SSMS International Conference, Tokyo Univ., 2019.09.12

# R/D Study on Plastic Waste Recycling/Circulation

## by Thermo-hydrolysis Processing

## using Subcritical Water Reactor

**Jun Matsushita[1*], Saburo Matsui[2*], Tomonao Miyashiro[3*], Naoko Nakagawa[1*]**




[1] Institute of Science and Technology, Chuo University
[2] Emeritus Professor of Kyoto University
[3] Ph.D., G-8 International Trading Co. Ltd.

# Presentation Summary

## 1. Background of our R/D study

of Current Concerns over Massive Plastics Use and Disposals

## 2. 3Rs + Renewables

New Strategic Policy toward Plastics Recycling/Circulation

(1) Reduce, (2) Recycle, (3) Bioplastics, (4) Incineration

## 3. Verification on the Workability of SCW Reactor

Proved to be Innovative enough in Plastic Waste Recycling /Circulation Business

## 4. Conclusion and Future Tasks

Multi-billion Dollars Business Model & New Jobs for People

# Vision toward Plastics Waste Recycling In the World by Subcritical Water Technology

## ○Plastics Waste Recycling enabled by Subcritical Water Tech.

The SCW/MRM is proved to be workable to dissolve plastics very fast to promote recycling and circulation of plastic-mixed urban waste.

## ○Contribution to Plastics Recycling/Circulation Policy

The SCW/MRM can enable the mixed-plastics recycling/ circulation for the following objectives:

(1) Production of compost (soil conditioner),

(2) Production of biofuel and/or bioplastics,

(3) Promotion of methane fermentation,

thus realizing plastics recycling/circulation policy urgently needed in the world.

# 1. Background of our R/D Study on Plastics Recycling


**On the Land**

Bottom

**Case of B City, India**

(गंगा)

