Incheon City investigated the effects of pollutants originating from Incheon, Seoul and Gyeong-gi Province, respectively, and discussed countermeasures and funding arrangements. Based on the 2001 survey results and in response to the initiatives of the Incheon City, the three local governments agreed that the cost for marine environment management should be shared.

4.2. Pollutants originating from Incheon, Seoul and Gyeong-gi

Sources of pollutants

An investigation of the sources of pollutants entering the Incheon coastal waters allowed the Incheon City to evaluate respective responsibilities of the three governments.

The sources can be categorized as (1) direct from land, (2) from the Han River and (3) from the Siwha Reservoir (see Figure 2).

The BOD (Biological Oxygen Demand) load from the Han River and Siwha Reservoir are 153,055 kg/day (65%) and 59,769 kg/day (25%), respectively (Figure 16 and Table 6). Total nitrogen (TN) and total phosphorus (TP) loads show similar patterns (Figure 17 and 18).

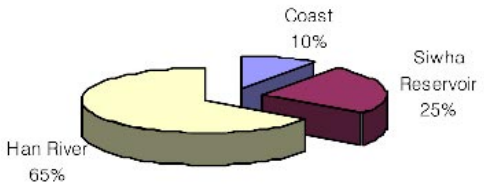


Figure 16. Percentage of BOD load by source.

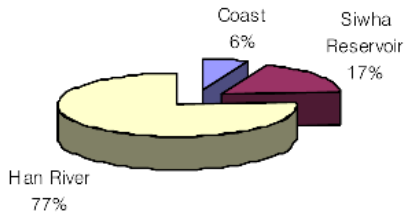


Figure 17. Percentage of total nitrogen (TN) load by source.

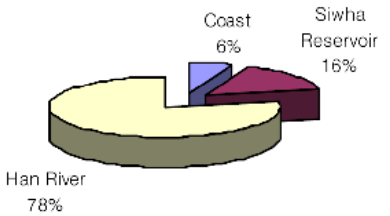


Figure 18. Percentage of total phosphorus (TP) load by source.

Table 6. Discharge loads from three sources (Incheon Metropolitan City, 2006)

Sources	BOD load (kg/day)	TN load (kg/day)	TP load (kg/day)
Han River	153,055	134,239	16,968
Coastal region	23,445	10,606	1,319
Siwha Reservoir	59,769	30,558	3,485

Discharge load by administrative district

The discharge load for each administrative district was estimated (Table 7). BOD load from Gyeong-gi Province, Seoul, and Siwha Reservoir are 44%, 23%, and 20%, respectively (Figure 19). For TN load, the proportional inputs are 39% for Gyeong-gi Province, 25% for Seoul, and 12% for Siwha Reservoir (Figure 20). For TP load, the proportions are 55% for Gyeong-gi Province, 22% for Seoul, and 14% for Siwha Reservoir (Figure 21). The BOD load for Incheon is 4,603.23 kg/day (2% of total load), a smaller contribution compared to other sources. TN and TP values for Incheon are also relatively small.

These results suggest that most of the pollution of Incheon coastal waters is not generated by Incheon itself.

Table 7. Contaminant discharge load of each administrative district (kg/day).

		BOD load	TN load	TP load
Incheon	Sea	17,953.60	7.462.60	926.00
	Han River	5,228.54	1,853.32	231.57
	Total	23,182.14	9,315.92	1,157.57
Gyeong-gi	Siwha & Ansan sewage disposal plant	2,997.60	1,369.10	173.70
	Han River	124,624.61	99,196.04	13,749.16
	Gimpo	2,493.50	1,774.20	219.40
	Total	130,115.71	102,339.34	14,142.26
Seoul	Han River	68,258.79	65,874.27	5,548.24
MLTM	Siwha Reservoir	59,769.00	30,558.00	3,485.00
Paldang	Paldang Dam	13,828.32	54,031.02	1,231.98
Total		295,153.96	262,118.55	25,565.05

(Incheon Metropolitan City, 2006)

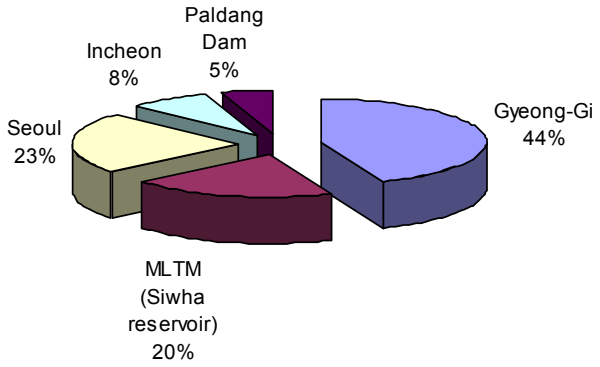


Figure 19. Percentage share of biological oxygen demand (BOD) load.

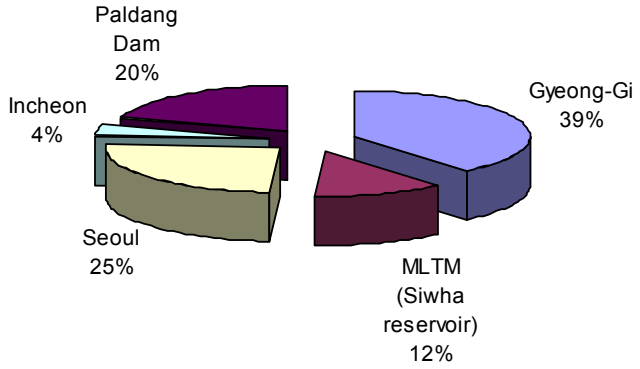


Figure 20. Percentage share of total nitrogen (TN) load.

