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農業用 멀칭 廢비닐로부터 人工魚礁 開發 및 商用化†

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Development and Commercialization of Artificial Reefs from Waste Mulch Plastic Films†

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요 약

인공어초는 수중에서 물고기들에게 피난장, 휴식장, 산란장 및 먹이장 기능을 제공하는 인공구조물이다. 전통적으로 인공어초는 우리나라나 일본에서는 시멘트나 강재로 만들어져 왔다. 그러나 자원 고갈이 심화되어 감에 따라 인공어초의 본체에 다른 재질의 사용이 요구되고 있다. 반면 농업용 폐비닐은 국내에서만 연간 약 30만 톤 이상이 발생되지만 재활용의 패도를 찾지 못하고 있는 실정이다. 이런 의미에서 영농용으로 사용된 농업용 멀칭 비닐을 수산증식용 인공어초로 재활용하면 자원순환사회구축에서 상징적인 면뿐만 아니라 실제적 면에서 효과가 지대할 것이다. 특히 이들 멀칭 비닐 재활용 인공어초는 1) 탁월한 위집효과, 2) 우수한 수중생물의 초기부착도, 3) 극히 낮은 해수에서의 부식성, 4) 비중 조절의 용이성, 5) 제작, 운송 및 침설에서의 경제성, 6) 낮은 유해물질 침출성 그리고 7) 사용 후 재활용의 용이성 등의 장점이 있다.

주제어 : 농업용 멀칭 폐비닐, 재활용, 인공어초, 상용화 보급

Abstract

Reefs are the marine structure that can give resting, inhabiting, feeding and nursing spaces for a variety of fishes. Usually artificial reefs are made of cement and steels respectively in Japan as well as in Korea. However since resources deficiency has been getting serious, other materials are taken into consideration for the basic bodies of artificial reefs. About 300 thousand tons of waste agricultural plastic films are generated every year in Korea, but no effective recycling techniques have been developed. In this sense, artificial reefs made of waste agricultural plastic films are the most representative symbol of the recycled products in the Resource Recycling Era. In particular, since these reefs could be made of the semi-cleaned waste agricultural plastic films that still contain high portion of soil, it is very environmentally friendly not only in manufacturing process but also in using under water. Furthermore they have some evident advantages as follows; 1) high fish swarming effect 2) good initial attachment of the marine growths 3) extremely low corrosion to brine 4) easy adjustment of the gravity 5) economical manufacture, transportation and jettison 6) excellent safety to ecosystem caused by lower elution of toxic substances 7) good recyclable property after application and so on.

Key words : Waste mulch plastic films, recycling, artificial reefs, commercialization

1. Introduction

In Korea, about 300 thousand tons of waste agricultural plastic films (hereafter WAPF) are generated every year. It is not easy to recycle them economically and efficiently since they are heavily contaminated by soil and moisture. On top of it, the mass consumption method of recycled plastic films has not been found yet.

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Meanwhile around 45 billion won in a year is invested for the jettison of artificial reefs along the coasts of Korean peninsula.[1] Especially, it has been expected that the investment for artificial reefs are getting higher continuously because it has been strongly demanded to obtain the rich protein resources from seas for Korean people after some negotiations on the fishing rights with neighboring countries.

Traditionally artificial reefs in Korea and Japan have been made of cement and steel mainly because these artificial reefs were easily built up.[2] However, if artificial reefs are made of waste plastic films, it could be fully expect that some evident advantages are shown as follows; 1) husbandry of useful resources suchlike cement and steels, 2) environmental conservation by sweeping up the wastes in the rural area, 3) excellent safety to marine ecosystem and 4) great effect in fish farming in the coastal areas and so on.

In this sense, a project for the development of 'artificial reefs from WAPF' (hereafter Polycon Reef) was officially launched by a joint team in January 2000. The joint team was comprised of several institutes and private companies. The key role and management of the project were done by Korea Environment and Resources Corporation (hereafter ENVICO). Some special fishery bodies such as National Fisheries Research & Development Institute (hereafter NFRDI) and Korea Ocean Research & Development Institute (hereafter KORDI) joined to provide the detailed designs and/or to perform the Effect Survey. Two private recycling companies also were engaged from the start to enhance the commercialization when the project would be successful.

2. Development

2.1. Feasibility Study

Initial feasibility studies were done by staffs of ENVICO in early 2000. At that time, it was found out that plastic material had many clear advantages and several minor disadvantages as the main bodies of artificial reefs. Among the disadvantages, ironically, it was the most serious issue that long lifetime of plastic products would not positive to the marine ecosystem.

