POLITECNICO DI TORINO



MASTER OF SCIENCE PROGRAM IN ARCHITECTURE FOR THE SUSTAINABLE DESIGN

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RESHAPE THE FUTURE OF PLASTICS WASTE

Candidate:

Supervisor:

Brunelli Anna Tulliani Jean Marc Christian

Department of Applied Science and Technology

...to all the brightest sides I found and didn't know mine

Try to imagine a world without plastics.

At first it seems easy.

Lots of things could be made of other materials.

[...]

Without belaboring the obvious, few of the objects we use daily would remain unchanged.

Some would be impossible.

We would inhabit a different world, parallel perhaps, but certainly not the same place.

> Jeffrey I. Meikle American plastic, a cultural history, 1995

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Today plastics are everywhere, try to imagine a world without plastics.

Lots of things could be made of other materials.

Eyeglasses could be made of glass and metal, computer cases of metal sheets, automobiles without plastics would become heavier and consume more fuel, frisbees would not exist, nor would compact disc. The list could go on and on.

We would inhabit a different world, parallel perhaps, probably better, or maybe worst but certainly different.

The 21st century society is blinded from the new trend of 'zero plastics', 'plastics free', 'bio', 'eco', 'zero impact' and so on slogan promoted by the big industry giants which rule world economy.

Learn and get informed about all the characteristics of this ubiquitous material is the only way that people have for try to limit plastics pollution.

This strong statement derived from a discussion that i had with my friend while we were having a meal.

She supported that people cannot use more plastics, that plastcs materials must be banned and so on.

While she was speaking testily about turtles trapped in nets, birds stomach filled of plastics, waterflows of bottles and so on, she was blending her coffe with a plastics spon, wearing plastics sunglasses, her slippers were entirely made of plastics, she came with plastics components car and drunk her water from a recycled PET bottle.



Hung I-chen, Guo Yi-hui e Cheng Yu-ti (Artists), 2017 Polluted Water Popsicles



After a while, during an university lesson, the teacher started speaking about plastics material and all the different charachteristics that this material hides. This developed in me a strange curiosity about this topic and from then start interest and researches about the wide world of plastics material.

The desire to deepen all the different aspects of plastics material starts from here.

Main aim of this work is to give a general overview of plastics.

Starting from its roots, from its first appereance in human life through the most important findings made until today, highlighting discoveries and bans.

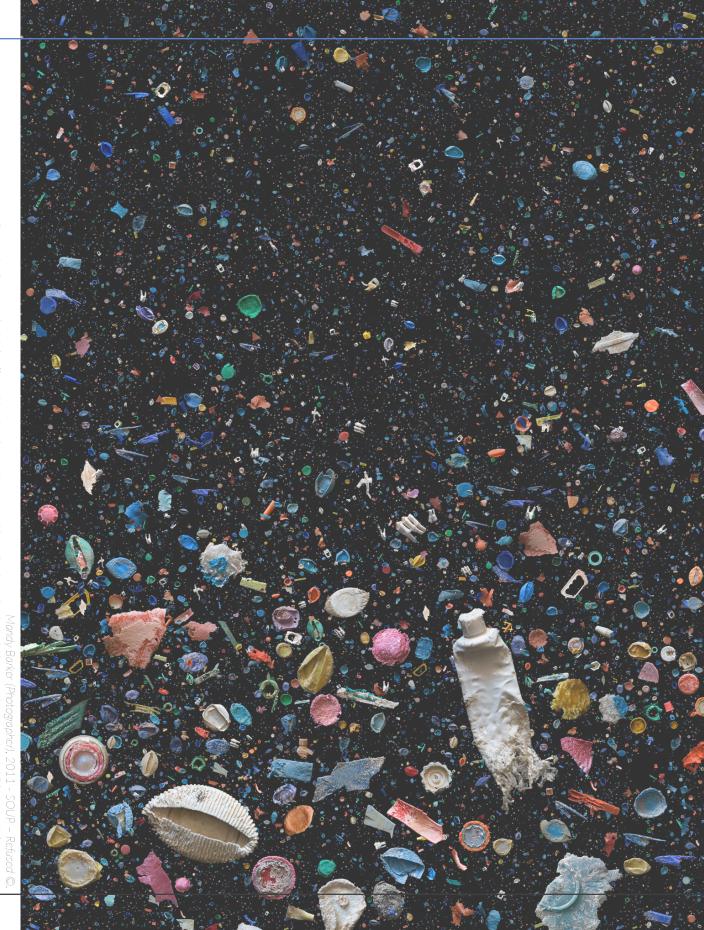
Getting inside the plastics chemical structure, the work flows over its production, demand and finally recycle highlighting the societal benefits.

These awarnesses could give a better understanding about all the effects that plastics wastes involves for the planet Earth and in detail how it acts on environment, on biota and on humankind.

Last, but not least, part develop the new age of plastics: exploring the articulated world of the company TheOceanCleanUp, the section would highlight some of the different organizations which act for clean up the planet guided from the same goal: use the already producted and discarded plastics for make neverend-of-use objects.

From building blocks of the ByFusion company to paving blocks of the Kenyan engineer Nzambi Matee, getting through some of the more active in the market companies which product design objects made entirely of recycled plastics.

The main goal of this thesis is to expose, without taking parts, how people could give to plastics another precious life instead of discarded it.



Plastics Age is not only the famous album of The Buggles. Plastics Age is today.

The past is categorized by named periods of time called ages. The most important ones are associated to the discovery of the most used material of that time which has driven, in a way or in another, the development of human beings.

First one was the Stone Age when our ancestors made their first stone tools used for the vital needs such as hunting.

Later, throughout the Bronze and Copper Age, societies began consciously to smelt and cast metals. Simultaneous with these technological innovations changes in settlement organization and ritual life happened, and the interactions between the different societies increased.

The characteristic of Iron Age culture is the mass production of tools and weapons replace their bronze equivalents in common use. The use of iron became more widespread after people learned how to make steel, typically alloys with a carbon. The use of steel has been based as much on economics as on metallurgical advancements.

Glass in its natural form has been on Earth since lightning first struck sand to produce fulgurities of fused quartz, which is to say long before humans started experimenting with.

But Glass Age can be traced back to when the Egyptians and Mesopotamians started to produce jewelry in the form of beads.

Plastics Age starts with the earliest form of natural polymer used by humans which included horn and

tortoiseshell. The first known reference, was when the ordinances of Horners Company of London were 'corrected' in 1284, making it one of the most ancient of livery companies.

The first man-made plastics was invented by a chemist, Alexander Parkes, who exhibited his Parkesine a nitrocellulose compound at the Great London Exposition. But the first fully synthetic plastics was Bakelite, invented in New York by Leo Baekeland, who also gave us the term 'plastics'.

Today plastics is both an icon of prosperity and a cautionary example of how linear models of consumption can undermine Earth's planetary limits.

Depending on your point of view, these petrochemical derivatives have the potential to stimulate the economies of emerging nations or create environmental meltdown.

Plastics has been long valued for its consumer benefits: affordability, lightness, low cost, convenience, performance, flexibility, durability, but a rapid shift in awareness among governments, civil society, investors, producers, and consumers is leading to increasing demands that industry takes the necessary steps to embrace circular economy approaches and mitigate climate change.

Plastics clearly constitute an important component of the range of materials used in modern society. Almost all aspects of daily life involve plastics or rubber in some form or the other.

The matter is not the ban of the plastics altogether, but the people must reset their relationship with it.

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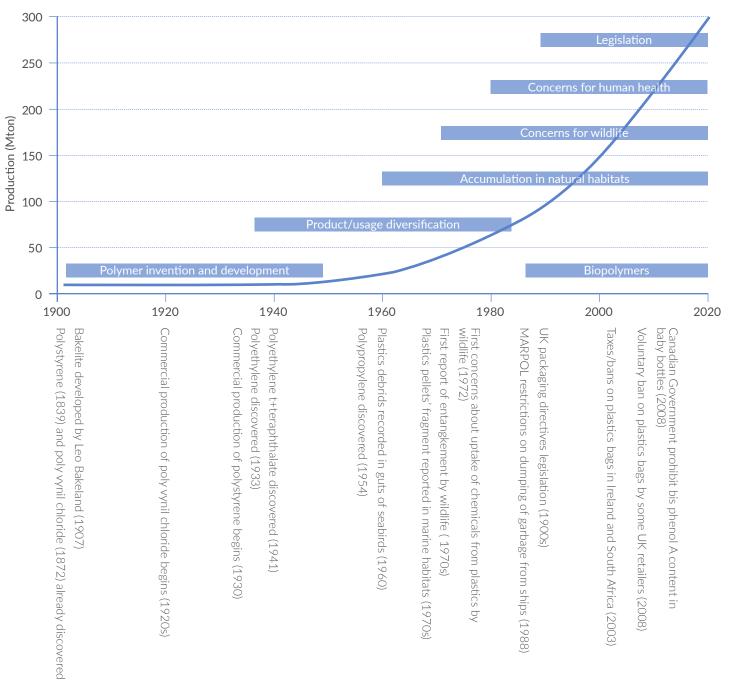












Summary illustrating historical stages in the development, production and use of plastics together with associated concerns and legislative measures. Blu line shows the evolution of the plastics production in millions of tonnes (Mt).