Top

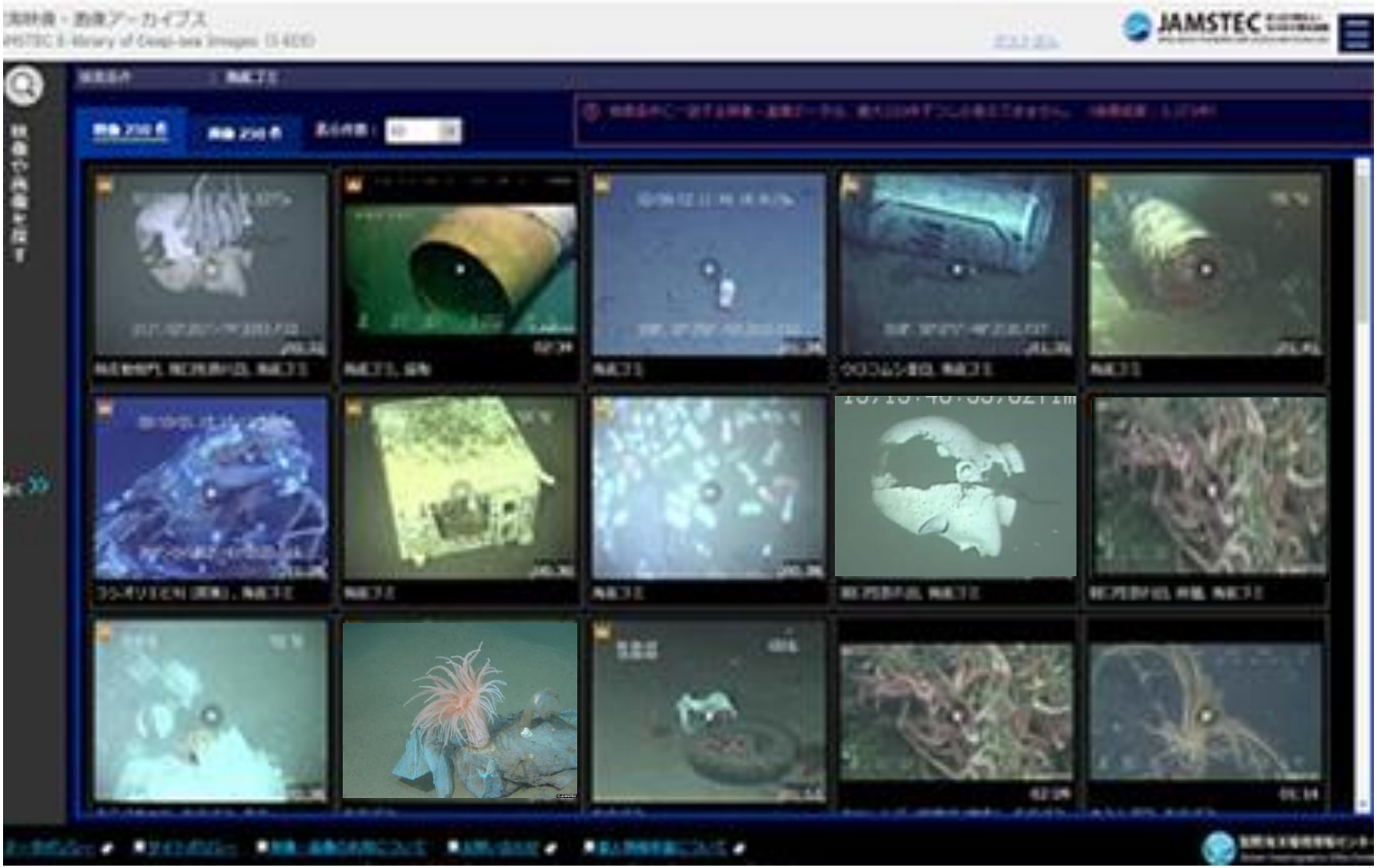
**Case of J City, Indonesia**

Daily Amount > 6,000 tons,

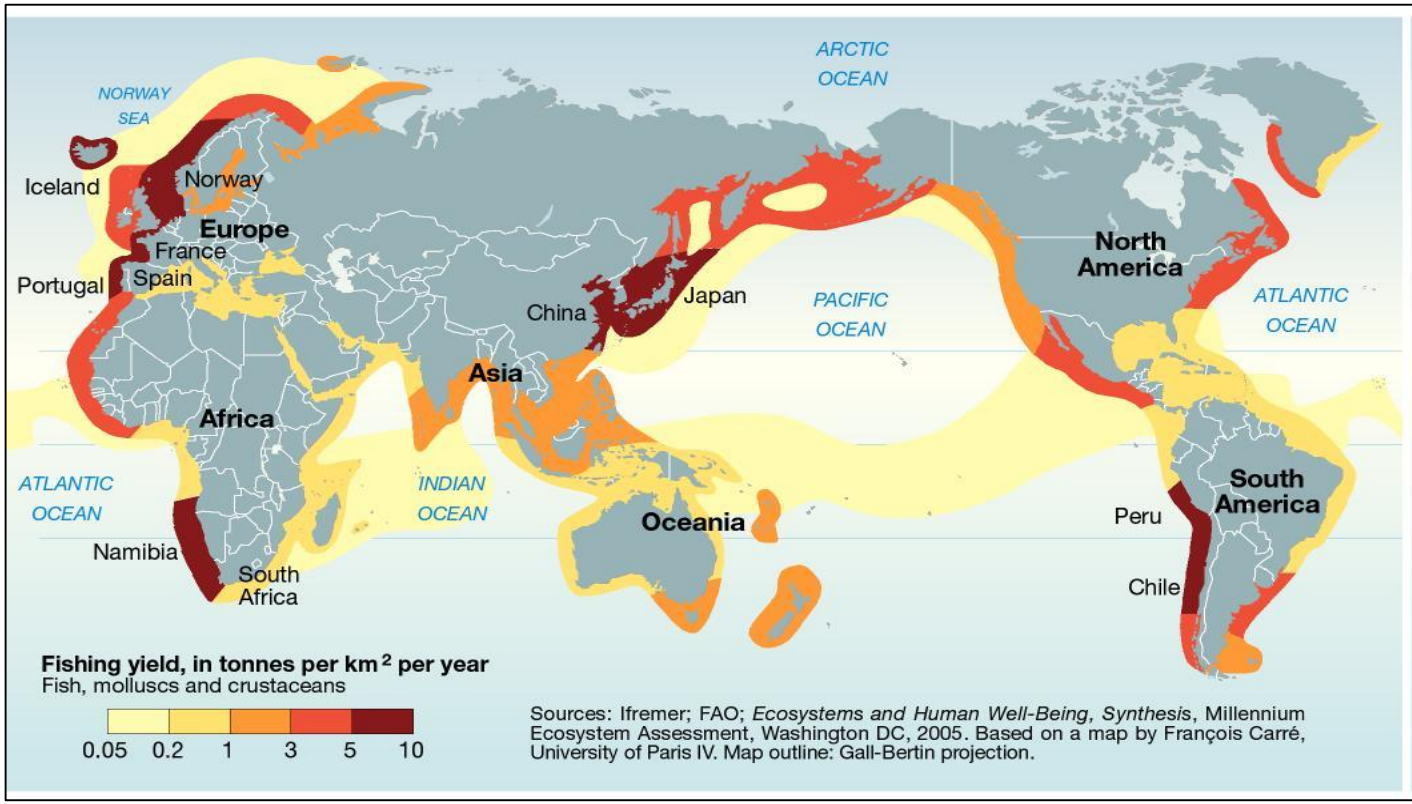
