Ocean Plastic Turned into an Opportunity in Circular Economy

OPTOCE

9 August 2022

Norad SINTEF Norwegian Ministry of Foreign Affairs

1. Introduction

This project is part of the Norwegian Development Programme to Combat Marine Litter and Microplastics launched in 2018. The programme is intended to contribute to Sustainable Development Goal (SDG) 14.1 which states that by 2025, the world should prevent and significantly reduce marine pollution of all kinds (Regjeringen, 2020).

2. The problem

An estimated amount of 13 million tonnes of plastic leak into our oceans every year, harming biodiversity, economies, and our own health (The State of Plastics, 2018). If nothing is done, the amount is expected to triple by 2040 (Breaking the Plastic Wave, 2020).

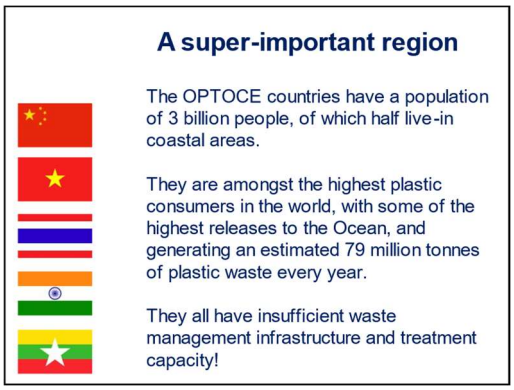
3. Reasons of the problems

International action is key to tackle the most significant sources of plastics litter in the oceans, i.e., insufficient waste management in developing countries and emerging economies, especially connected to major world river basins, dumpsites/landfills, and industrial hotspots.

It is estimated that more than 80% of marine debris comes from land-based sources and Asian countries are among the top contributors to marine litter and microplastics (Jambeck et al., 2015).

4. Objective of OPTOCE

The regional project Ocean Plastic Turned into an Opportunity in Circular Economy OPTOCE will showcase how the cement industry can be involved and increase the treatment capacity for Non-Recyclable Plastic Wastes in China, India, Myanmar, Thailand, and Vietnam and thereby contribute to reduce the release of plastics to the Sea.



These countries are producing an estimated 217 000 tonnes of plastic waste every day, or 79 million tonnes/year, and have some of the highest releases of Plastics to the Sea. Relatively small quantities are handled in an environmentally sound way.

But they also have the highest industrial production of cement, steel, and electric power, using huge amounts of coal and contribute with a large chunk of the world's CO_2 emissions.

Replacing parts of the coal with non-recyclable plastic waste constitute a win-win opportunity, preventing the plastic from ending up in the ocean, reducing the need for large amounts of fossil coal and indirectly reducing greenhouse gas emissions by avoiding building new incinerators or landfills.

This is called Co-processing or Integrated waste management.

What is considered waste in one sector becomes a resource in another. This concept represents circular economy in practice and incorporates waste treatment with existing industrial production, which is also preferred to Incineration and Landfilling in the internationally accepted Waste Management Hierarchy.

5. Additional Objectives

Additional objectives and synergies of the OPTOCE-project will be the following:

- Reduce marine debris from land-based activities.
- Enhance multi-stakeholder coordination and partnerships.
- Promote private sector engagement.
- Strengthen research to support science-based policy and decision making.

6. Where does all the plastic go?

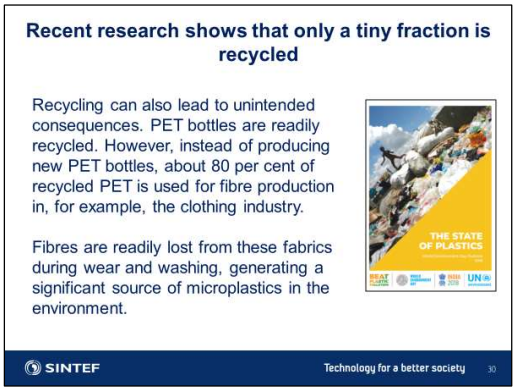
An estimated 9.3 billion tons of virgin plastics was produced globally up to 2019.

Out of this, around 6.3 billion tonnes have ended up being plastic waste; of this, only 9% was recycled, 12% incinerated and 79% dumped.

If current production and waste management trends continue, roughly 12 billion tonnes of plastic waste will be in landfills or in the natural environment by 2050 (Geyer et al. 2017).

7. What about Recycling?

Recycling is the preferred option but not all plastic waste is suitable for recycling. From a technical aspect, it is challenging to recycle plastic that consists of several types of polymers, as you need to separate them.