Combs are one of human oldest tools, used across cultures and ages for decoration, detangling, and delousing. They derive from the most fundamental human tool of all: the hand. And from the time that humans began using combs instead of their fingers, comb design has scarcely changed.

The Stone Age craftsman who made the oldest known comb, a small four-toothed number carved from animal bone some eight thousand years ago, would have no trouble knowing what to do with the bright blue plastics version sitting on every bathroom counter.

For most of history, combs were made of almost any material humans had available, including bone, tortoiseshell, ivory, rubber, iron, tin, gold, silver, lead, reeds, wood, glass, porcelain, papier-mâché. But in the late nineteenth century, that panoply of possibilities began to fall away with the arrival of a totally new kind of material: celluloid, the first man-made plastics.

Combs were among the first and most popular objects made of celluloid. And having crossed that material, comb makers never went back. Ever since, combs generally have been made of one kind of plastics or another.

The story of the humble comb's makeover is part of the much larger story of how human life has been transformed by plastics. Plastics freed from the confines of the natural world, from the material constraints and limited supplies that had long bounded human activity. That new elasticity unfixed social boundaries as well. The arrival of these malleable and versatile materials gave producers the ability to create a treasure trove of new products while expanding opportunities for people of modest incomes to become

consumers.

Plastics held out the promise of a new material and cultural democracy.

The comb, the most ancient of personal accessories, enabled anyone to keep that promise close.

Since the very beginning, plastics materials were born as a solution for the substitution of scarce and non-sustainable resources such as tortoiseshell, ivory or animal bones.

While the first plastics came from natural resources, including trees, over time petroleum became the primary raw material used to produce plastics.

The success of plastics as a material has been substantial; polymers have proved versatile for use in a range of types and forms, including natural polymers, modified natural polymers, thermosetting plastics, thermoplastics and, more recently, biodegradable plastics. Plastics have a range of unique properties: they can be used in a very wide range of temperatures, are chemical- and light-resistant and they are tough, but can be easily worked as a hot melt.

From the alone bathroom plastics object, today plastics are ubiquitous; only over the past century or so, plastics have taken over from other materials to become common in our homes, work activities, cars, toy boxes: the use of lightweight plastics components in cars and airplanes to reduce fuel usage; the use of inexpensive plastics casings to make information technology and electrical goods far more readily accessible than would otherwise have been possible; and the use of plastics for sterile dressings and medical products.















PRE 1900

The earliest form of natural plastics used by man included horn and tortoiseshell. 1284 sees the first mention of the Horners Company of London. The first known reference to it was when its ordinances were 'corrected' in 1284, making it one of the most ancient of livery companies. Horn is made of natural polymer (keratin), which allows it to be molded into many articles, such as beakers, utensils, combs and buttons, but its greatest use, right up to the 18th century was in being beaten into translucent sheets to be fabricated into lantern leaves and even windows.

Time goes on and the following reference is about Charles Macintosh, a Scottish chemist, who devoted his life to science. In 1823 his experiments with naphtha led to his invention of waterproof fabric. By sandwiching a layer of liquid rubber (made with naphtha) between two layers of fabric, Macintosh had created a new material that would be resistant to water while also remaining flexible and wearable. Resistant to wet and rainy conditions, the new fabric was perfect for making coats, the Mac was born.

The latest '30 of the Nineteenth Century sees the invention of the vulcanized rubber made by the engineer Charles Goodyear.

In 1839, Goodyear was at the Eagle India Rubber Company in Woburn, Massachusetts, where he discovered that combining rubber and sulfur over a hot stove caused the rubber to become rigid, a process which he called vulcanization because of the heat involved. Together with an old business partner, he built up a factory and began to make clothing, life preservers, rubber shoes, and a great variety of rubber goods.

Meanwhile in Berlin, the apothecary Eduard Simon accidentally discovered polystyrene. During the distillation of an oily substance derived from the Sweetgum tree, he found the 'styrol' which, several days later had thickened, probably due to polymerization, into a jelly which he dubbed styrol oxide 'Stryroloxyd'.

Next step is for gutta percha, also known as balata, it is a natural thermoplastics of fundamental importance in the history of the plastics industry.

This new material was soon adopted by a vigorous innovative society and by the time of the Great Exhibition in 1851 a host of different applications had been found covering many aspects of those day-life. The major use of gutta percha was for the insulation of submarine cables which revolutionized communica-

1 2 8 4
First mention of the
Hornest Company of London



1 8 2 3 The Mac was born



tions throughout the world.

A revolution of a different kind resulted from the introduction of gutta percha for golf balls in 1848. Until then feathers encased in leather was used which was very expensive and quickly became unplayable in wet weather. Balls made of solid gutta percha had no such disadvantages and their cheapness and reliable performance was a major influence in the vast expansion of the game in subsequent years.

Another innovation was the development, also in 1848, of a dental stopping compound which is the forerunner of all temporary filling materials in use to-day.

The excellent molding properties of this material are still exploited for making replicas of medals and coins and, coloured red, for seals on official documents in Scotland.

It was 1862 when Alexander Parkes introduced the world's first-ever man-made plastics, at the London International Exhibition. 'Parkesine' as it was called, was marketed as an alternative to ivory and horn that Parkes discovered while trying to develop a synthetic substitute for shellac for waterproofing.

Even though the product was not a commercial success, Parkesine represented an important first step in

the development of man-made plastics. The material didn't start to truly show its potential value and diversity of applications.

In the 19th Century, the excessive hunting of elephant aimed to use their tusks for get ivory, caused the giant population decline. Main application of ivory was for the production of billiard balls.

Therefore, billiard balls maker began to look for alternatives offering huge rewards.

So, an American named John Wesley Hyatt took up the challenge.

Over the 70' of the 19th century he discovered a way to manufacture an improved version of Parkesine, most commonly known as celluloid, made from cellulose, a compound found in wood and straw.

Hyatt soon understood that celluloid could not solve billiard ball problem.

The material wasn't heavy enough and didn't bounce quite right but it could be tinted and patterned to mimic more expensive material like coral, tortoise shell, amber and mother-of-pearl.

He created what we can name as the first plastics.

While on holiday in Santo Domingo, George Eastman

1 8 3 9
Vulcanized rubber
invented rubber shoes



Accidental discovered of **Styroloxyd**, the granfather of polystyrene



1 8 5 1

Gutta percha revolutionized comunication



1862

Introduction of the **Parkesine** the first-ever man-made plastics





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Kodak, decided to document the trip. But the photography equipment alone was enormous, heavy and costly.

Instead, he began researching how to make photography less cumbersome and easier for the average person to enjoy. After seeing a formula for a 'dry plate' emulsion in a British publication, and getting tutelage from two local amateur photographers, Eastman formulated a gelatin-based paper film and a device for coating dry plates.

He resigned from his bank job after launching his fledgling photography company in April 1880.

In 1885, he headed the patent office with a roll-holder device that he and camera inventor William Hall Walker had developed. This allowed cameras to be smaller and cheaper.

One story mentions that one night, one cat in one lab, knocked over a bottle of formaldehyde which dripped into the hapless animal's dish of milk.

In the morning, the owner discovered that the formaldehyde had curdled the milk into a solid, horn-like material, which set him off on a train of research and development. Once their method was perfected, Krische and Spitteler set up the first company to make casein plastics on an industrial scale and filled in a patent for their new milk-based material in 1899. It was quickly taken up by manufacturing firms across Europe eager for new plastics to play with.

Sometimes described as 'the most beautiful of plastics', buttons, buckles, knitting needles, jewelry, pens, pots and much, much more were quickly crafted from solid casein. For the fashion-conscious, it could be easily dyed into a rainbow of different colors, although there were many different brand names for casein-based plastics like Lactoid, Aladdinite, and Galalith (Greek for 'milk stone').





1 8 8 5
Eastman formulated a gelatin-based paper film



1889

Spitteler's cat discovered

Galalith



EARLY '50s of 1900

The 20th Century was the beginning of the industrialization of the plastics material's production.

In little more than a century, plastics have spread through the material world, moving from almost no presence at all to near ubiquity.

In 1903, Arthur Eichengrün co-developed the first soluble form of cellulose acetate called Cellit.

He developed processes for the manufacture of cellulose acetate materials and during First World War. These relatively non-inflammable synthetic cellulose acetate lacquers were important in the aircraft industry.