Eq. to 2,000 truck loads

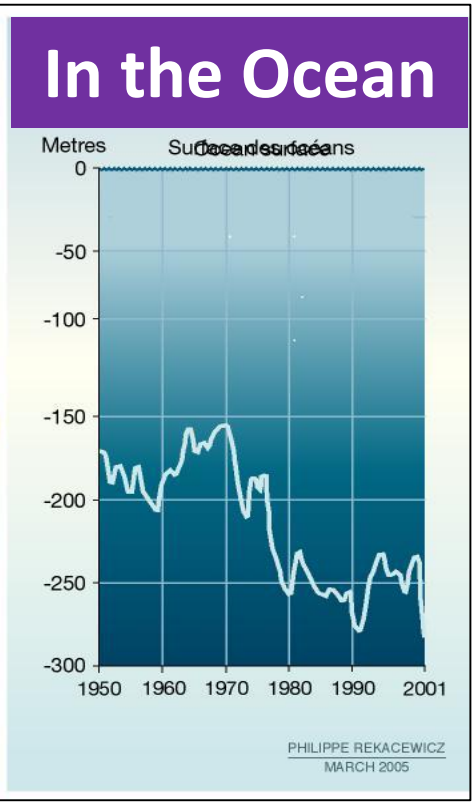
# Bottom of Deep Seas___ a ‘Tomb of Plastics’?