From an economic perspective, the recycling sector suffers if the oil prices go down.

Studies from Asia has shown that the recycling sector saw a 50 percent drop in demand and a 20 percent drop in prices during the Covid-19 pandemic.

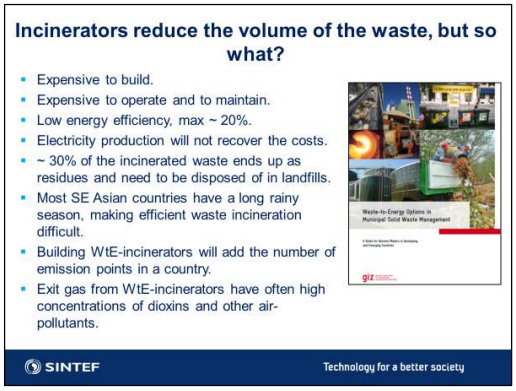
Studies has also shown that most of the plastic that ends up in the oceans is low-quality plastic that is hard to recycle (Ocean Conservancy, Stemming the Tide, 2015).

8. Incineration is becoming increasingly popular

Energy recovery from wastes and plastics in Municipal Solid Waste Incinerators with Waste to Energy (WtE) normally involves generation of electricity in steam turbines, but the conversion efficiency to electricity is poor and may not recover the construction costs (Mutz et al., 2017).

WtE-plants are expensive to build and operate, they represent an additional emission source and produce large amounts of residues (exit-gas cleaning residues, fly ash, bottom ash etc.) that need to be treated/landfilled.

Incineration of wet wastes in the rainy season is another challenge, which causes difficult burning conditions and often results in elevated emissions.



9. What about integrated options?

Countries with cement industry may to a certain degree forego building expensive WtE-incinerators.

Cement kilns are already in place and operation and may increase the waste treatment capacity significantly if integrated into the waste management strategy. They are usually cost-efficient and do not produce any residues that needs disposal.

Co-processing of wastes in cement kilns versus incineration

	Cement kilns	Incinerators with generation of electricity/steam
Purpose	Industrial production of cement clinker	Reduce the volume by burning
Temperature ranges	1500-2000 ºC.	800-1100 ºC
Construction investment costs	Facilities are already in place and operates at all time. The industry bears the investment and operation costs	Expensive to build, operate and maintain
Cost	Usually cost-efficient	Varies widely; 10-200 USD/t of waste
Energy efficiency	Approaches 100%.	Low energy efficiency, range 15 ~ 25%. Electricity production will not recover the Construction costs
Waste types versatility	Certain limitations; pre-treatment of the wastes is usually needed	Wet wastes in rainy season makes operation difficult and will lead to elevated emissions
Production of residues	Usually no residues to dispose of	25-35% of the incinerated waste ends up as residues and need disposal
Emissions	Normally unaffected if properly operated	Exit gas have often high concentrations of dioxins and other air-pollutants
Green house gases	Reduces CO2 emissions compared to landfilling or incineration the same waste	Building WtE-incinerators will add the number of emission points in a country

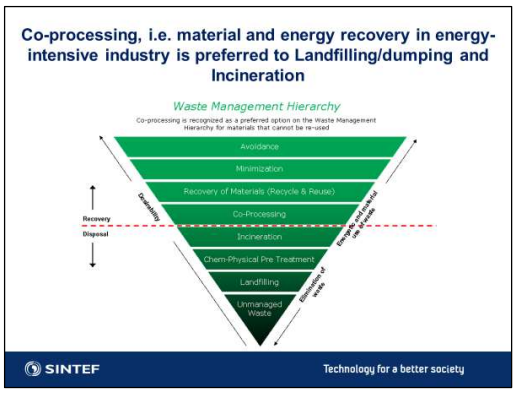
10. Possible to use Cement kilns?

Cement kilns have proven to be effective means of recovering value from waste materials and co-processing in cement kilns is now an integral component in the spectrum of viable options for treating several waste categories, practised in developed countries for the last four decades.

The two cement plants we have in Norway, replace today around 75% of its coal with waste, including plastic, and this has been the only treatment option for disposal of organic hazardous wastes in Norway for the last 30 years – a dedicated incinerator for hazardous wastes was never built.

This practice has been cost-effective, resource-efficient, and environmentally sound compared to incineration. The energy utilization efficiency is much better than in an Incinerator with WtE – and no residues are produced, compared to around 30% in a WtE.