In 1907 Leo Baekeland, an American chemist, combined phenol, the waste product of coal-tar, and formaldehyde, creating a hardy new polymer called Bakelite, the world's first entirely synthetic plastics. Bakelite was much less flammable than celluloid and the raw material used to make it were more readily available.

In the 1916, the Rolls Royce company begins to use phenol formaldehyde resin, known also as Bakelite in its cars and boasts interiors. Bakelite was only at the beginning.

In 1900, inspired by seeing wine spill on a restaurant's tablecloth, the Swiss chemist Jacques Brandenberger decided to create a cloth that could repel liquids rather than absorb them. His first step was to spray a waterproof coating onto fabric, and he opted to try viscose. The resultant coated fabric was far too stiff, but the diaphanous film coating could be separated from the backing cloth easily and in one undamaged piece.

It took ten years for Brandenberger to perfect his film. His chief improvement over earlier work with such films was adding glycerin to soften the material. By 1912 he had constructed a machine to manufacture the film, which he had named Cellophane, from the words cellulose and diaphane ('transparent'). Cellophane was patented that year. The following year, the company Comptoir des Textiles Artificiels (CTA) bought the Thaon firm's interest in Cellophane and established Brandenberger in a new company, La Cellophane S.A.

The term 'plastics' is introduced for the first time in 1925 to describe the new group of compounds that are becoming more widely used. Its roots are from

1 9 0 3

Cellit improve the performance of the aircraft industry



1907

Bakelite: the world's first entirely synthetic plastics



1916

Phenol formaldehyde resin used in Rolls Royce



the Latin word 'plasticus' (to mold) and from the Greek word 'plastikos' and 'plassein' (to form).

Rossiter at British Cyanide develops urea thiourea formaldehyde resins, subsequently commercialized as the first water white transparent thermosetting molding powder. These lightweight plastics were made in pastel colors for inexpensive clock cases and radios.

The already known and produced polyvinyl chloride yielded difficulties in processing the rigid, sometimes breakable polymer constrained their efforts.

Waldo Semon and the B.F. Goodrich Company worked on the problem and finally in 1926 they developed a method to plasticize polyvinyl chloride by blending it with various additives. The result was a more flexible and more easily processed material that soon achieved widespread commercial use.

Polymethyl methacrylate was discovered in the early 1930s by British chemists Rowland Hill and John Crawford. The pioneers attempted to produce safety glass by polymerizing methyl methacrylate between two layers of glass. The polymer separated from the glass as a clear plastics sheet, which they gave the trademarked name of Perspex.

Meanwhile in Germany, the chemist and industrialist

Otto Rohm was working on the same innovative material registrered it as Plexiglass.

It was 1935 when the most common and produced plastics was invented.

The first industrially practical polyethylene synthesis was again accidentally discovered in 1933 by chemists of the Imperial Chemical Industry. Upon applying extremely high pressure, they produced a white, waxy material; nevertheless, starting contamination of oxygen made the experiment unrepeatable.

Michael Perrin developed this accident into a reproducible high-pressure synthesis for polyethylene that became the basis for industrial low-density polyethylene. It becomes the most common plastics produced in the world. High density poly ethylene (HDPE) is used to make milk jugs and bottles. Low density polyethylene (LDPE) is used to make plastics bags and squeezable bottles.

This story began on 1938 while J. Plunkett was working with gases related to refrigerants. After checking a frozen, compressed sample of tetrafluoroethylene, he and his associates made an unexpected discovery: perfluoroethylene was polymerized with the iron from the inside of the container having acted as a catalyst at high pressure. They registred the new ma-



1 9 1 2
Brandenberger:
from wine
to cellophane

1 9 2 6
Developed plasticized PVC



1 9 3 0
Plexiglass
was layered

1 9 3 5
Perrin reproduce the accidental finding of HDPE and LDPE

terial as Teflon.

A few years later, Colette Grégoire convinces her husband to put Teflon on her cooking pans, and they create a product still in use today: non-stick pan.

Meanwhile the American company DuPont released a nylon-bristled toothbrush. A year later, it introduces women's nylon stockings. Nylon fibers soon become popular for dress fabrics, carpets, tents and many other products.

In 1944 Ray McIntyre and Dow Chemical Company produced a lightweight water-resistant material, patenting it as Styrofoam. Polystyrene is currently used for many purposes. Rigid or molded polystyrene is used for food and drink containers, while foam and expanded polystyrene is used in packaging and building insulation.

In 1946, Earl Tupper first purified opaque, greasy, clumpy black polyethylene slag, waste product of the industry where he worked.

He and his son boiled the scrap samples at home, eventually finding the right balance of pressure and temperature so the polyethylene flowed into the desired shapes and thickness. Tupper also fashioned a

system for dyeing his containers in pastel colors. Thereafter, the Tupperware company never stopped producing product bowls that every kitchen in the world must have.

Acrylonitrile butadiene styrene (ABS) is a thermoplastics polymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. It was first patented in 1948 and introduced commercially in 1954. This plastics is best known for its toughness, which is the reason LEGO chooses this material when designing and patenting its trademark bricks in 1958.

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1 9 3 8Teflon filmed pan started save dinners first entrance



Nylon fibres first entrance in the daily life products

1 9 4 4 Stylofoam discovered by Ray McIntyre



1 9 4 6
Polyethylene slag waste
became Tupperware



1 9 4 8 LEGO choosen its type of plastics ABS is patented

LATE HALF OF 1900

During these following decades, almost all the polymers that could be discovered have been.

The focus is now on the management of plastics and mostly the waste that the popular single-use objects discard in the environment.

1953 was the time of the commercialization of polyester fibers.

Based on polyethylene terephthalate, it spread in the clothing industry and its use is currently diffuse.

For those years it was a great innovation because the new textile material introduced the concept of 'dipdry' and 'non-iron' clothing.

Before its innovation, hoops were made of willow, rattan, grapevines, stiff grasses, metal or wood and primary were used for medical treatment.

International popularity was gained by its plastics version which successfully joined the market in the 1957.

Another of the five most common plastics were discovered in the early 50s. The polymerization of the polypropylene was first demonstrated by American chemists but its large scale commercial production was led by the Italian company Montecatini from

1957 onwards.

Polycarbonate was first discovered at the end of the 19th Century but without commercialization of the product. It is a group of polymers containing carbonate groups in their chemical structure. Their commercialization starts in 1958 when the Bayer's group patented the product named Makrolon.

Mattel, an American toy company, launched in 1959 the first ever Barbie fashion doll made of polyvinyl chloride. Barbie and her boyfriend Ken will be the most famous dolls in the world.

1961 was the year of the shifting focus.

The Keep America Beautiful, a no-profit organization, popularized the idea that individuals must help protect against the effects litter has on the environment, they shifted the problem of plastics wastes from plastics producers to consumers.

The story tells that one day of 1965, one woman chemist, Stephanie Kwolek, convinced her chief to test her solution. The solution was cloudy, opalescent upon being shaken, and of low viscosity that was usually thrown away but it was five times stronger



1 9 5 3Textile industry innovation: **Polyester fibers**



1 9 5 7 LDPE Hula Hoop join the market

PP was finally commercialized

1 9 5 8 Makrolon spread into market the polycarbonate products



2

than steel. The Kevlar was born. It's one of the most expensive and strong synthetic fibers material in the world.

Neil Armstrong posed the American nylon flag on the moon.

On the first page of the New Zealand journal Notornis, in a 1977 daily morning, the citizens found the reports that 15% of dead prions, kind of seabirds, examined from 1958 to 1977 contained plastics pellets. These findings showed that plastics debris has been in our local oceans since the early 1960s.

Until 1979, all the windows were made of alluminum, steel or wood. But one day the PVC-u double glazed windows appeared on the market. The U stands for unplasticized and it means that the material has not been softened by the addition of chemicals known as plasticizers.

A number of rubber pump and aluminum chambers were composed together and for the first time in 1982 an artificial heart was transplanted by the scientist Dr. Robert Jarvik and the patient survived for 112 days.

New plastics arrived in the market: polyether ether ketone (PEEK), polyphenylene sulfide (PPS) and polyether sulfones (PES), all of them discovered few years before.

PEEK is an organic colorless polymer used in engineering applications. PPS is also an organic polymer and the synthetic fiber and textiles derived from it resists chemical and thermal attack. PES is a high performance thermoplastics and is usually used as a superior replacement for polycarbonates.

One day of the 70s, in California, a large producer of recycled paperboard launched a contest for art and design students at high school in response to the First Earth Day.

Gary Anderson, a senior student, won the contest with an interpretation of the Mobius Loop, a mathematical object. From 1988 it became the international symbol for recycling activity.

From the First Earth Day the focus starts to shift. The researchers started to study ways to biodegrade plastics previously discovered and, most importantly, they tried to find substitute for all of them.