**In the Deep Sea**



# ‘Ocean Plastic Debris’___ More than Total Fish Weight?



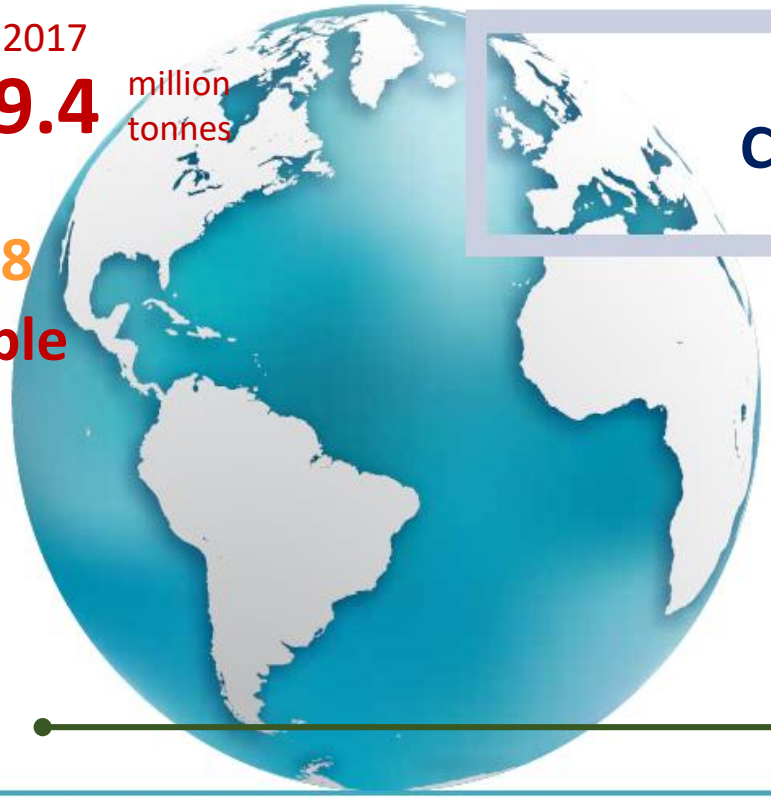


**More than 86 million metric tons of plastics are in the Pacific Ocean.**

*Source: NASA **Garbage Patch** Visualization Experiment*

# 2. Strategic Approach toward Plastics Recycling/Circulation

## Japan



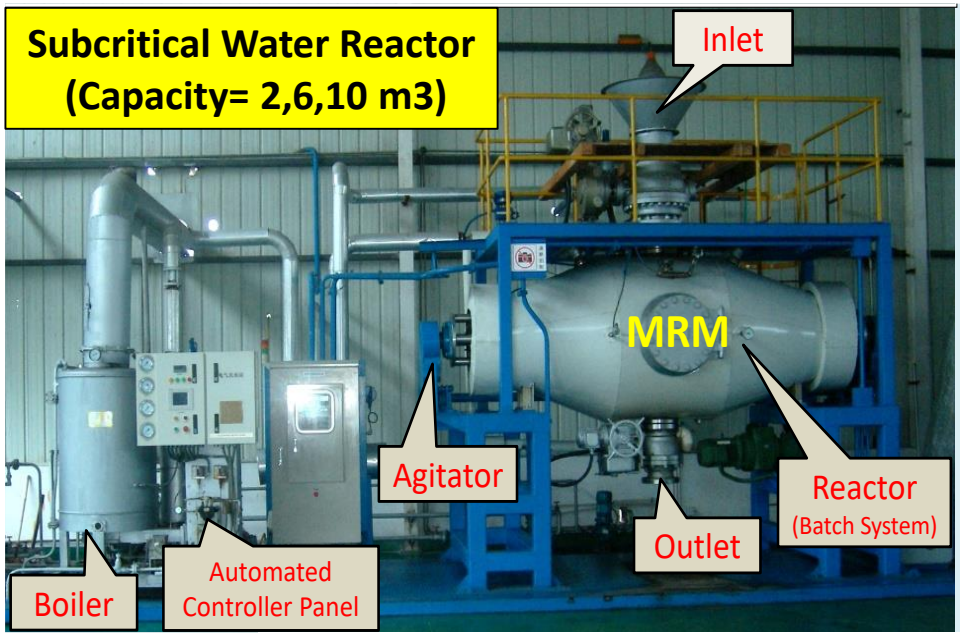

Source: Plastics Europa + Japan's Statistic of Plastics Production and Disposal

# 3. Verification of the Workability of Multiple SCW Reactor

How it works to decompose/dissolve various bio-waste & plastics

## Applicable to Various Bio-wastes

◆From decomposing of organic materials to dissolving of plastics




## Simple & Speedy

◆Saturated steam from a boiler combined with agitation system

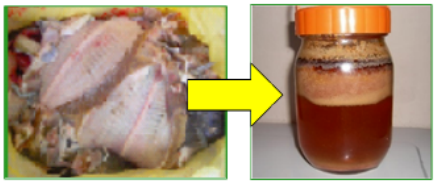
- 100-200℃@10-20 atm (1-2 MPa)
- Processing Time: 10-60 min.