A preheater cement kiln possess many inherent features which makes it ideal for waste treatment; high temperatures, long residence time, surplus oxygen during and after combustion, good turbulence and mixing conditions, thermal inertia, counter currently dry scrubbing of the exit gas by alkaline raw material (neutralises all acid gases like hydrogen chloride), fixation of the traces of heavy metals in the clinker structure, no production of by-products and efficient recovery of energy and raw material components in the waste.

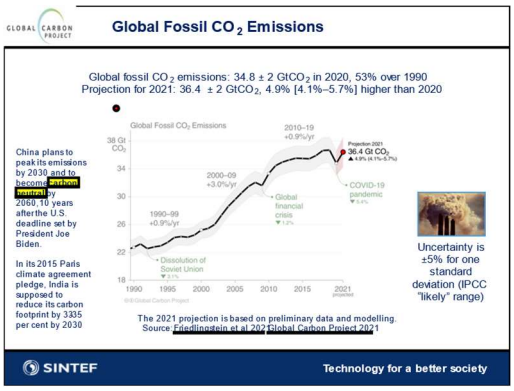


11. A win-win opportunity?

As not all plastic waste can be recycled, we need to find additional solutions to avoid that the plastic strangles us and our planet!

The OPTOCE project is expected to uncover an untapped potential to remove, treat and beneficially utilise non-recyclable plastic wastes by the private sector.

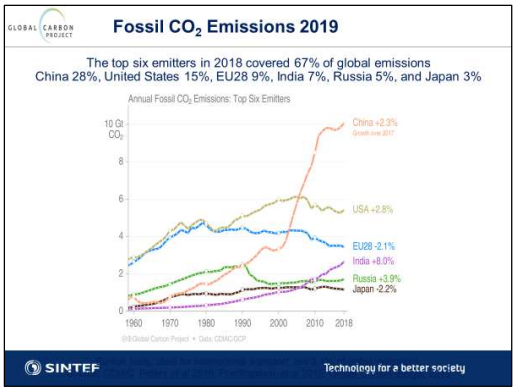
Research has shown that co-processing mixed plastic waste can potentially save as much as 1200 kg CO2-equivalents per ton waste treated, when accounting for avoided emissions from provision and usage of coal (Astrup, Fruergaard and Christensen, 2009).



The world likely needs to halve greenhouse-gas emissions within 2030 to prevent dangerous levels of global warming.

Global carbon dioxide emissions from fossil fuels will rise in the coming years due to Geo-political factors like war in Ukraine.

Slight declines in the US and EU were offset by projected increases in China, India, and other parts of the world, where economic growth is fuelling rising energy demands.



12. We want to showcase the plastic removal potential through local proof of concept

OPTOCE is carrying out Pilot Demonstrations in local cement plants to investigate and document the feasibility, to prove the concept under various local

conditions and to uncover potential limitations of the practice.

We have entered into agreements with central and local authorities, and with leading Waste management companies and Cement industry in all the OPTOCE-countries; we have agreements with universities and NGOs and will cooperate with international organisations like the World Bank, UNDP, UNEP etc.

Pilot Demonstrations will compare the technical and environmental performance under Baseline conditions, i.e., when using coal only, with co-processing conditions where various sources of non-recyclable plastic waste are used as a co-fuel together with coal.

Independent and accredited third party companies will sample and analyse pollutants in the stack emissions. Possible impacts on the process and the product quality will be assessed. Results will be published in scientific Journals.

The overall aim is to provide a quantitative and qualitative assessment of how the involvement of private industry can improve plastic waste management and prevent marine litter reaching the ocean in each country.

13. Pilots was conducted in China in December 2020

The Yangtze River in China is draining waste materials from hundreds of millions of people which leads to turbine problems in a large hydropower dam called Three Gorges located in Hubei Province.

We entered into an agreement with Huaxin cement in the town of Zigui, located upstream of the dam, to document the possibility of collecting and co-processing floating materials from the river, including large quantities of plastic.

A Pilot Demonstration was conducted in Yangtze River with Huaxin Cement in December 2020. The result – as much as 20 000 tons of plastic waste can yearly be prevented from potentially reaching our oceans.

The OPTOCE-project also investigated the feasibility of using MSW as Refuse Derived Fuel (RDF) from Zigui city as co-fuel.

The feasibility of disposing low-infectious Covid-19 hospital and health care plastic wastes in cement kilns around Wuhan has also been investigated.

14. Pilots was conducted in Vietnam in December 2021

Asian paper mills use mostly used paper and cardboard imported from Europe and the Middle East in their production of new paper. Used paper with laminated plastic is a major waste problem throughout Asia.