However there were also many evident advantages that would fully overcome the disadvantages easily.

2.2. Raw Material

The raw material used for the basic panels of Polycon Reef was beaten waste mulch plastic films by simple and dry processes that still contained around 40% of soil and 30% of moisture. It means that the portion of pure PE reached around 30% only when it was wet and around 43% in the final products. Fig. 1 shows the status of raw material.

2.3. Basic Panels

In a unit of Polycon, about 90~120 pieces of the basic panels were employed depending on the distance between panels. The dimensions of the panels were 120(L) x 120(W) x 10 cm(T) and its weight was 145 kg/piece.

Fig. 1. Beaten mulch plastic films by dry processes.

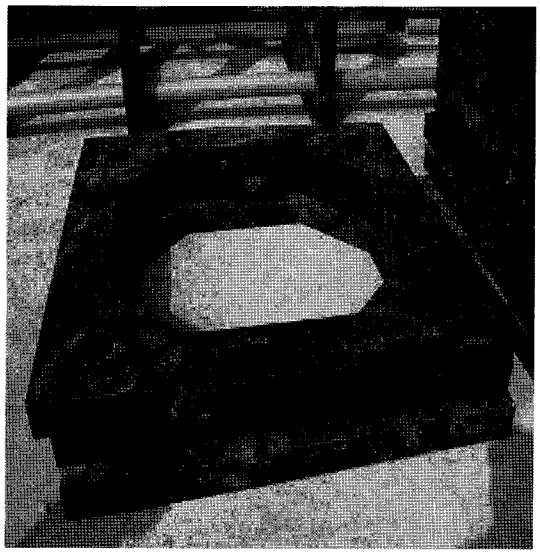

Fig. 2. Basic panels for Polycon Reef.

The basic panels for Polycon Reef are shown in Fig. 2.

2.4. Design

Considering the facts that the velocities of tidal currents in the Korean west coasts were so high (around 0.7 m/s) and the gravity of plastic material could be adjusted by adding some inorganic compounds and/or attachment of heavier stuffs as the reef anchors, the shape of Polycon Reef was designed as a huge house type that had 4 stories, 411 m^3 in volume and about 100 basic panels with 34 profiles. The total weight per 1 unit reached around 30 tons. The measurements were 12(L) x 8.6(W) x 5.4(H) m. For information, 800 m^3 of artificial reef(s) should be placed in every 16 *ha* according to Implementation of Artificial Reef Facilities Projects and Management Methods in Korea. So jettison of 2 units of Polycon Reefs would be fully enough for a zone.

The design of Polycon Reef was done by Donga University and ENVICO, whereas the structural analysis was carried by a team from KORDI. Fig. 3 is a concept drawing of Polycon Reef.

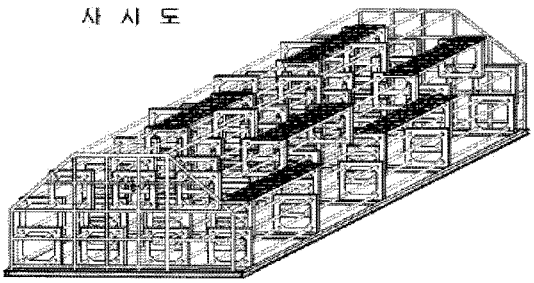

Fig. 3. A concept drawing of Polycon Reef.

2.5. Reliability of Basic Material

In order to check the reliability of PE material as the main body of artificial reefs, several tests were carried out.

First of all, from the results of elution test, no harmful substances were detected. The test items were Cd, As, Hg, CN, PCBs, Pb, Cr^{6+}, organic-P, Bisphenol A and anionic surfactants according to the regulations of GR (Good Recycle) Marks.[3)]

In the second place, physical properties were tested in the marine condition. According to the test, it could endure the condition of the most serious typhoon in 50 years.[4)]

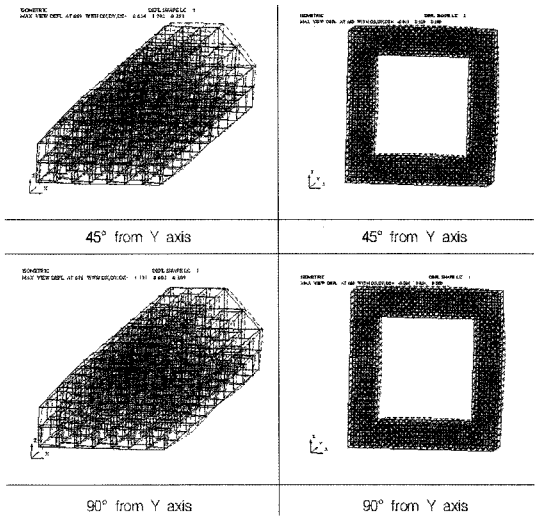

Fig. 4. Stress diagrams for basic panel and structure.