So, in 1990, Imperial Chemical Industries and a local venture capital firm established the first bioplastics

1959 Barbie and Ken love story began



1965 Kevlar was born



NOTORNIS

OUARTERLY JOURNAL

Omithological Society of New Zealand

1 9 7 7
Dead prions contain plastics pellets

company, Marlborough Biopolymers. Their bioplastics was made by bacteria and was called Biopol. The bacteria-produced Biopol could be processed into strips, filaments, chips, panels and powders.

Polyester was the primary material of the famous retailer of outdoor clothing Patagonia. They chose polymers fibers for their dip-dry and lightweight characteristics.

From 1993, the brand started to use recycled PE for his pile and with the last season collection they arrived to use 88% of recycled PE in their clothing items.

Scientists had been aware of the growing problem of plastics debris in the world's oceans since the late 1980s. However, the Great Pacific Garbage Patch came to public attention only after 1997, when yachtsman Charles Moore, returning home after participating a race, chose a route that took him through the North Pacific subtropical gyre. He found himself traversing a sea of plastics. When he returned to the area the following year, he discovered that the patch had grown in both extent and density. Moore began making speeches and writing articles and he changed the mission of his Algalita research foundation.

1 9 8 8 Recycle activity triangle appeared





1 9 9 3 Patagonia brand started use Recycled PE

1 9 9 7 Awarness of the existence of the Great Pacific Garbage Patch



THE 21st CENTURY

These years are characterized by researches and development of organic substitutes of plastics and also by government, institution and other kind of organizations that try to manage waste problems and above all try to ban single-use plastics objects.

In the early years of the century, in Bangladesh there was the problem of keeping growing flooding especially during the monsoon season. Some researchers found out that plastics bags were blocking the drainage system. For this reason, the Bangladesh government decide to ban single-use plastics bag since 2002.

2004 sees the first voluntary BPA phase out made by Australian Government.

BPA, bisphenol A is a chemical compound primarily used in the manufacturing of various plastics and it's toxic for the human being and the primary source of exposure is via food. Although BPA does not accumulate within the body and the science have found out a substitute that is water-soluble and can be removed by urine.

Another country pioneered a new ban: the Netherlands in 2014 officially banned microbeads in cosme-

tics and wash-off cleaning products.

Researchers found out in 2011 that one million of plastics bags were consumed every minute.

As of July 2018, the United Nations Environment Program found that 127 out of 192 countries reviewed have enacted some form of national legislation to address the problem of plastics bags.

In the 2021 the New Zealand government revealed its plan to phase out hard-to-recycle plastics products, including single-use plastics products such as takeaway cutlery, polystyrene meat trays and takeaway packaging. A new Plastics Innovation Fund is announced to help support projects that reimagine how we make, use and dispose of plastics.

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2 0 0 2
Bangladesh
ban single-use



2 0 0 4
Australian BPA
phase out

2 0 1 4
Netherlands ban
microbeads in
cosmetics



2 0 2 1 New Zeland ban hard-to-recycle plastics products



What to do for the future of plastics?

Next step in the evolution of plastics is the most important for the human being and perhaps also for the Earth.

Further innovation has to begin with people, inside each individual, in daily life with separate collection, reuse when it's possible, textile grocery bags, paper packaging.

Legislation has already made all these actions mandatory with the Action Plan disposed by the European Commission. There, it identified plastics as a key priority and committed itself to 'prepare a strategy addressing the challenges posed by plastics throughout the value chain and taking into account their entire life-cycle'.

In 2017, the Commission confirmed it would focus on plastics production and use and work towards the goal of ensuring that all plastics packaging is recyclable by 2030.

Not only legislation has a key role on the further evolution of plastics.

The individual innovation led by awareness of plastics pollution, has to be evolved also through special actions.

All over the world uncountable action groups and events are springing up with a common goal: clean up the environment.

This evolution aimed to try to fix unaware actions made by ancestors, learn from them and won't repeat in the future all the past mistakes.

Individual actions can make the difference, groups action could get us started this evolution.



Dubai's World Clean Up Day



Kyrgyzstan's World Clean Up Day



Italy's World Clean Up Day



Mexico's World Clean Up Day



France's World Clean Up Day



Ukraina's World Clean Up Day



Hawaii's World Clean Up Day



Costa Rica's World Clean Up Day



Switzerland's World Clean Up Day

GOVERNATIVE LEGISLATION

European Commission website, We must break free from plastics!



The problem of plastics pollution has been in the European political sphere for many years. Until recently, however, the issue has been more at the periphery, as it was not considered significant enough to push up the political hierarchy. In the years preceding the call for a European Plastics Strategy and the impact assessment of the Single-Use Plastics Directive, a range of policies and initiatives were shaped by the European Commission.

In order for a specific strategy on plastics to be considered worthwhile, a combination of clearly identifiable environmental and human health pressures was necessary. These key pressures can be generalized as marine litter, hazardousness of specific additives and resource efficiency. The clarity of understanding of these problems has been evolving over time, and

the policy responses to them have been developing in tandem. However, the issue that has most pushed plastics into the consciousness of the public and politicians has been marine plastics pollution.

While there were earlier conventions related to dumping at sea, one of the first European policies related to this issue was the Port Reception Facility Directive. The Port Reception Facility Directive was introduced in 2000 with the aim to reduce waste from ships at sea, including lost or abandoned fishing nets predominantly composed of plastics.

Soon after, a communication from the European Commission in 2002 highlighted the potential need for a strategy to protect and conserve the marine

2

environment. In this document, specific reference is made to litter as a form of pollution, with 95% of litter consisting of nondegradable plastics, mainly related to waste generated by shipping and tourism and recreational activities.

This communication stimulated the development and introduction of the Marine Strategy Framework Directive in 2008.

Under the framework, Member States must take action to achieve and maintain Good Environmental Status of marine waters by 2020, part of which is ensuring that marine litter does not harm coastal and marine environments.

Around the time the Marine Strategy Framework Directive was being developed, a whole range of Euro-

pean legislation regarding hazardous substances was being harmonized.

For example, the 2006 Registration, Evaluation, Authorisation and Restriction of Chemicals regulation set the precedent for requirements regarding how properties of chemical substances, certain substances, or substances of specific concern may be evaluated and restricted.

Furthermore, in 2008, the Waste Framework Directive was revised.

This sought to formalize the management of waste and improve the efficiency of material use through the introduction of a 'waste hierarchy' and binding recycling targets, as well as including concepts such as the 'polluter pays principle' and 'extended producer responsibility', which was considered a beneficial mechanism for Member State to apply.



Mr.anaked (Photographer), Garbage in the ocean

Complementary recycling targets in the Packaging and Packaging Waste Directive included a specific target for plastics.

Although, at that stage, the recycling target was low in comparison with other materials at 22.5%.

It was important to introduce a framework for managing plastics wastes as they are a highly adaptable materials that can be manipulated with many different chemicals in order to achieve certain performance characteristics.

In certain cases, however, these chemicals can pose risks to humans and the environment. Consequently, European legislation have sought to regulate specific elements of plastics materials that could have serious consequences for human health.

The recycled plastics have to meet the same requirements as virgin materials, a condition which is independently authorized by the European Food Safety Authority.

By 2013, the pressure on the marine environment from marine plastics pollution was very apparent. Supported by the monitoring required under the Marine Strategy Framework Directive, calls for a legally binding reduction target were made.

It was argued by Sherrington et al. that focusing on implementing specific, concrete policy measures that demonstrably prevent waste and litter would be a much more effective approach than setting marine litter reduction targets.

While political pressure relating to marine litter and chemicals was building, from 2012 to 2015, a significant shift in the political mindset relating to resource efficiency also occurred. This was, in part, stimulated by the 'circular economy' concept popularized by

Ellen MacArthur. During this time, the Waste Framework Directive and Packaging and Packaging Waste Directive were also being revised, including new ambitious recycling targets for Europe.

Recycling is a core element of the circular economy and so the legal revisions were included in what became known as the 'Circular Economy Package'.

In parallel, plastics were identified as one of the five priority areas to be addressed in the 2015 EU action plan for the Circular Economy. The action plan committed the European Commission to the preparation of a strategy that addressed the challenges posed by plastics throughout the value chain. It would take into account their entire life cycle, including reuse, recyclability, biodegradability, and the presence of hazardous substances of concern in certain plastics and marine litter.

In response to the action plan, the growing understanding of the issues surrounding marine litter, and broader concern about substances used in plastics, the European Commission published two roadmaps in January 2017.

Firstly, the roadmap for a Strategy on Plastics in a Circular Economy aimed for:

- 1 Decoupling plastics production from virgin fossil feedstock and reducing its life cycle greenhouse gas impacts;
- 2 Improving the economics, quality, and uptake of plastics recycling and reuse;
- **3** Reducing plastics leakage into the environment.