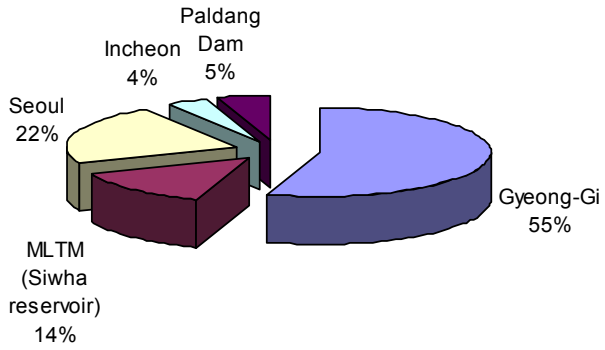


Figure 21. Percentage share of total phosphorus (TP) load.

4.3. Cost-sharing factors for improvement of Incheon coastal waters

To calculate the cost-sharing factors between the three municipalities, two principles were considered, i.e., the polluter-pays principle and the beneficiary-pays principles.

Factor 1: The Polluter-Pays Principle

The Polluter Pays Principle (PPP) holds those who create the environmental problem responsible and requires them to pay for the damage caused. The three local governments agreed that environmental problems of Incheon coastal waters are caused by pollutants from the Han River watershed and the long history of industrial activities.

Based on the research results described above, Incheon, Seoul and Gyeong-gi Province have worked together over the many years in an effort to calculate their respective financial contributions, basing their calculations equally on two factors: population data and drainage basin area (potential pollutant production rate, Incheon Metropolitan City, 2006).

Factor 2: The Beneficiary-Pays Principle

The Beneficiary-Pays Principle (BPP) holds that whoever benefits from a cleaner environment should bear the costs of pollution control. It is often used for resolving local conflicts, and is aimed at seeking an equitable agreement among interested parties on a reasonable cost-sharing programme.

Incheon is considered a direct beneficiary of short-term management, and the greater National Capital region will benefit indirectly from improvement of the coastal and marine environment brought about by long-term management (Incheon Metropolitan City, 2006).

Table 8. Example of cost-sharing for improvement in Incheon coastal waters.

Government share (C_1)		Joint share (C_2)	
		Polluter	
Central Government	Incheon City	Direct beneficiary (Incheon City)	Indirect beneficiary (Joint share)

Estimation of relative contributions

There are two methods for calculating the pollution contribution of the three governments.

Method 1 calculates the cost-share rate based on population in the watershed (50%) and BOD load (50%). According to this calculation, Seoul assumes responsibility for a relatively high proportion – 35% – of the management expenses (Figure 22).

Method 2 distributes costs according to drainage basin area (potential pollutant production rate, 50%) and BOD load (50%). According to Method 2, Seoul's contribution drops to 19%. The value for Gyeong-gi Province, which has the largest drainage area, rises to 39% while Incheon's share is more-or-less 42% (Figure 23).

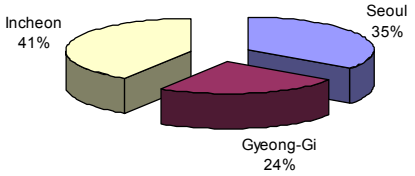


Figure 22. Cost-sharing rate according to Method 1.

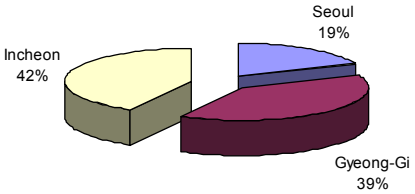


Figure 23. Cost-sharing rate according to Method 2.

Weight by cost-sharing factor

The three local governments held several meetings to determine the respective values of the two weighted factors, beneficiary-pays (α) and polluter-pays (β), for long-term management. The polluter factor (β) was determined to be the primary cost-sharing index for improving seawater quality in Incheon coastal waters based on the Polluter Pays Principle. The governments finally agreed on a factor of **0.3 for α** and **0.7 for β**, as shown in Table 9 (Incheon Metropolitan City, 2006). Because Incheon is a primary beneficiary, a factor of 0.3 (α) is charged for Incheon. Regarding the 0.7 (β), a combination of method 1 and method 2 was used to calculate the relative contribution of the three municipalities.

Table 9. Weighted values by the principles of cost-sharing for the improvement in Incheon coastal waters

	Beneficiary-pays (α)	Polluter-pays (β)
Weight	0.3	0.7

In this reason, Incheon would contribute 50.2% (US$2.5 million), Gyeong-gi Province, 27% (US$1.3 million), and Seoul, 22.8% (US$1.1 million) of an annual budget of US$5.0 million (Incheon Metropolitan City, 2006).

4.4. Cost-sharing agreement

The cost-sharing agreement for litter management in Incheon coastal waters agreed by the three governments reads as follows:

- **Subject**

  The cost-sharing agreement for litter management in Incheon coastal waters.

- **History and background**

  This agreement was established for sharing the expenditure for litter management in Incheon coastal waters and the Han River watershed in April 2001.

- **Subject of the project**

  The litter management project is based on a joint research in 1999 with five local governments – Seoul, Incheon City, Gyeong-gi Province, Kangwon Province, Chungcheongbuk Province – titled 'Cost-sharing research for water quality management in the Han River watershed'. It covers the investigation of marine litter distribution, litter removal and disposal, and management of the cleaning vessel.

- **Project period**

  2002 – 2006.