◆High performance with smaller energy consumption

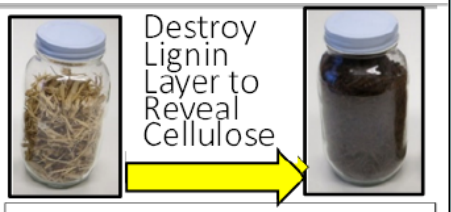
(2m3 Case)

- 2m3＠10 batch/day=20m3/day =10 ton/day (0.5 ton/m3)
- Equivalent to garbage amount of 10,000 people

*Plastic-mixed Biowaste*



*Fish Residue*




*Wood Chips*

**Multi-Functional Recycle Machine (MRM System)**

# Road Map of Japan, 2018
# Current Status of the Biomass Utilization Technology

Regarding “the current state of biomass utilization technology and roadmap” (hereinafter referred to as “technology roadmap”), which was decided along with the “biomass commercialization strategy” in September 2012, a review was conducted based on the information from relevant ministries and the National Research and Development Corporation.

## ◆ Newly added technical case

## Thermochemical conversion/fast hydrolysis (Subcritical Water)

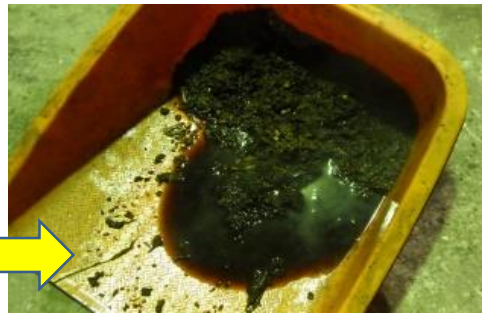
Raw materials: Wood-based, herbaceous, food waste, sewage sludge, livestock waste etc.
Products: feed and fertilizer
Technology level: Research and demonstration (partly put into practical use)
Current status: This technology decomposes organic materials efficiently and converts it into resources using subcritical water region which is below the critical point (temperatures of 100-200 degrees Celsius and pressures of 10-20 atm.). Various technological developments such as high-performance compost and detoxification of bacteria are expected.

May 17, 2019 Biomass Utilization Promotion Council decision
Quoted from "the current status of the biomass utilization technology and its roadmap

# Verification Test (1): Hydrolyzing of Plastics by SCW Processing

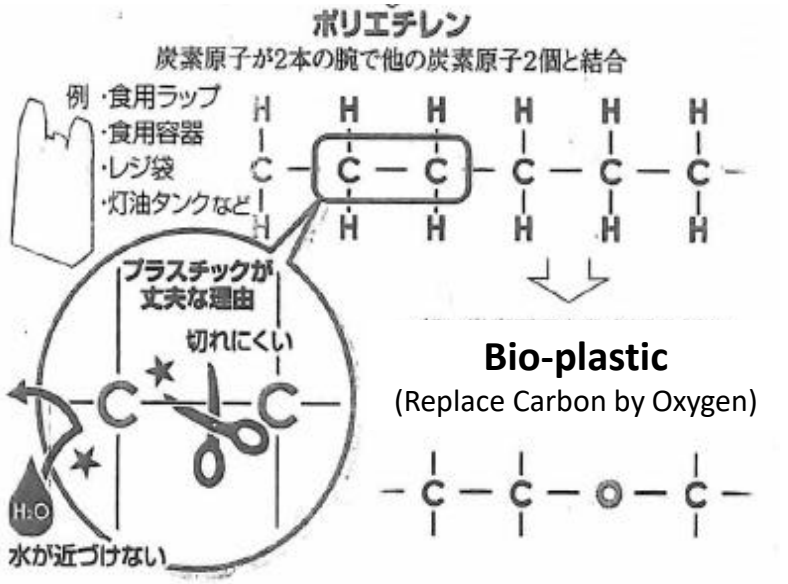
① **Raw Materials:**
**Plastic-mixed Food Residues**

② **Subcritical Water Processing**
（130℃/12atm@10min.）



③ **Hydrolyzed Plastics**
(Converted into alcoholic liquid)

## Hardly Decomposable Structure of Polyethylene (PE)




**Bio-plastic**
(Replace Carbon by Oxygen)



## Results:

Hydrocarbon structure of plastic (PE) is durable and hydrophobic, therefore hard to be dissolved by water.