The roadmap stated that achieving these objectives should contribute to implementing the circular economy action plan, as well as to the EU's jobs, growth, low carbon, and energy efficiency agendas. The Strategy further aligned EU policy with actions under the UN Sustainable Development Agenda 2030.

Secondly, the roadmap on the 'analysis of the interface between chemicals, products, and waste legislation and identification of policy options' was introduced. This roadmap highlighted four key issues that needed to be addressed in order to improve the management of plastics wastes:

- 1 Insufficient information about substances of concern in products and wastes;
- 2 Presence of substances of concern in recycled materials and in articles made thereof;
- **3** Uncertainties about how materials can cease to be waste;
- 4 Difficulties in applying EU waste classification methodologies and impacts on the recyclability of materials.

These key policy initiatives led to the development of the new Strategy as a policy response to the plastics challenge, tackling the design, manufacture, use, and disposal of plastics.

This strategy proposes concrete actions designed to make the vision for a more circular plastics economy a reality. The Commission will focus on making decisive progress within its current mandate, while preparing the ground for longer- term action. It will be essential for other key actors to also play their part. The Commission therefore calls on the European Parliament and Council to endorse these strategies and its objectives, and calls on national and regional authorities, cities, the plastics industry, and all relevant stakeholders, to commit to resolute and concrete action.

















ACTION GROUP

18th September 2021 Edition



13.5 million people involved



191 countries



53'000 ton of rubbish collected



10 million of cigarette picked up



41 million volunteer hours dedicated



1.7 billion of € saved



WORLD CLEAN UP DAY

World Cleanup Day is an annual global social action program aimed at combating the global solid waste problem, including the problem of marine debris. It is coordinated by the global organization 'Let's Do It! World', which headquarter is located in Tallinn, Estonia.

World Cleanup Day includes litter cleanup and waste mapping activities spanning every time zone.

Environmental cleanup events are held in nearly every country until concluding near the international date line in Hawaii.

World Cleanup Day aims to raise awareness of the mismanaged waste crisis by mobilizing all spheres of society to participate in cleanup actions.

Individuals, governments, corporations and organizations are all encouraged to take part in cleanups and to find solutions to tackle mismanaged waste. There are numerous organizations that facilitate and host

World Cleanup Day events globally.

Like Earth Day, World Cleanup Day is non-partisan, apolitical, and is not affiliated with any national or global political party or discrete ideology.

A goal that crosses borders and defies religious and cultural differences. World Cleanup Day is one of the biggest civic movements of nowadays, uniting 191 countries across the world for a cleaner planet. On that day volunteers and partners worldwide again came together to rid our planet of trash, cleaning up litter and mismanaged wastes from our beaches, rivers, forests, and streets.

World Cleanup Day harnesses the power of people around the world to achieve incredible things by joining together. Its beauty lies in cooperation and collaboration: building bridges between disparate communities and including all levels of society – from citizens to business, to government.

All these environmental heroes came out despite the challenges of 2020 and 2021.

"Every body is part of the problem - and the solution"

Wim Geirnaert, Founder

Their projects

Playa Pallet

Wooden beach bin made out of recycled materials. It is placed all over the island of Fuerteventura to nudge and motivate people to do beach cleanings daily.



Women and the Wind
Is taking Clean Ocean
Project on a voyage across
the Atlantic Ocean with
captain Kiana Weltzein and
her wooden catamaran
Mara Noka.

Save Canarias

REPSOL, planned to drill for oil close to Fuerteventura. They took action and initiated a petition page to collect signatures against the audacious behaviour of REPSOL.





STOP SUCKING

Simple approach to taget this problem locally. Members visit local bars and restaurants, asking them to sign a compromise contract with the environment. By signing the contract, they would promise to never use plastics straws again.

CLEAN OCEAN PROJECT

When Wim Geirnaert went to Fuerteventura in 1993, the Northshore with its beautiful waves and volcanic scenery became his playground.

At that time, the beaches were filled with waste, both what would wash up from the sea, but also due to people using it as a dumping place for their garbage. Something had to be done and instead of pointing fingers, Wim decided to take action.

He invited his friends and together they cleaned the beach in Cotillo. Clean Ocean Project was born.

For the last 20 years, the organization has removed tons of trash from beaches all over Fuerteventura, Lanzarote, Morocco, Brazil, El Salvador, and Belgium. Besides cleaning the beaches, the goal of the Clean Ocean Project is to educate people about the issue of ocean waste and create awareness towards more sustainable living.

Over the past years, the organization have initiated projects to inform and educate about plastics pollution and ocean conservation.

They have joined actions of other organizations on Fuerteventura, the Canary Islands, and abroad and have helped push for positive change.

Lately, their main focus is to stop the source of the pollution problem and close the tap.

'To recycle and reuse is a good step but if we want a clean ocean, we have to stop the single-use mentality' that's their life motto.















Credits: KEEP AMERICA BEAUTIFUL Facebook community



A leading national nonprofit organization, Keep America Beautiful inspires and educates people to take action every day to improve and beautify their community environment. They envision a country in which every community is a clean, green, and beautiful place to live based on the citizens help.

Established in 1953, Keep America Beautiful provides the expertise, programs and resources to help people End Littering, Improve Recycling, and Beautify America's Communities.

The organization is driven by the work and passion of nearly 700 community-based Keep America Beautiful affiliates, millions of volunteers, and the support of corporate partners, municipalities, elected officials, and individuals.

Their collective action champions environmentally healthy, socially-connected, and economically-sound communities.

Each year, the powerful network of community-based affiliates conducts a comprehensive assessment of the overall appearance of their community using indicators such as litter, illegal signs, graffiti and more.

This proprietary tool, called the Community Appearance Index, is designed to gather data annually by surveying a random, statistical sample of a city or town. The annual results are then used to develop a local plan to change attitudes and behaviors regarding litter and related issues.

Keep America Beautiful has several initiatives aimed at expanding and improving the effectiveness of public space recycling programs, also referred to as recycling on the go. They work with corporate sponsors to place recycling bins in public spaces including parks, schools, streetscapes, fairs, venues, colleges, and special events. The main aim is understand what motivates recycling behavior and leads to increased recovery, and then disseminate this information to local communities implementing public space recycling programs.

Through organized programs, volunteers actions lead to native species plantings, sustainable community gardens including fruit and vegetable gardens, tree plantings, urban forestry, vacant lot transformation, graffiti abatement, and more.



NE BASTA UNO

The story goes that one day six friends decided to have a walk on the Natural Park on the mountain of Verona. That day their attention focused on how many wastes there were on the road side while they were driving and also on the woodland where they had walked. From there they decided to came back again the day after but with the goal of clean up the mountain as their best in one day.

Their best produced 1'000 kg of litter.

This was the starting poin of their action group: they opened a web site and thanks to social networks, these girls started to organize walks primarly on the initial location then, due to the pandemic restrictions, have been forced to limit their zone action inside boundaries of Verona city for collecting litter everywhere.

During the summer they organized also a photographic exhibition aimed to sensibilize the visitors and give them awarness of the amount of things which chock the planet due to human action.

They expose photograph of the walks and of the loot but also the stangest objects found during the collecion campaign, for example a bottle of Fanta which has lived the woodland for 20 years.

The exhibition is the perfect moment for the education also of the child, with different kind of laboratory, the girls learn how to obtain animals from bottles, caps, or other single-use plastics objects.

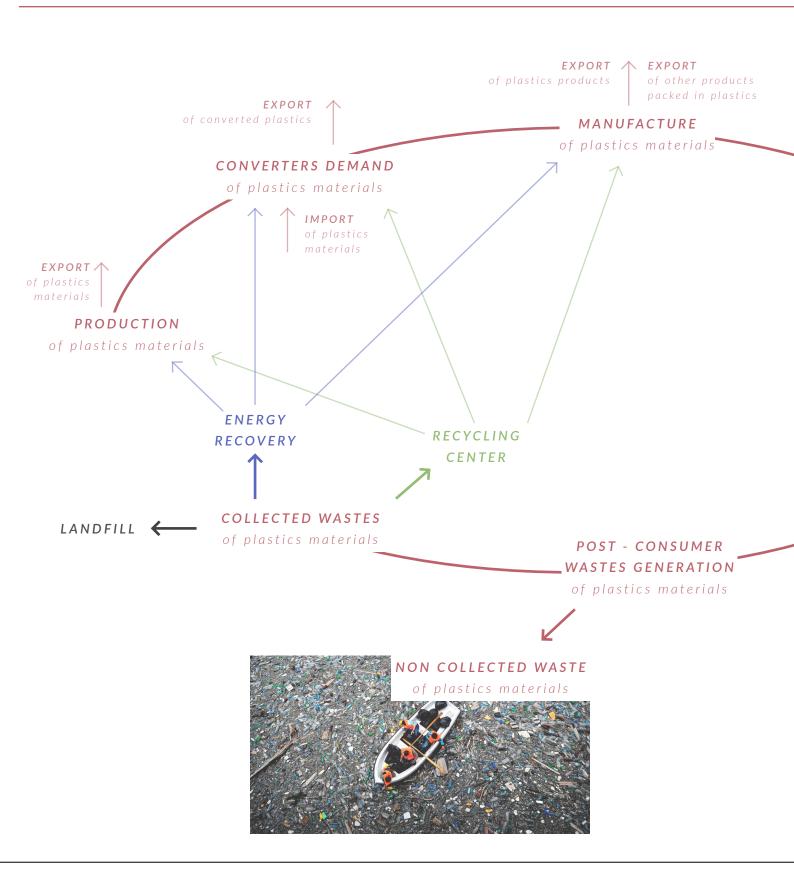






Credits: NEBASTAUNO website - photogallery







IMPORT of converted plastics IMPORT
of other products
packed in plastics

LIFE SERVICE OF PLASTICS PRODUCTS

the service life of plastics products goes from less than **1 year** to **50 years or more**



Today, plastics deliver numerous benefits to society: they help feed the world, they contribute to more energy efficient buildings and houses, they allow great fuel savings in all transportation means ensuring the transition to a green mobility, and they can even save human lives.