- **Project expenses**

  Total disbursement for the project in Incheon coastal waters is 25 billion won (about US$25 million) for a five-year period (2002 – 2006).

- **Cost-sharing rate**

  Based on the results of research, the cost-sharing rate for the project agreed at the convention of 12th Administrative Commission is as follows: 22.8% for Seoul, 50.2% for Incheon, and 27.0% for Gyeong-gi Province.

4.5. Agreement for 2007-2011

The cost-sharing agreement for litter management in Incheon coastal waters was established in 2001 by local governments (Incheon, Seoul and Gyeong-gi Province) for a period of five years (2002-2006).

At the 2007 meeting in February of the cost-sharing programme, the three local governments approved an extension of the agreement for another five years (2007-2011), with a total budget of 27.5 billion won (about US$27.5 million). Moreover, the Korean Government, Ministry of Land, Transport and Maritime Affairs (MLTM), and Ministry of Environment decided to provide support for this programme.

4.6. Conclusions

Necessary budget was raised through the cost-sharing programme for marine litter management, such as purchasing programme (section 5), trash boom (section 6), and collection of marine litter (section 7).

The agreement of the three governments to continue funding of their cost-sharing programme illustrates their confidence in the fairness and effectiveness of the programme, as well as their willingness to accept responsibility for the preservation of Incheon coastal waters.

Section 5: Purchasing programme for marine litter in Incheon City

5.1. Background

The purchasing programme ("Buy Back Programme") for marine litter requires fishermen to bring back the collected litter when they are fishing, such as worthless fishery-related marine litter i.e., rope, net and vinyl (Figure 24). This programme is not only an efficient and cost-effective way to collect marine litter, but it also increases the fishermen's awareness of the destructiveness of such litter to the marine environment. Another benefit of the programme is that it also brings fishermen some extra income.

This programme was developed by the Ministry of Land, Transport and Maritime Affairs (MLTM), and successfully implemented by Incheon City as well as other local governments in Korea (NOWPAP MERRAC, 2006).

Figure 24. A boat that was wrapped by ropes around the propeller (Photo from the Ocean Conservancy).

The main objectives of the purchasing programmes are to improve the marine environment and aid the recovery of fish populations.
When fishermen pull up such wastes as fishing nets, they generally toss them overboard. Without incentives, they hardly bring them into port.

As a result, a great deal of fishery-related marine litter has been deposited in coastal areas where they damage the spawning grounds and habitats of marine wildlife, threaten the safety of vessels and impact fishery operations and resources.

For this reason, the Korean government established the purchasing programme, under which the local government purchases the litter pulled up by fishing boats and disposes of it under proper procedures.

5.2. Procedures

Several entities have helped to implement the purchasing programme, including MLTM, local municipalities, the fisheries cooperative union, Korea Marine Pollution Response Corporation (KMPRC), Korea Fisheries Infrastructure Promotion Association (KFPA), and the fishermen themselves (NOWPAP MERRAC, 2006).

Table 10 illustrates the role of each organization. MLTM accepts project applications from local municipalities, decides on project areas, allocates funds, and creates a project guide. Local municipalities also invest in the projects and help with supervision. The fisheries cooperative union plays a role in the direct purchasing of marine litter from fishermen on-the-spot. KMPRC and KFPA play a role in waste disposal, providing collection sacks and supplying national funds to the fisheries cooperative union.

The fisheries cooperative union distributes sacks to fishermen as they leave port. Fishermen put the collected litter into sacks labeled with the vessel name, fishing type, fisherman's name and phone number. When they return to harbour, they give the sacks to the fisheries cooperative union.

Table 10. The respective roles of organizations participating in the waste purchasing programme

	Roles
MLTM	● Selects the project areas ● Allocates the national fund estimate ● Makes a project guide ● Supervises the project
Local municipals	● Estimates local participation ● Supervises the project
The fisheries cooperative union	● Purchases marine litter from fishermen ● Requests national funds ● Distributes sacks to fishermen
KMPRC & KFPA	● Disposes of marine litter ● Makes sacks and distributes them to the fisheries cooperative union ● Supplies national funds

Sacks are provided in three sizes of 40 L, 100 L and 200 L. When they are returned full, the Incheon City pays the fishermen 4,000 won (US$4), 10,000 won (US$10), 20,000 won (US$20) respectively (Figure 25). In the case of the larger wastes which can't be packed into sacks, the fishermen attach a tag onto it, and the government pays them 260 won (US$0.26) per kilogramme. The government also purchases shell, crab and eel traps.

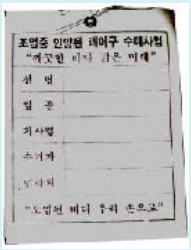
Size	40 L	100 L	200 L	Tag
Picture				
Purchasing Price	4,000 won	10,000 won	20,000 won	260 won/kg

Figure 25. Sacks provided to fishermen, and an example of a tag.

Figure 26. Fishermen unloading sacks filled with marine litter.

Figure 27. Purchased marine litter on the barge vessel.

5.3. Results

A great deal of marine litter was collected during 2002-2005 through the purchasing programme (Figure 26 and 27). Table 11 shows the volume of litter collected by the programme in Incheon each year.

The purchasing programme collected a total of 7,237 m^3 for the period at a cost of US$724,000. In comparison, if this volume of litter were collected directly by government, the cost would double. Direct collection would require a fleet of vessels, a waste collecting boat, a towing boat and a crane barge, to which would be added standard operating costs and fuel.