We entered into an agreement with Vietnam's largest Paper producer, which is located at the Mekong River and produces large quantities of Non-Recyclable Plastic

Waste, such as pieces of tape, laminated plastic pieces and stickers

In December 2021 we conducted a pilot demonstration in the INSEE cement plant located in Hon Chong, Kien Giang province, to assess the feasibility of using non-recyclable plastic waste from Vietnams biggest paper recycling plant and Rubber waste from shoe/footwear-manufacturing as co-fuel.

15. Planned pilots in Thailand

Some Waste landfills and dumpsites in Thailand contain up to 42% plastic. There are about 2500 of these scattered around the country, which together will contain up to 190 million tonnes of accumulated plastic waste if representative (Sharma et al., 2020).

We have entered into an agreement with the second largest cement producer in the country, which extract plastic waste from dumpsites and use it as a coal substitute.

There is a great interest in utilizing resources and cleaning up landfills and dumpsites in Asia - they occupy large areas of valuable land and contributes with local and global pollution.

We intend to investigate and document the environmental implications and benefits of landfill mining together with the Asian Institute of Technology. The pilot demonstrations will be conducted in 2022.

16. Pilots in India

We have agreements with central and local environmental authorities in India, as well as the country's largest waste management companies, to demonstrate the feasibility of handling Non-Recyclable Plastic Wastes from major cities such as Nagpur.

17. Pilots in Myanmar

Myanmar has currently no treatment options for non-recyclable plastic wastes but due to the military coup in February

2021, the project activities in Myanmar have been put on hold.

We will, if possible initiate demonstration experiments in cement factories outside Mandalay and Yangon and assess whether plastic waste can be handled in an environmentally sound manner by the industry.

18. Academic Collaboration

An Academic Collaboration was launched in the partner countries in 2020.

The objective was to build competence on treatment options for Non-Recyclable Plastic Wastes (NRPW) and provide better knowledge about the NRPW situation in the countries. Parallel MSc-thesis research has been carried out in four partner countries.

Some of the topics of the finished and on-going studies are:

- Non-recyclable plastic waste (NRPW) generated in cities and municipalities: how much NRPW is generated, how does the informal waste collectors assess recyclable versus non-recyclable and how is the NRPW disposed of.

- NRPW in dumpsites/landfills: how much NRPW and which kinds of NRPW are accumulated in dumpsites, and how much/how is it released to nearby waterways/groundwater.

- NRPW in landfill/dumpsite mining: how can landfill mining contribute to mitigate the leakage of plastic waste to the ocean, how can quality fuel be produced from the landfill NRPW, and what can be done with the rejects.NRPW in rivers: how can floating materials in rivers, including NRPW, be removed from the rivers and treated in an environmentally sound way.

19. Marine Plastic Abatement

The Asian Institute of Technology in Thailand launched the first postgraduate program on marine plastic litter in the Asia, called Marine Plastic Abatement (MPA) in 2020.
https://www.ait.ac.th/2020/04/ait-launches-marine-plastic-litter-msc-with-us-3-mil-japanese-grant/
This programme is supported by the Japanese Government and funds one-year MSc-scholarships for many students.

OPTOCE has been involved in the development of the course curriculum, in teaching and in relevant research and student follow-up.

20. Capacity Building

Lessons learned from OPTOCE pilot demonstrations and from the academic collaboration will be shared through a regional multi-stakeholder forum, enabling awareness raising, capacity building and replication across the continent. The first

forum is planned organised in Bangkok 27-28 October 2022.

21. Main conclusions of the Pilots up to now

The two Pilots conducted in China and Vietnam have tested four different types of large volume non-recyclable plastic waste and demonstrated that co-processing in local cement kilns is technical and environmentally feasible.

The tests showed that the emissions of dioxins are unaffected by plastic-waste feeding and in compliance with the most stringent international emission limit value, 0.1 ng TEQ/Nm^3.

Such practice will increase the local treatment capacity significantly, save large amounts of coal, and reduce the release of plastic/microplastic to the East and South China Sea.

22. Selection of articles and publications

An overview of articles, publications presentations, and other links can be found on our webpage: https://optoce.no/

23. Contact/information

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Ocean plastic: an opportunity in the circular economy?

A few articles about the use of Cement Kilns:

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Karstensen, K.H. et al., 2014. Destruction of concentrated Chlorofluorocarbons in India demonstrates an effective option to simultaneously curb climate change and ozone depletion. Environmental Science and Policy, 38 (2014) 237-244. ISSN No. 1462-9011.


Article in International Cement Review, March 2020

Asia's plastic potential