Plastics are incredibly versatile materials; they are inexpensive, lightweight, strong, durable, corrosion-resistant, with high thermal and electrical insulation properties. The diversity of polymers and the versatility of their properties facilitate the production of a vast array of plastics products that bring technological advances, energy savings and numerous other societal benefits.

The word 'plastics' can describe any material made of polymers. This includes all human-made plastics as well of many of the materials found in living things. But in general when people refer to plastics, they're referring to synthetic materials. The unifying feature of these is that they start out soft and malleable and can be molded, extruded, casted, spun into particular shape or applied as coating.

In this section the focus is on the material itself from its data sheet for understanding what is, its nowadays demand and production, till its disposal and recycle. It also created enormous environmental problems that today cast a long shadow over the production, use and consumption of plastics. The second part of this section aimed to analyze its impacts on environment, biota and human health.

The aim is to give an overview of the material that is the most ubiquitous in daily lives of every individuals, highlighting also how much plastics is deep insight in human lives and how humans cannot live without. 2

A S T L C

 \triangle \vdash

The word plastics derives from the Greek πλαστικός (plastikos) meaning 'capable of being shaped or molded', and in turn from πλαστός (plastos) meaning 'molded'. As a noun, the word most commonly refers to the solid products of petrochemical-derived manufacturing. The term is applied to a wide range of materials that at some stage in manufacture are capable of flow such that they can be extruded, molded, cast, spun or applied as a coating.

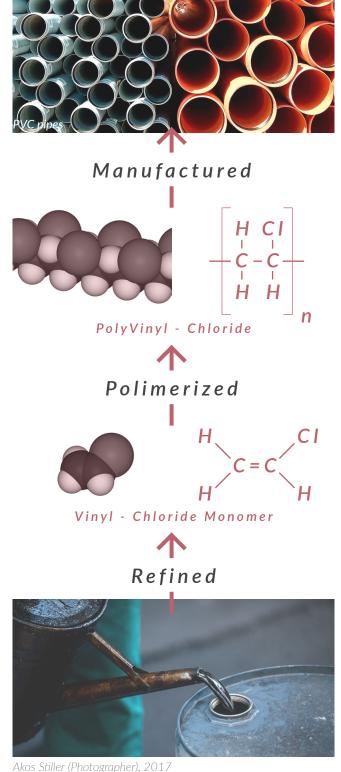
Plastics are long chains of polymers bound together and mixed to create a diverse array of new material. The word polymer derives from the Greek π o λ úc (polús) meaning 'many' and μ épo γ (méros) meaning 'part'. A polymer is a substance or material consisting of very large molecules, or macromolecules, composed of many repeating subunits.

They are a group of materials, either synthetic or naturally occurring, typically prepared by polymerization of molecules and they range from familiar synthetic plastics such as polystyrene to natural biopolymers such as DNA and proteins that are fundamental to biological structure and function.

The starting point for the description of the structure of a polymer is the identity of its constituent monomers.

The word monomer derives from the Greek μόνος (mono) meaning 'one, alone, solo' and μέρος (méros) meaning 'part'.

Monomers are obtained by refining petroleum. They are usually found naturally in oil or can be easily manufactured through simple chemical processes. It is important that the monomers are pure, as contamination prevents them from polymerizing to form a chain and can also lead to weak or brittle plastics in



Akos Stiller (Photographer), 2017 Bloomberg

the end.

Plastics come in many shapes and sizes and can be flexible or rigid. They can be made from a single polymer, or multiple layers of different polymers, or other materials. Generally, plastics can be classified into petrochemical-based or bio-based, depending on the material from which they are made from.

Petrochemical-based plastics are plastics made from a wide range of polymers derived from petrochemicals, also referred to as conventional plastics. They can be separated into thermoplastics and thermosets. Thermoset plastics are permanently cross-linked together and therefore difficult to be remelted and reformed. Thermoplastics can be remelted and reformed and are the most commonly used plastics in the economy.

Biobased plastics are plastics derived from biomass;

with biomass being any material of biological origin. Biobased plastics can be classified into polymers made entirely from biomass and polymers made partly from biomass.

All plastics can be designed to behave in two distinct ways: biodegradable and nonbiodegradable.

Biodegradable plastics can be decomposed in the environment. A subset of biodegradable plastics may be compostable. Compostable plastics must be capable of undergoing biological decomposition in a compost site as part of an available program, and the resultant breakdown fragments are completely used by the microorganisms under certain conditions certified by the international standards.

Consequently, not all biodegradable plastics are compostable, but all compostable plastics are biodegradable.



Barry Rosenthal (Artist), 2017 Barry Rosenthal foam seascape

The types of plastics, petrochemical-based and biobased plastics, currently available in the market and the applications in which they are commonly used are presented in the following table. They are also classified according to the source of raw materials from which they are made and their biodegradable potential.

Bioplastics, which include both the biobased and biodegradable plastics, represent about 1% of total global plastics produced annually. Europe is a significant contributor to the global production of bioplastics, covering 19% in 2018. The demand for bioplastics is likely to increase rapidly in the future with more sophisticated biopolymers, applications, and products emerging.

Bio-PET is the most prominent bioplastics accounting for 40% of the global production of bioplastics, followed by cellulose acetate, polybutylene adipate-co-terephthalate (PBAT), and polylactic acid (PLA). Many well-known companies such as Coca- Cola, Vittel, Volvic, and Heinz use bio-PET in their packaging.

Besides the choice of materials used to make up plastics, additives are also used during their production. Additives are auxiliary ingredients added to the base polymer in order to improve the production process and enhance the properties of plastics polymers without changing their chemical structure. By using additives, plastics can be safe, clean, tough, enduring, and colorful.

Although similar additives to those used in conventional plastics are also used in biobased plastics, efforts are largely focused on creating alternatives such as polyamide additives or biodegradable fertilizers that are of a renewable nature.

TYPE

Petrolchemical-based NONbiodegradable











Petrolchemical-based **Biodegradable**

POLYMER

Poly**E**thylene

Poly**P**ropylene

Poly**S**tyrene

PolyVinyl Chloryde

PolyEthylene Terephtalate

Poly**C**arbonate

PolyVinyliDene Chloryde

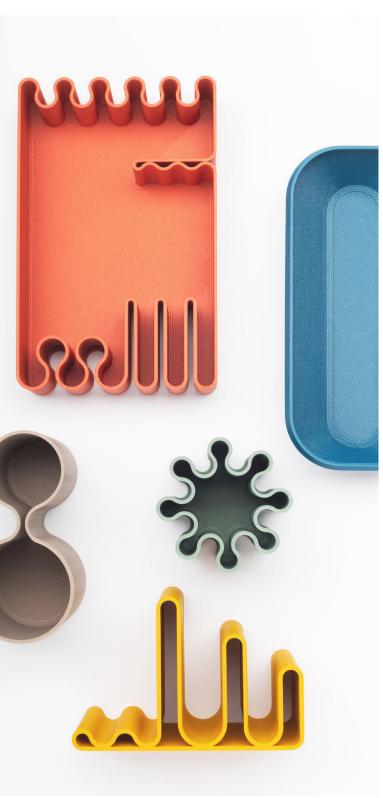
PolyEthylene Naphthalate

Poly**A**mide



Ethylene Vinyl alcOHol

SUBSTITUTE FOR			LICATIONS	
	NONRenewable Recyclable	_ Packaging _ Agriculture _ Electronics	Building and constructionSport and leisure	~
	NONRenewable Recyclable	PackagingHealtcareElectronics	Building and constructionSport and leisure	T
	NONRenewable Recyclable	_ Packaging _ Healtcare _ Electronics	Building and constructionSport and leisureEnergy	۵
	NONRenewable Recyclable	_ Packaging _ Healtcare _ Energy	Building and constructionSport and leisureMobility and transport	4
	NONRenewable Recyclable	PackagingElectronicsMobility and trans	port	ェ
	NONRenewable Recyclable	PackagingElectronicsMobility and trans	port	O
	NONRenewable Recyclable	_ Packaging		
	NONRenewable Recyclable	_ Packaging _ Healtcare _ Blending material	for improving PET performance	
	NONRenewable Recyclable	PackagingElectronicsMobility and trans	port	
	NONRenewable Recyclable	PackagingAgricultureElectronics	Mobility and transportHealtcare	