Fig. 4 shows resistant property of the basic panel as well as the basic structure against stress from outside.

The last one was the environmentally friendly property to the undersea condition. The initial marine growths on the walls of the sample panels were different depending on materials. Of course, PE panel showed the best result among some materials suchlike cement and steel. It might be caused by the facts that PE did not emit any harmful substances to marine growths.

The results are shown in Fig. 5.

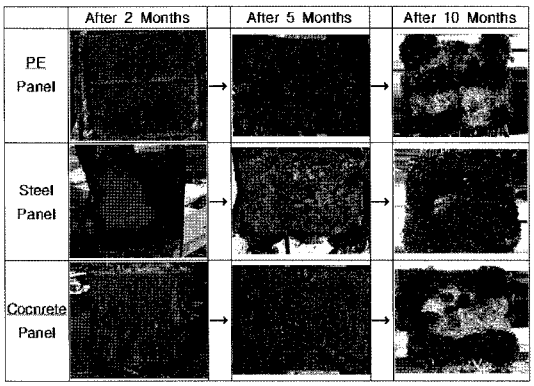

Fig. 5. Initial marine growths.

2.6. Jettison

A big advantage of Polycon Reef was in the jettison into the sea. It was very easy to pick them up and

move to the undersea with a crane. Especially it was a clear advantage that a set of Polycon Reef that had around 400 m^3 of volume could be jettisoned in a time.

Fig. 6 shows the simple jettison of Polycon Reef.

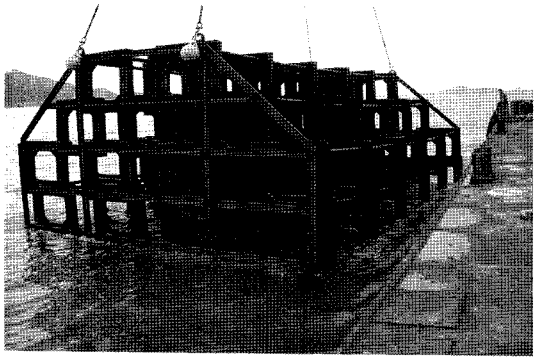

Fig. 6. Jettison of Polycon Reef.

3. Advantages of Polycon Reef

3.1. High Fish Swarming Effect

It was proved that Polycon Reef had a great fish swarming function through the Effect Survey. The difference of swarming effect in between the target area and non-target area were compared. As shown in Fig. 7, the difference of effect reached nearly 19 times in the 11th month.[5] For information, the difference of fish swarming effect in between both areas are very variable depending on reefs and areas, but the average is around 6~10 times in the coasts of Korea.

In particular, crowding of some superior fishes such as *Pleuronectes yokohamae* and *Hexagrammos otakii* is apparently observed as shown Fig. 8.[5]

The Effect Survey was done by NFRDI for a trial artificial reef of Polycon Reef that was installed on the bottom bed of the coastal sea near Daeijakdo Island, Ongjin-gun, Incheon-city. The average depth of water was around 20 m, and the bed was relatively flat. The location is shown in a map of Fig. 9(N37°10'085", E126°14'770").

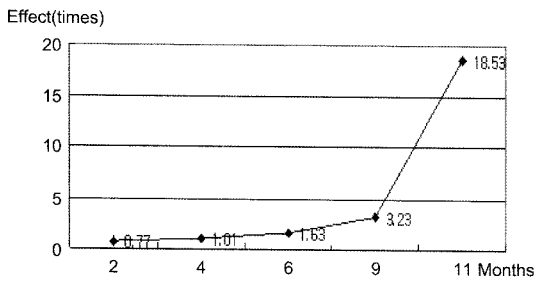

Fig. 7. Test results on fish swarming.

3.2. Excellent Economic Effect

The second largest advantage of Polycon Reef was its economic feasibility. As mentioned above, since artificial reefs were usually made of cement and steels in Japan as well as in Korea, the costs including were relatively higher than Polycon Reef that could be manufactured from waste in large portion. The reasons Polycon Reef had evident economic advantages were from the facts that it could be manufactured, tran-sported and jettisoned easily and the raw material was very cheap.