SCW processing is proved to be workable to hydrolyze them shortly into alcoholic liquid, useful for methane fermentation and/or biofuels

# Verification Test (2): Hydrolyzing of Plastics by SCW Processing

①**Raw Materials:**
**Plastic-mixed Urban Waste**
（Shanghai, China, 2008）

②**Subcritical Water Processing**
（180℃/15atm@20-30min.）


**Solution to solve Bottlenecks of Current Landfill Systems**

## Results:
**(Shanghai, 2008)**

◆SCW processing is proved to shortly dissolve plastics components, thus realize organic fertilizer production as circular economy business model.

◆It could help solve bottlenecks of current landfill systems, plus create plastics-based biomass plastics production models.


③**Final Product**
(Organic Fertilizer)

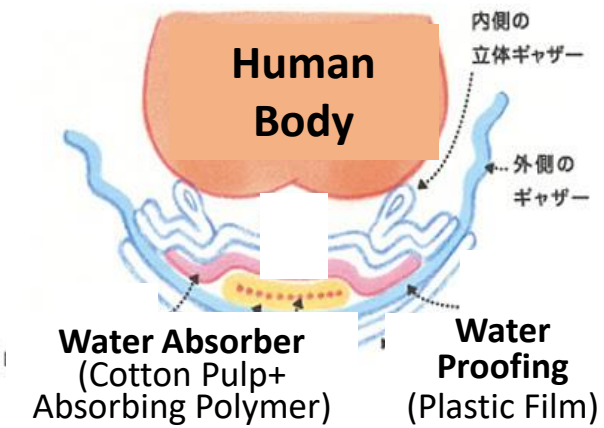
# Verification Test (3): Hydrolyzing of Paper Diaper by SCW Processing




**①Raw Material: Used Paper Diaper**
(Plastic-mixed Organic Waste)

**②Subcritical Water Processing**
（190℃/13.5atm@30min.）

**③SCW-hydrolyzed Product mixed with Dissolved Plastics**




**Structure of Paper Diaper**
(Plastic + Organic Fiber)

## Results:

Paper diaper is plastic-organics-mixed compound. After disposal, it becomes wet and unhygienic, plus costly for incineration, posing heavy financial load to municipalities.

The diaper is proved to be hydrolyzed/dissolved by SCW processing quite shortly.

The processed final product forms fine fiber-based material to be utilized as high calorie biofuel and/or paper container.


SCW Processing of
Medical Waste including
Used Shringe by
Multiple Recycling Machine
(MRM)

# Solution (1) : Production of High-calorie Solid Fuel

Solid Fuel for Warming Greenhouses and/or Hot Bath (Artificial Hot Spring)

**Carbon Neutral**

**◆Material （1）**
Unused Wood
Saw Dust
Drift Wood

**◆Material （2）**
Plastics Waste
Used Paper Dust

**○Chipping**
Mixing
Chipping

Adding Plastics

**○SCW Processing**
Fast Hydrolyzing
Dissolving of Plastics
（Conversion to Alcohol）

**○High Calorie Fuel**

**○Biomass Boiler**
Production of Hot Water

**◆Consumers**

**○Power Plant**
**Pulp Plant**
**Cement Plant**

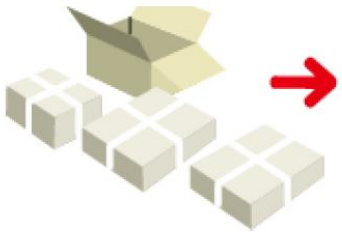
**○Greenhouses**
**Hot Bath**
**(artificial hot spring)**