Table 11. Amount of litter collected through the purchasing programme

Year	2002	2003	2004	2005	Total
Amount (m^3)	380	1,170	1,206	4,481	7,237

(Incheon Metropolitan City, 2006)

5.4. Conclusions

The purchasing programme is clearly a very cost-effective system with added benefits. It increases environmental awareness among the fishermen and provides them with an extra source of income. It prevents damage to marine life, and uses existing resources (i.e., the fishing fleet). It is hoped that the purchasing programme will be expanded in Incheon coastal waters and used as a model in other regions.

Section 6: Trash boom to block floating litter

6.1. Equipment

Floating marine litter, like that of litter on the seabed and in the water column, is generated mainly by land-based human activities and transported to the sea by rivers and channels.

One way of blocking floating litter before it reaches coastal waters is through the use of a trash boom (Sung et al., 2005). The Korea Ocean Research and Development Institute/Marine and Ocean Engineering Research Institute (KORDI/MOERI) developed a trash boom similar to a conventional oil boom, but with a mesh skirt and the collection mechanism at the center. Although the oil booms have been well-designed to cope with waves and currents (Cross and Hault, 1970; Milgram and Houton, 1978; Sung et al., 1995), the often severe weather conditions of the Korean coastline necessitated on-site experimental trials with the prototype of trash boom.

6.2. Trash boom for the Han River

The Incheon City considered three types of boom: air inflatable boom, fence type boom, and solid buoyancy boom (Figure 28). In order to check the design parameters, site experiments were carried out in a branch stream of the Han River

The air inflatable boom is a typical emergency boom designed for rapid deployment. It is easily damaged by floating litter and is relatively expensive as US$300 per meter. Moreover, it is not strong enough to resist river or tidal currents.

The fence type boom is constructed in PVC and at US$125 per meter is the least expensive of the three. But it proved too weak to resist tides or current, and is likely to tear.

The solid buoyancy booms (JTF-1000) is the most expensive alternative, at US$310 per meter, but it is strong enough to stop a wide range of floating materials. This type of boom can be associated with permanent installations with a multitude of uses.

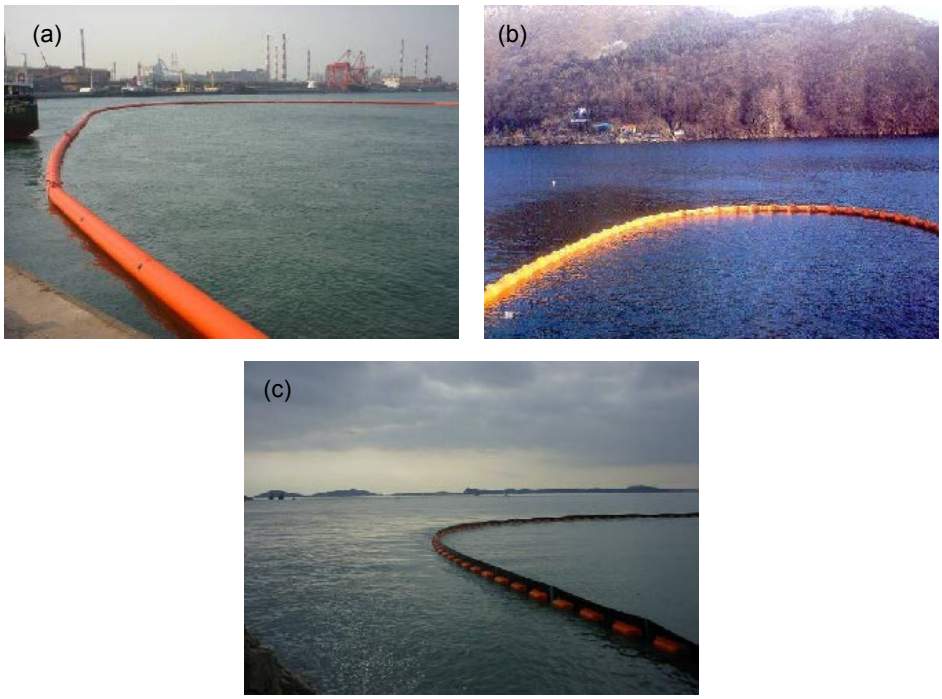


Figure 28. Three types of trash boom (a) air inflatable boom, (b) fence type boom, and (c) solid buoyancy boom.

6.3. Trash boom at the Yumha Channel

As seen in Section 3.2., most floating litter enters Incheon coastal waters from the Han River, especially during the flood season. According to the Incheon City, the Han River contributes about 190,000 m^3 of litter annually, 62% of it during the rainy season (see Table 2).

It was decided that a 500-m solid buoyancy boom was the best choice among the three types available. A JTF-1000 model was installed at a depth of 1 m at the Yumha Channel during the rainy season (Figure 29).

This trash boom – selected for its ability to resist strong tides and currents – was the first of its kind used in Korea. A trash boom used on rivers was annually upgraded or redesigned aiming to mending.