On top of it, when about 30% of total artificial reefs are replaced by recycled ones suchlike Polycon Reef, about 7 billon won can be saved in a year.

Fig. 8. A Polycon Reef surrounded by fishes under sea.

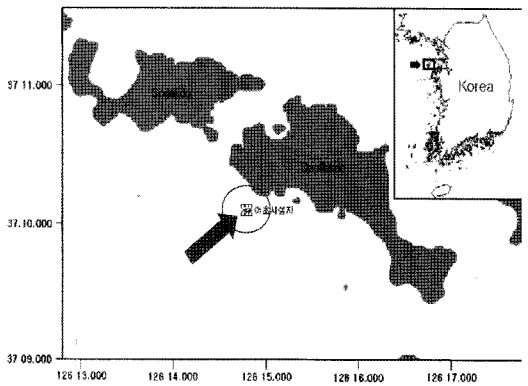

Fig. 9. A location for Effect Survey of trial reef.

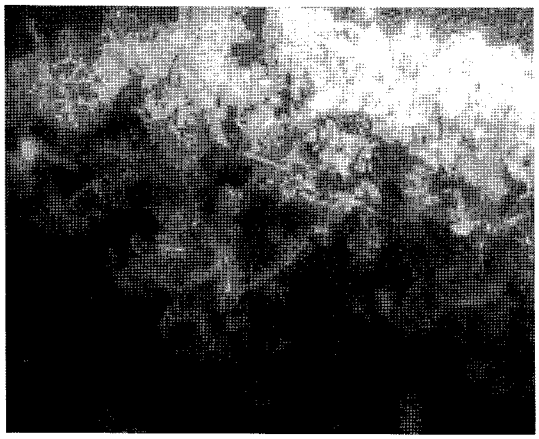

Fig. 10. Marine growths on the walls of basic panels.

3.3. Good Attachment of Marine Growths

As mentioned in section 2.5, since the environmentally friendly property of PE was so good, the initial marine growths on the walls of basic panels were excellent. *Apana venosa, Mytilus edulis* and *Asterias amurensia* were grown up flourishingly. Fig. 10 shows the marine growth after 11 months from jettison.[4)]

4. Commercialization

Of course, Polycon Reef was registered into the official artificial reefs' list of Korean government after strict and full deliberations in July, 2005. Since the first distribution was initiated in 2006, about 60 units of Polycon Reef were purchased by local governments such as Incheon-city and Chungnam, Jeonnam, Jeobuk provinces.

Total amount of sales of Polycon Reefs in the first 2 years reached about 3.5 billion won. It is estimated that distribution of Polycon Reef would increase continuously in coming years.

For Information, two private recycling companies, Jangho Co., Ltd. and Green Korea Co., Ltd. participated from the development stage and are now distributing Polycon Reef in the Korean market. Of course all industrial rights are under control of ENVICO.

5. Conclusions

In spite of some minor disadvantages, it was evident Polycon Reef, which was mainly made of waste agricultural plastic films had many strong advantages as well. Among them, high fish swarming effect, good initial attachment of the marine growths, strong merits on economical side and excellent safety to ecosystem are incomparable.

The success of Polycon Reef symbolizes vividly the importance of resource recycling in these days. Also it drops a hint that high valuable commodities can be produced from the wastes.

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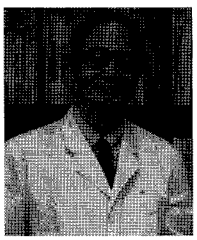

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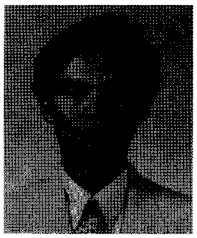

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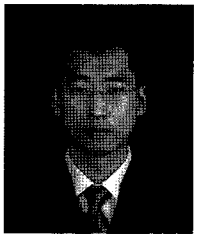

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學會誌 投稿 安內

種 類	內 容
論 說	提案, 意見, 批判, 時評
展望, 解說	現況과 將來의 견해, 研究 技術의 綜合解說, Review
技 術 報 告	實際的인 試驗, 調査의 報告
技術, 行政情報	價値있는 技術, 行政情報를 간결히 解說하고, comment를 붙인다.
見 聞 記	國際會義의 報告, 國內外의 研究 幾關의 見學記 등
書 評	
談 話 室	會員相互의 情報交換, 會員 自由스러운 말, 隋霜 등
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