**Calorie Evaluation**
- Wood：4,500Kcal/kg
- Wood-plastics Mixed：6,000kcal/kg

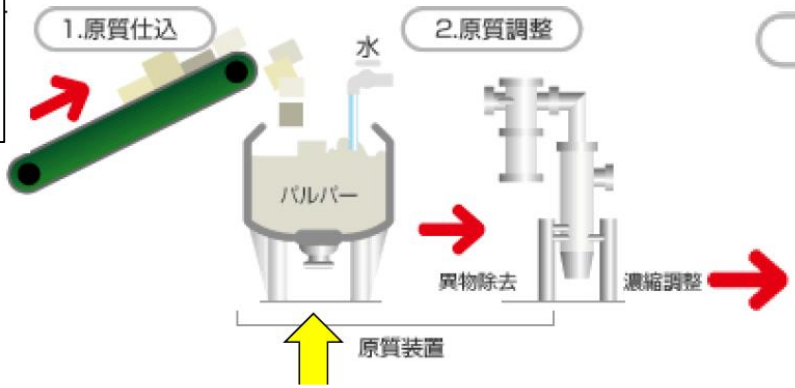
# Solution (2) : Production of Recycled Paper Packs

## Mold Tech.+ SCW Reactor to Produce Recycled Paper Packs

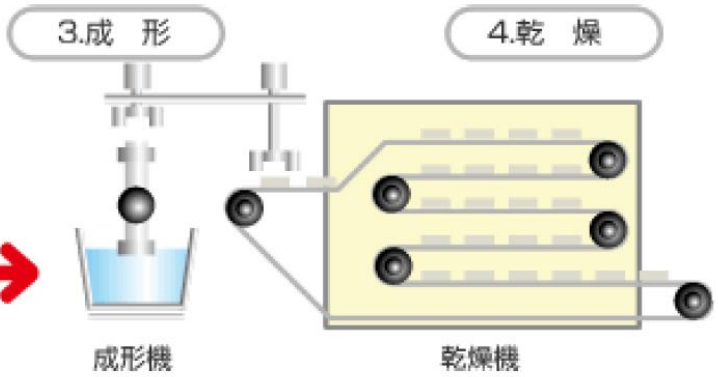
**◆Original Material**
Used Paper,
Cut Board, etc.



**○Pulpier Processor**




**○Molding/Drying**




**○Hydrolyzed Used Plastics/Compounds**

**◆New Material**
Used Plastics,
Used Paper Diaper
(Fiber-plastics Compounds)

Used Plastics, Paper Diaper

**○SCW Processing**

**◆Consumers**



Paper Packs
Packing's

# Conclusion & Future Tasks

## Conclusions:

- **The Subcritical Water reactor** is proven to be enough functional to hydrolyze plastics and its compounds fast.
- The machine is contributable to plastics recycling by producing **high calorie fuel** and/or **recycled paper packs**.