TYPE

POLYMER

PolyVinyl alcOHol

PolyButylene AdipateTerephtalate

PolyButylene Succinate

Bio-basedNONbiodegradable

 ${\color{red}\textbf{BIO}} based {\color{red}\textbf{PolyE}} thylene$

BIObased PolyEthylene Terephtalate

PolyEthylene Furonate

Bio-based Biodegradable ThermoPlastics Starch

PolyLactic Acid

PolyHydroxyAlkanoates PolyHydroxyButyrate

Bene bFriends Collection Office 3D printing objects made of recycled bioplastics

SUBSTITUTE FOR	CIRCULARITY POTENTIAL	MAIN APPLICATIONS	
P oly S tyrene	NONRenewable Recyclable in the Paper recycling steam	_ Papermaking _ Textiles _ Coatings	~
LowDensity PolyEthylene HighDensity PolyEthylene	NONRenewable	_ Packaging	ш
P oly P ropylene	NONRenewable	_ Packaging _ Agriculture _ Building and construction	۵
P oly E thylene	Renewable	_ Packaging	V
P oly E thylene	Recyclable Renewable	_ Packaging	Ξ
T erephtalate	Recyclable		U
Poly E thylene T erephtalate	Renewable Recyclable	_ Packaging	
P oly S tyrene	Renewable Recyclable	_ Packaging _ Agriculture	
PS PET PP LDPE HDPE	Renewable Recyclable	_ Packaging _ Healtcare	
PolyPropylene PolyEthylene	Renewable	_ Packaging _ Mobility and transport _ Sport and leisure _ Healtcare	

PRODUCTION

Mass production of plastics began during the Second World War and was driven by the material intensity of modern warfare, the increasing shortage of other materials, and the versatility of synthetic polymers. After the war, the newly created plastics production capacity was redirected toward civil society. The invention of the modern consumer society and the sustained economic growth of the postwar period created a perfect environment for these new materials.

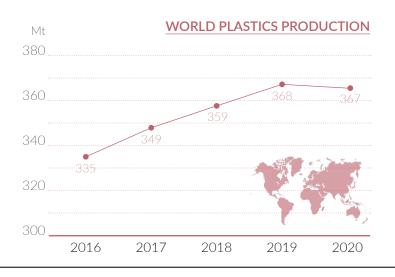
By 1950, global annual plastics production had reached two million metric tonnes (Mt). For reasons of data availability and convenience, 1950 is frequently used as the starting year of plastics mass production.

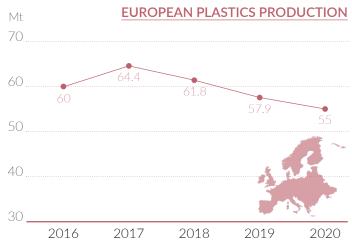
A readily accessible and frequently used data source for global plastics production is published by Plastics Europe Market Research Group (PEMRG).

According to this data, global annual plastics production has increased year over year with the exceptions of 1975, 1980, and 2008, which coincide with the two global oil crises and the Great Recession. The PEMRG data includes thermoplastics, thermosets, elastomers, adhesives, coatings, and PP fibers, but excludes all other synthetic fibers and also all additi-

ves. Altogether, global plastics production, according to the data of Plastics Europe research, in 2020 is estimated as 367 Mt including 55 Mt of European plastics production. According to the update data for the fourth quarter of 2021, industries increased their production compared to previous one. But production level has been still more than 19 percent under the precrisis level due to the COVID-19 related restrictions. Production of plastics in primary forms increased strongly by 4.2% in the last quarter 2021 compared to previous one.

The recovery of European industries, like the automotive industry, but also outside of Europe, had a positive impact on production. Producer prices of plastics in primary forms continued to rise in the fourth quarter, main reasons were the significantly higher prices for naphtha in the EU, the most important feedstock for the plastics manufacturers. Compared to last year prices for European naphtha increased even by 95%. Besides the higher prices for Naphtha, energy prices, transportation costs and costs for additives increased as well. The overall cost increase puts more and more pressure on margins for the European plastics manufacturers.





DEMAND

Due to their versatility and low relative cost, plastics are used in all industrial sectors. There is probably no product type that does not exist in a version that contains significant amounts of plastics.

Plastics resins are used extensively in packaging, building and construction, transportation, electrical and electronic equipment, and agriculture. It is also widely used in furniture and household, leisure and sports goods, and medical supplies and equipment.

Dependency on plastics today is entangled with daily lives and activities that human quality of life would not be the same without it. It ripples through production of everyday goods to the provision of vital services.

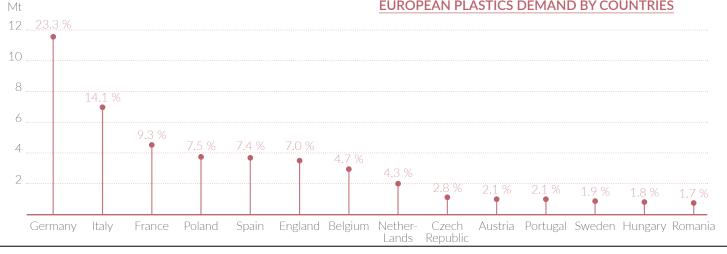
The relationship with plastics has infiltrated lives to a much deeper role than that of simply adding convenience or maintaining acceptable comfort levels.

It's difficult or impossible now to do without plastics in many areas: rate of consumption of some plastics goods would be difficult to maintain using alternative materials. For example, the soles of modern shoes are often made of durable synthetic material. Before human reliance on plastics, the soles of shoes were made from natural materials such as leather, rope, or wood. If the world switched to non-plastics for all of the 22 billion pairs of shoes manufactured every year, it would need to find an abundant suitable substitute material that would be as durable and would fit with current manufacturing processes.

Similarly, elasticated fabrics provide comfortable underwear and swimwear that would be difficult to produce from natural fabrics such as wool, cotton, and hemp. Modern fabric production replacing cotton and silk is another major contributor to plastics use that would be difficult to supply solely from natural means, and with demand ever increasing, it is a source of plastics use that is not showing signs of slowing down.

Much of this production of synthetic textiles feeds a growing appetite for 'fast fashion' where low-cost fashionable clothes are purchased, worn, and discarded, sometimes only after a single use. A radical shift away from single use to longer life cycles is needed to improve the sustainability of textiles, requiring a change to behavior and lifestyle, but to move away completely from all synthetic polymer based clothing without changing consumption demand would be im-

EUROPEAN PLASTICS DEMAND BY COUNTRIES















practical.

Countries with a percentage lower than 1.5% are unrepresented becouse it provide a demand lower than 0.5 Mt.

Instead of analyzing product by product consumption in the European market, the following scheme shows data of converted plastics products demand by seg-

EUROPE PLASTICS DEMAND BY SEGMENTS

PACKAGING
including commercial and industrial packaging

BUILDING AND
CONSTRUCTION

R. AUTO MOTIVE

R. BUILDING AND
CONSTRUCTION

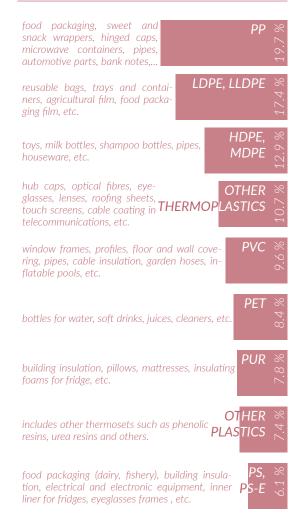
R. BUILDING AND
CONSTRUCTI

ments primarily based on expert estimations by Plastics Europe Market Reserch Group.

Demand estimations do not include recycled plastics. It can be seen that primary plastics demand in Europe is dominated by packaging. In 2020 the claim of plastics for the packaging sector reached nearly 20

Mt. Followed by the Building and Construction sector with more or less 10 Mt. The segment named 'others' cover 8.5 Mt of demand and includes plastics for furniture, medical applications, machinery and mechanical engineering, etc.

EUROPE PLASTICS DEMAND BY POLYMERS



Another useful analysis for a comprehensive view of this topic is the examination of the plastics product demands by polymer type.