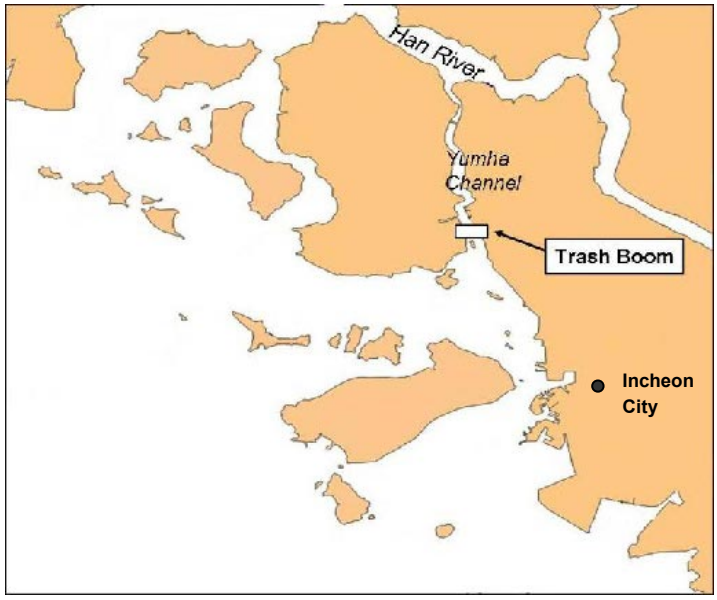


Figure 29. The location of the Yumha Channel trash boom.

Figure 30. Trash boom at the Han River during the flood season.

Figure 31. Floating litter collected by the trash boom at the Han River.

6.4. Results

The litter was transported from the boom to the ship by means of a conveyor belt and packed in sacks (Figures 30). Back in port, it was lifted off the ship with a crane, and incinerated (Figures 31). Table 12 shows the amount of litter collected by the trash boom in Incheon.

Table 12. Annual amounts of litter collected by trash booms.

Year	2002	2003	2004	2005	Total
Amount (m^3)	1,290	1,112	2,089	692	5,183

(Incheon Metropolitan City, 2006)

The most abundant material collected was wood, but plastic bags, vinyl, polyethylene bottles, were also found. Occasionally, pigs killed by floods, refrigerators, and other unusual materials were discovered.

6.5. Conclusions

Trash boom is useful mean of preventing floating marine litter from entering the coastal zone through rivers, particularly during the rainy and flood seasons. However, the trash boom installed in the Yumha Channel was able to collect a small part of the estimated floating litter transported by the Han River during the rainy season. The use of trash booms should therefore be extended to other channels of the Han River to collect more litter entering the sea.

Section 7: Removal of marine litter

7.1. Development of a marine litter collecting system

Ocean cleaning vessel (Ocean Clean)

The Korea Ocean Research and Development Institute/Maritime and Ocean Engineering Research Institute (KORDI/MOERI) developed a marine litter collecting vessel (Figure 32). Unlike previous ships, this vessel was especially designed to work in shallow coastal waters.

This ship is operated by the Korea Fisheries Infrastructure Promotion Association (FIPA). The total cost of construction was US$2,350 thousand, 1,650 for the vessel itself and 700 for multi-purpose collecting equipment. It was inaugurated on 31 December 2003.

Figure 32. Specially designed vessel for marine litter collection, *Ocean Clean*.

Table 13. Features of the *Ocean Clean*

Gross tonnage	Horsepower	LBP x B x D (m)	Speed	Ship type	Number of crew
99 tons	360 HP x 2	29.90 x 10 x 2.3	7 knot	Barge	5

Main equipment

The *Ocean Clean*'s main equipment is listed below and shown in Figure 33.

- Orange grapple
- Rake
- Pick-up net
- Bucket
- Wire cutter
- Trawl
- Automated connecting/disconnecting device
- Podded propulsor (propeller)

Supplementary tools include an automatic washer system, fixed gallows and winch system. The operator of the multi-joint crane on board can replace a recovery device by another very easily and quickly.

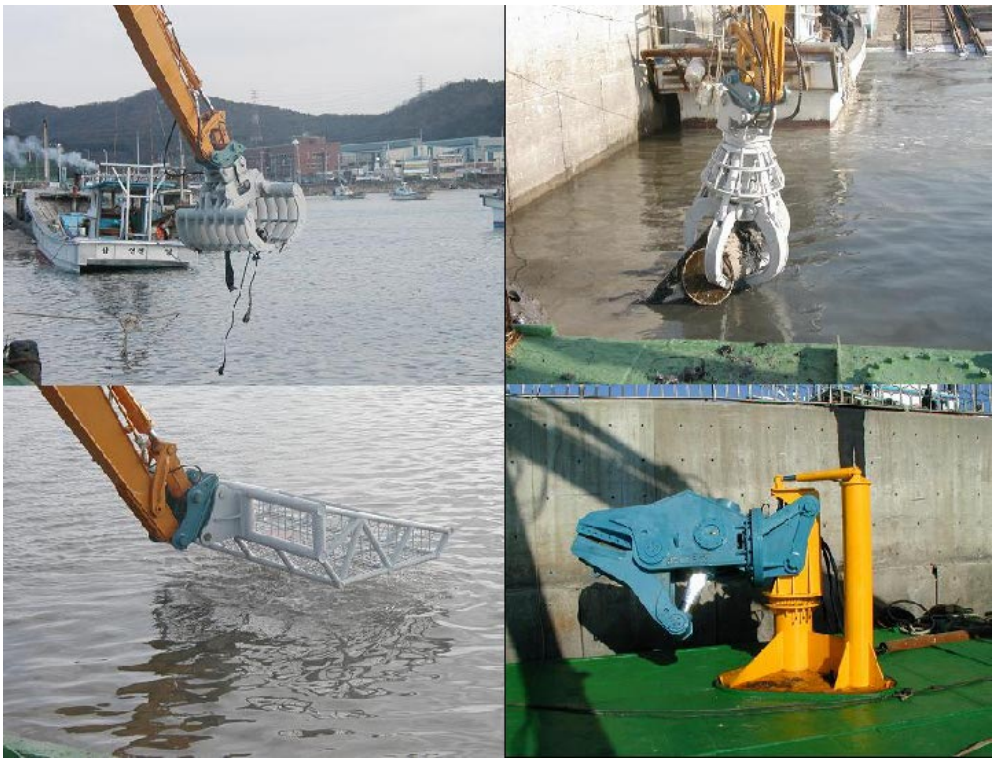


Figure 33. Marine litter recovery equipment of the *Ocean Clean*. Clockwise from top: rake, orange grapple, wire cutter, and pick-up net.