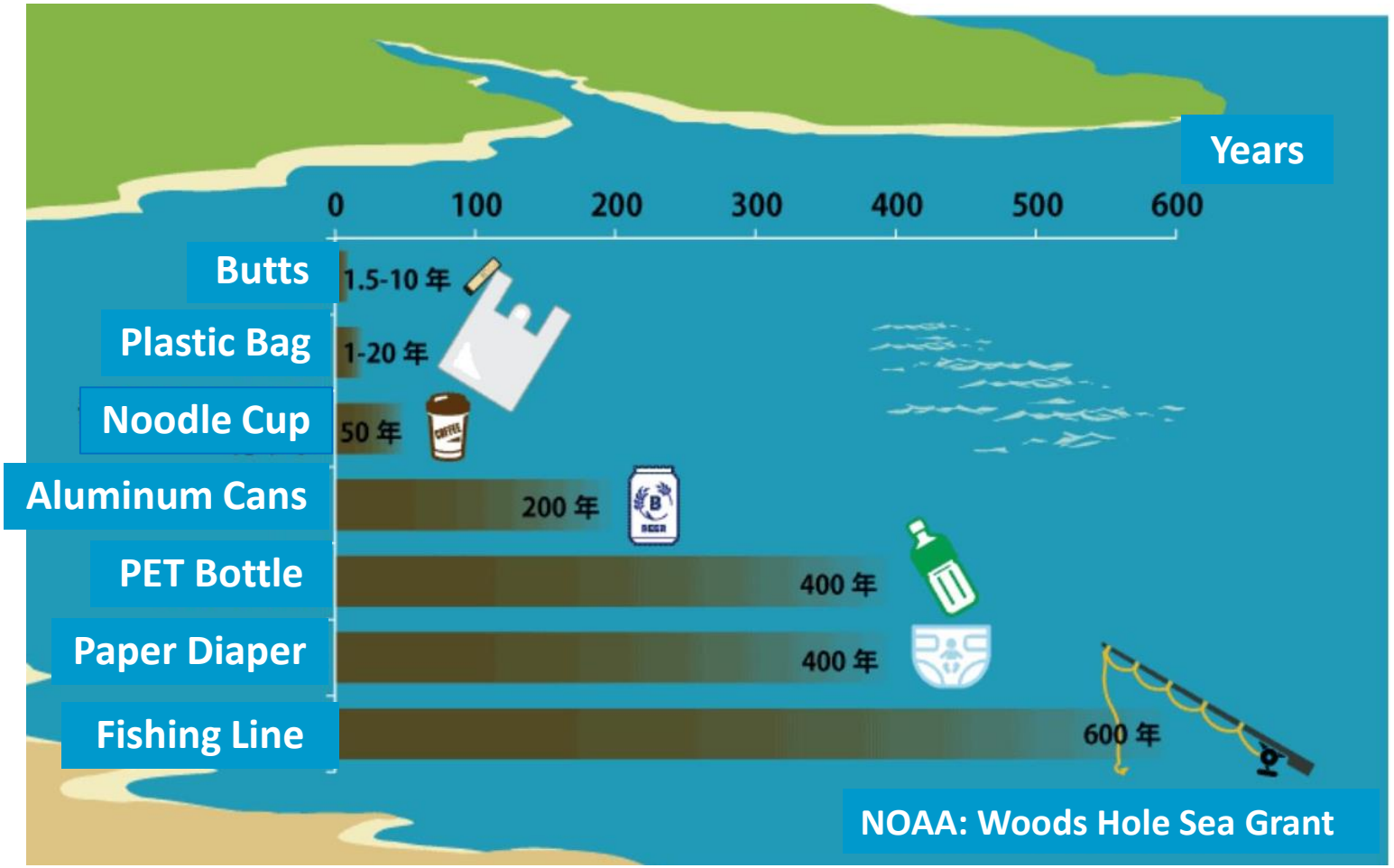
## Future Tasks:

- **Business model creation** in any countries where recycling of plastics is strongly requested.

| | |
|---|---|
| **No. of SCW Units (6m3)** | 10 units for processing 100,000 tons/y (300 tons/d) of Plastics |
| **Initial Cost** | Approximately 2,500 million yen (24 million US$) |
| **Annual Sales Income*** | Approximately 2,000 million yen (19 million US$)<br>on the condition of price evaluation of the product: 20 yen/kg |

*Additional income may be expected to accept plastics waste from waste collectors.

# Thank you for your kind attention.




Life Longevity of Plastics/Metal Materials

# Total Integration in "Resources-from-Biowaste" Model

*Sustainable Use of Wood Resources*

**Carbon Field**

**Logging Residues**

Barks

**【Core Tech.】 SCW Reactor**

Multiple-function Recycling Machine

Creation of Recycle-oriented Sustainable Community Models

**Wood-based Cattle Feed Hub**

Ranchers & Breeders

**Domestic Waste**

(Biowaste Portion≒60%)

Separation

Collection of Excreta

**Bio-Waste**

- Urban Biowaste
- Food Residues
- Animal Excreta
- Barks, etc.

**Biomass Field**

**Recycling Hub**

**Value-added Organic Farming**

*Reduction of massive chemical fertilizer use in farmlands*
*Production of value-added agri-business.*

*Volume Reduction of Plastics Waste*

**Functional Compost**
(Bio-pesticide Effect)

*Prevention of Water Contamination by Garbage Landfill System*