Cleaning ship for marine litter (Sea Clean)

The Incheon City collects marine litter with a cleaning ship:

Sea Clean

- Gross tonnage: 85 tons
- Horsepower: 1800 PS x 2
- LBP x B x D (m): 24.72 x 9.0 x 2.6
- Speed: 14.5 knot
- Number of crew: 18 (7)

Water surface cleaning ship

Korea Fisheries Infrastructure Promotion Association (FIPA) is collecting marine litter by three water surface cleaning ships consigned from the Korean government:

Incheon 936

- Gross tonnage: 38 tons
- Entry into service: March 1989
- 220 HP/220 kw
- Number of crew: 4
- Inner harbour

Incheon 937

- Gross tonnage: 149 tons
- Entry into service: December 1989
- 150 HP/112 kw
- Number of crew: 4
- Outer harbour

Incheon 938

- Gross tonnage: 36 tons
- Entry into service: December 1995
- 1440 HP/1074 kw
- Number of crew: 4
- Outer harbour

7.2. Results

The Korea Fisheries Infrastructure Promotion Association (FIPA) reported the results of collecting three categories of litter – floating litter, deposited litter, and obstacles in Yellow Sea, including Incheon coastal waters (Table 14).

Table 14. The amount of marine litter collected by the *Ocean Clean*, 2004-2005

Year	Plan (number)	Accomplishment (number)	Amount (kg)			
			Total	Floating litter	Deposited litter	Obstacles
2004	70	136	133,000	6,500	81,000	45,500
2005	60	146	201,000	49,500	115,000	36,500
Total	130	282	334,000	56,000	196,000	82,000

(http://www.fipa.or.kr)

Table 15 provides the results from the Incheon City of the annual collection of deposited marine litter by dredging of the seabed. The litter included refuse ropes, metal, wire, wood, tires and plastics (vinyl, polyethylene bottles, etc). After collection it was packed in sacks and transported to the appropriate port reception facilities.

Table 15. Deposted litter collected by dredging in Incheon coastal waters, 2002-2005

Year	2002	2003	2004	2005	Total
Deposited litter (m^3)	3,647	2,075	721	1,373	7,816

(Incheon Metropolitan City, 2006)

Section 8: Treatment and recycling of collected marine litter

8.1. Development of treatment and recycling equipment

Research on marine litter treatment methods were initiated around 1999 by the Ministry of Land, Transport and Maritime Affairs (MLTM), former Ministry of Maritime Affairs and Fisheries, and the Korea Ocean Research and Development Institute/Marine and Ocean Engineering Research Institute (KORDI/MOERI). With support from MLTM, an initial fact-finding project was followed by development of practical response equipment and facilities (Sung et al., 2005).

Although preventing the generation of marine litter at its source is the best way of eradicating the problem, it will never be 100% efficient. Marine litter which reaches the sea must be removed using cost-effective methods and tools.

For example, both land-based and sea-based marine litter can contain large amounts of salt, dirt and other substances (Keel et al. 2001; Table 16). Therefore, pre-treatment to remove these materials prior to final disposal is necessary.

In this regard, a pre-treatment procedure was developed by KORDI as a chain process including sorting, cutting, lead separation, crushing, and removal of salt and sludge (Keel et al. 2001).

Table 16. Characteristics of sea-based and land-based litter (Sung et al., 2005)

List	Sea-based marine litter	Land-based marine litter
Main items	Plastic, lumber, tire, fishing nets, ropes, etc (simple composition)	Household items, plastic, etc (complex composition)
Caloric heating value	About 4,000 kcal/kg	About 1,500 kcal/kg
Water content	Variable percentage	Almost constant percentage (50%)
Main treatments	Reuse, landfill, incineration	Landfill, incineration, reuse
Property	Salinity, sludgy, high heat release rate, heat plasticity	Watery, low heat release rate

Figure 34 illustrates the entire treatment process of marine litter from collection to pre-treatment to the major sub-processes of Refused Plastic Fuel (RPF) production, a thermal volume reduction system, and incineration.

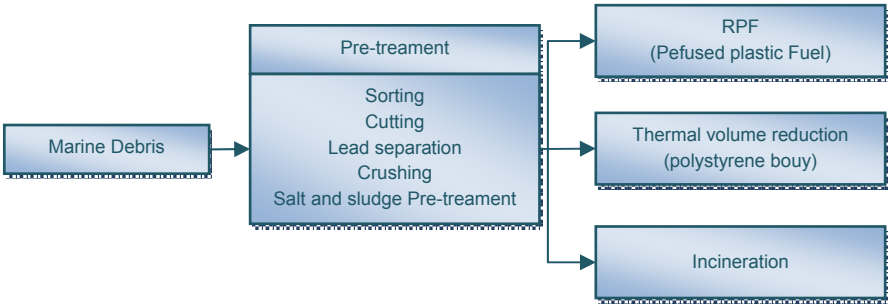


Figure 34. The treatment process for marine litter (Sung et al., 2005).

8.2. Thermal volume reduction system

Waste polystyrene buoys are one of most cumbersome types of marine litter because of their bulky volume (Figure 35).

A thermal extrusion system for volume reduction of waste buoys was developed (Keel et al. 2002; Figure 36). The reduction rate for the present equipment is about 1/60 and the total cost is estimated as 1/10 of current treatment.

Figure 37 shows the ingots produced by this process, which are reusable by waste plastic recycling companies (Figure 38).

Figure 35. Collected waste buoys.

System outline

- Location: 878-1, Yongjeong-ri, Ganghwa-Eub, Ganghwa, Incheon
- Area: 116 m^2
- Working expenses: 200 million won (US$200 thousands)
- Construction: 21 October 2005 – 22 February 2006
- Capacity: 100 kg/hr
- Operator: 1 person

Figure 36. Thermal extrusion system for waste buoys.

Figure 37. Recyclable ingots from waste buoys.

Figure 38. Products made from ingots.

Treatment process

The procedure of the thermal volume reduction system consists of the following steps.

- Cutting
- Crushing
- Cleaning
- Polystyrene separation
- Drying
- Storage
- Thermal extrusion

Operating characteristics of the process include:

- Stable extrusion of high water content's buoy
- Perfect separation of shell and stone
- Introduction of auto sensing and time control for easy operation

Treatment cost

Before the Thermal Volume Reduction System was developed, the cost of processing of marine litter was 18,000-50,000 won (US$18-50)/$m^3$. The reduction system could reduce this expenditure to as little as 1/10 of this. In addition, the ingots could be sold for about 500 won (US$ 0.5)/kg.

8.3. Incineration

Some types of marine litter cannot be transformed into reusable or recyclable materials, and must be incinerated.

An incinerator for marine litter was developed by the Korea Ocean Research and Development Institute/Marine and Ocean Engineering Research Institute (KORDI/MOERI) as a MLTM project, and installed at Incheon in November 2006 (Figure 39). The incinerator has a capacity of 100 kg per hour, and can accept household wastes as well as marine litter (Kang et al., 2003).

Combustible solid wastes include litter deposited on the seabed or floating on the sea surface, solid wastes generated by fishery activities, and domestic litter including household items.

The incinerator is composed of a crusher, charge crane, main body, exhaust heat recovery boiler, acid gas washing machine, active carbon unit (for removal of dioxin) back-filter, induced gas fan and stack.

The capacity of an incinerator is different depends on the type of waste to be processes. Sea-based litter has higher rate of heat release (4,000 kcal/kg) than that of land-based litter (1,500 kcal/kg), and can be incinerated at a rate of 100 kg/hr. When mixed with other combustible litter it will burn up to 180 kg/hr.

Safety is an important consideration when designing an incinerator. Standard incinerators consist simply of a furnace/boiler and particulate removal mechanism. This type of incinerator generates exhaust pollutants such as acid gases (hydrogen chloride, sulfur dioxide, nitrogen oxides, and carbon dioxide), dioxin and heavy metal particulates. In addition, their efficiency is relatively low.

According to the official analysis of discharge gas, the Incheon incinerator produces a negligible concentration of dioxin compared to the norm.

The incinerator in Incheon was designed to protect plant workers and nearby residents through the installation of an air pollution control system to prevent any such emissions (see box)

Features of the Incheon incinerator

- Safe operations
- Air pollution control monitoring system and preventing gas emission
- Efficient treatment of various types of marine litter, such as high caloric value marine litter, high water content materials, domestic litter, etc.
- Automated control system

Figure 39. Marine litter incineration facility.

8.4. Conclusions

The Incheon City constructed two new treatment facilities for marine litter, a thermal volume reduction system and an incinerator.

The thermal volume reduction system was shown to be an efficient method of treating waste polystyrene buoys. It reduces costs, generates income in the form of recyclable materials and helps to improve the marine and coastal environment.

The incinerator used in Incheon City, for marine litter only, was designed to endure corrosion caused by water and salt, and to lessen the high cost of sending industrial by-products to disposal facilities. Its cost is only about one-third that of existing disposal. The incineration process can produce electricity for many uses. Incineration may be a method of last resort for marine litter, but the Incheon incinerator demonstrated that it can be made efficient, cost-effective and relatively non-polluting.

Integrated marine litter management requires that treatment be both effective and appropriate. Continued development of new processes and new technologies is needed to provide alternatives, so that a method of disposal can be selected that fits a particular situation and type of litter to be processed.

Section 9: Mitigation activities related to marine litter

9.1. Coastal cleanup campaigns

A Coastal Cleanup Campaign is held annually on 31 May in co-operation with local non-governmental organizations (NGOs). An International Coastal Cleanup campaign is also held annually, around the third Saturday of September. These events help raise public consciousness of the severity of the marine pollution problem, through personal involvement in actions to protect the environment. But they would need to be held continually throughout the year to have a significant beneficial effect on the coastal environment.

9.2. One Beach, One Company campaign

The One Beach, One Company campaign has been developed by MLTM in order to raise public awareness of the marine environment. The campaign involves fishery-related corporations, local organizations, communities, and volunteer groups from more than 30 companies.

The objective of the campaign is the removal of marine litter on Incheon beaches by volunteers. Each area of removal is assigned according to its proximity to the participating company and its likelihood of accumulating litter – beaches, harbours, port, etc.

9.3. Education programmes on marine pollution

The Incheon Regional Maritime Affairs and Fisheries Office organized an educational programme to raise awareness of the importance of the marine environment and the need to confront the problem of marine pollution in general and marine litter in particular. Students and the general public visited cleaning ships, where an officer demonstrated the use of sea surface collecting devices. It is hoped that participants in such programmes will continue to pass on their experience, and help raise general awareness of the threats of marine litter.

Section 10: Summary and concluding remarks

Due to the increasing input of marine litter from daily life and the recreational, industrial and fishing activities associated with economic development, marine pollution is becoming severe. It affects ecosystems from the remote islands to nearby coastal areas. Considerable amounts of litter are directly or indirectly discarded into the sea and the rivers which empty into it, where they accumulate on beaches and the seabed.

There have been many efforts to reduce marine litter throughout the world. The case study presented in this report introduces one of the more successful of these: the well-organized and practicable methods of controlling and managing marine litter conducted by the Incheon City and Ministry of Land, Transport and Maritime Affairs (MLTM).

An initial survey was carried out on the amount, type and distribution of marine litter in Incheon coastal waters. The results were used as a basis for a long-term plan of systematic marine litter collection and management.

The survey revealed that most of litter found on the sea surface, in the water column and on the seabed is transported by the Han River passing through Incheon, Seoul and Gyeong-gi Province. The three local governments admitted the joint responsibility of marine litter and discussed ways to share the budget for the long-term management of marine litter, from the viewpoint of the polluter pays principle.

The three municipalities agreed to raise funds aiming to a variety of marine litter management programme, including use of a trash boom to prevent the transport of floating litter from the Han River, collection of litter by ocean cleanup vessels, and the treating and recycling of collected litter. It also carried out complementary mitigation activities, including beach cleanups, public awareness campaigns and environmental education programmes.

The outcome of these cooperative efforts was a great improvement in the quality of Incheon coastal waters as well as increased public awareness. Credit goes to the Incheon City and its many partners – MLTM and other government agencies, organizations, and institutes in the Republic of Korea.

REFERENCES

Cross, R.H. and Hault, D.P. (1970) Oil Booms in Tidal Currents, Proc. 12th Int. Conf. on Coastal ASCE, pp. 1754-1758.

Incheon Metropolitan City (2001) Current status of marine litter for collection and treatment in Incheon Coastal Waters, MOERI/KORDI Project Report (in Korean).

Incheon Metropolitan City (2006) Investigation on Contaminant and Improvement of Water Quality in Incheon Coastal Waters (in Korean).

Jung, R.T. et al. (2006) Integrated Management System for Marine Debris (III), MOERI/KORDI Project Report, MOMAF (in Korean).

Kang, C.G. et al. (2000, 2001, 2002a, 2002b, 2003) Integrated Management System for Marine Debris (I, II, III, IV, V), MOERI/KORDI Project Report, MOMAF (in Korean).

Kang, C.G. et al. (2004, 2005) Integrated Management System for Marine Debris (I, II), MOERI/KORDI Project Report, MOMAF (in Korean).

Kang, W.S. (2004) Study on the Development of Methodologies for the Systematic Survey of Marine Litter on the Seabed and Its Application in the Korean Sea, Department of Naval Architecture and Ocean Engineering, Doctoral Thesis, Chungnam National University, Deajeon, Korea.

Keel, S.I., Kim, S.J., Yun, J.H. and Yu, J.S. (2002) Application of Thermal Extrusion System for the Resource of Waste Polystyrene Buoy, Proceedings of the KOSMEE Spring Annual Meeting, pp. 41-46 (in Korean).

Keel, S.I., Yun, J.H., Kim, S.J., Shim, S.H. and Choi, Y.S. (2001) Recycling of Marine Debris for Refuse Derived Fuel, Proceedings of the KOSMEE Spring Annual Meeting, pp. 85-90 (in Korean).

NOWPAP MERRAC (2006) The 1st NOWPAP Workshop on Marine Litter.

UNEP (2005) Marine Litter, an analytical overview.

U.S. Environmental Protection Agency (2002) Assessing and Monitoring Floatable Debris, Washington, D.C. 20460, Oceans and Coastal Protection Division, Office of Wetlands, Oceans, and Watersheds, Office of Water.

Sung, H.G., Cho, I.H., and Choi, H.S. (1995) The Motion Characteristics of a 2-D Flexible Oil Boom in Regular Waves, MARIENV95, Int. Conf. of Tech. for Marine Env. Preservation, Tokyo, Japan, pp. 339-344.

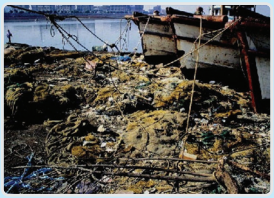
Sung, H.G., Jung, R.T., Kim, S.D., Kang, C.G. and Keel, S.I. (2005) Integrated treatment system to marine debris at Korean Offshore, The 2nd Joint Japan/Korea Workshop on Marine Environmental Engineering, Kasuga, Fukuoka, Japan, pp. 201-213.

Incheon Metropolitan City website: http://www.incheon.go.kr

Incheon Tidal Wetland website: http://wetland.incheon.go.kr

Korea Fisheries Infrastructure Promotion Association website: http://www.fipa.or.kr

U.S. EPA website: http://www.epa.gov/owow/oceans/debris



NOWPAP MERRAC

Northwest Pacific Action Plan
Marine Environmental Emergency Preparedness and Response
Regional Activity Centre

P.O. Box 23, Yuseong, Daejeon 305-600, Republic of Korea
(c/o MOERI/KORDI)
Tel: (+82-42) 868-7214, FAX: (+82-42) 868-7268
E-mail: nowpap@moeri.re.kr
Website: http://merrac.nowpap.org

9 788995 921920 93650
ISBN 978-89-959219-2-0