Recycled plastics is still not included.

22

Linking the information between the two graphs, it's comprehensible that the food packaging sector and the polymer used for the packaging are for sure on the top.

How many packaging are there in the daily grocery cart?



No credits Grocery shopping cart

SOCIETAL BENEFITS OF PLASTICS

It is clear that population addiction to plastics has got out of hand and it takes to retract from unhealthy dependence, but it is also clear that while there are a progress of many unnecessary plastics products that can be avoided, there are also plastics objects that cannot be avoided nor replaced as they are making such an important contribution to the quality of millions people life.

Driven by the fact that plastics are relatively cheap and easy to mass manufactured, by 2020, global production reached 367 million tonnes and made a major contribution to economies, contributing close to 1.5 million jobs in Europe alone.



EMPLOYMENT CLOSE TO 1.5 MILLION

Plastics industry in 2020 includes over 50'000 companies, slightly decreased compared with the 2019, but still demonstrating the contribution of this sector to the European industrial fabric.



COMPANIES CLOSE TO 52'000

This industry generated in 2020 a turnover close to 330 billion €, slightly decreased compared to the previous year, mainly due to the impact of the pandemic crisis on the majority of constumer industries.



TURNOVER CLOSE TO 330 BILLION €

DISPOSAL

Coming up with a definition of waste material seems simple as first but becomes more complicated at closer inspection.

Defining wastes as materials with negative economic values does not work, since some waste materials, like many types of metal scraps, have positive economic values. Wastes can also not be defined as material for landfill, since significant amounts of waste material now have other fates, such as incineration and recycling. Maybe, wastes can be defined as the unintentional material outflows of a production or consumption activity. Waste materials generated during production activities is called production or preconsumer waste. An example would be all the plastics wastes generated during the production of plastics parts. Wastes materials generated during or after product use is called end-of-life or postconsumer waste. An example would be all those plastics parts from above, once people have used them.

In general, preconsumer waste is much easier to recycle since it is typically much less contaminated than postconsumer waste and generated in fewer locations. The former makes it easier to reprocess, the latter makes it easier to collect. Not infrequently, production waste is recycled right in the facility where

it was generated. Waste generation data are much harder to find than materials production data, and the data that do exist also tend to be of considerably poorer quality than production data. There are two fundamentally different methods to estimate plastics waste generation, which could be called 'bottom-up' and 'top-down'.

Fortunately, the Plastics Europe Market Research Group elaborated this data and the resulting numbers are shown thereafter. In 2020, more than 29 Mt of post-consumer plastics waste were collected in the EU. Because plastics products have different life span (ranging from 1 to 50 years or more), post-consumer plastics waste collection figures do not match demand or consumption figures.

More than one third was sent to recycling facilities inside and outside the European Union but over 23% was still sent to landfill and more than 40% was sent to energy recovery operations. Comparing the 2018-2020 evolution of the data, it's understandable that the post-consumer plastics waste treatment increased by 4% for waste collected in the recycle center, the energy recovery segment is unaffected, while the landfilled plastics waste decreased by 2%.

Another positive information is that Extra-EU plastics waste exports decreased by 16%.

29.5 Mt

COLLECTED PLASTICS POST-CONSUMER WASTE

100 %







RECYCLE

The advantages of plastics have continuously expanded the possibilities to utilize plastics in consumer goods, this development has been amplified by the increasing living standards of wide population.

The consequence of this well-being is the continuous increment of plastics production which involves a large amount of plastics waste. More than half of this amount consists of short-lived products that, with high return flows, enter the waste streams, due to their short life cycles, less than 1 year.

Waste plastics disposal is a serious environmental problem as a result of high volumes and low density of the material. Landfilling is a popular and cheap way of coping with plastics waste and is used in many countries worldwide. Other ways of disposing of waste plastics include the use of plastics as a substitute for pulverized coal in blast furnace feedstock ironmaking, conversion of plastics waste to fuel, mechanical compaction and reuse, and also chemical recycling.

Plastics mostly consists of C (carbon), H (hydrogen), and O (oxygen), which is similar to the elements that make up coke and coal that is used in the blast furnaces as reducing agents and as heat sources; however, component ratios and chemical structures are very different. There are two ways of using plastics waste in blast furnaces ironmaking processes. One is to use plastics waste in the blast furnaces as a substitute for reducing agent (charged coke and injected pulverized coal). The other is to use plastics waste in coke oven as a substitute for metallurgical coal for cokemaking. The former is called 'blast furnace feedstock recycling', and the latter is called 'coke oven chemical feedstock recycling'.

Utilizing plastics waste in blast furnace as substituent of coke and pulverized coal contributes not only to solving the problem of what to do with plastics waste but also to reducing CO₂ emissions, reducing production cost, and offering an alternative solution to natural resource depletion.

Researchers have recently found ways of producing liquid fuels from plastics waste through pyrolysis-based processes. Unfortunately, the process is energy intensive, and there is an ongoing debate as to whether it takes more energy to produce the fuel than there is in the fuel itself. Not all kinds of plastics can produce good quality fuel from pyrolysis: generally the thermoplastics such as PE (polyethylene), PP (polypropylene), and PS (polystirene) produce fuel that is similar in properties to diesel fuel.

Mechanical recycling is the most common approach used for recycling plastics like polyethylene terephthalate (PET) and high-density polyethylene (HDPE). PET and HDPE are typically used to make soft drinks bottles or containers and are relatively easy to recycle.

It refers to the processing of plastics waste into secondary raw material or products without significantly changing the material's chemical structure.

In principle, all types of thermoplastics can be mechanically recycled with little or no impact on quality. Mechanical recycling process take place in different steps described below.

Main steps for mechanical recycle process started from the people in their house. Spend some time for a good separation of the wastes is the most important













MECHANICAL

step for the best results of the mechanical recycle process. Following stage is the collection point at the neighborhood scale from where the garbage truck can gather the wastes.

Next is the transport of wastes through garbage truck in specific collection systems aimed to create technologically favorable framework conditions in view of the final recycled product to obtain.

Following passagges aimed to pre-enriched the recyclable material by separating foreign matter becouse if the input material is of high quality, then the output will be better. This is developed through sorting steps.

First is called comminution and it is the first step of sorting plants, where only the bags, usually bags of thin polyethylene film, should be opened to expose the contents.

Then screening machine sorted according to the geometric dimensions of the mass flows. Plastics products can be identified by the near-infrared-spectroscopy (NIR) according to their polymer structure,

chemical properties as well as their article properties. The objects can be sorted also via air pressure pulses or by mechanically controllable flaps; manual picking can be used as simple alternative to sensor-based sorting.

After the material flows had been separated according to polymer classes and article proprieties, these materials need to be transported to the actual





MELTING AND REORGANIZATION

WASHING

SORTING CENTRIFUGES



R E Ε L

CONSUMERS

recycling plants. For this reason, plastics are generally compressed into bales of defined dimensions and weight. Compaction occurs in bailing presses where preconcentrated are compacted in a semicontinuous pressing step and are finally stabilized by tying the bales with wire.

> Bales arrived at the recycling plants, are now opened with a single-shaft shredders which can reduce working widths of up to 5000 mm to less than 60 mm in just one operation.

WASTE SEPARATION

NEIGHBORHOOD SCALE COLLECTION

PLASTICS WASTE

TRANSPORT

COMMINUTION

SORTING

OMPACTING - BUNDILING

Before further steps, is reccomended to remove impurities and magnetic contaminants by magnetic separation.

FRICTION WASHERS FOR **CLEANING**

BALES COMMINUTUION

The cleaning/sorting step take place in the friction washers: by intensive mechanical agitation, the plastics surfaces are cleaned of adhesives, glued-on labels, food and drink traces. Wet washes are often operated with detergents and at high temperature. If wastes are wet-mechanically cleaned, this is often done in combination with a wet density sorting. For the separation of polymers, the simplest option is



static floating sink density sorting in the separation medium, water. The tanks consist of elongated troughs with discharge devices for the floating and sinking material. Metallic and mineral impurities, besides 'heavy' plastics, accumulate in the sink lower fraction, while the 'light' ones flow and take another way. Similar to the principle of the wet friction washer, during the dry cleaning, dirt and labels are removed via friction by high material concentrations and fast-rotating throwing blades and are then separated in the surrounding screening basket.

Cutting mills are especially suited for comminution to flake size. The cutting action is attained by narrow gap between the blade rows of the fast-rotating rotor. The comminuted material is then directed over a discharge screen. Subsequently, a granulation can take place by extrusion or agglomeration of the particles. Agglomerator melt the plastics by friction while the extruder homogenization, intensive compression and indirect heating of the housing, ultimately cause a melting of the plastics.

The extruded plastics strand is cut to granulates of a defined size by means of rotating cutters in a water bed; alternative forms like semifinished products can be created by adapted surface geometries.

The production of plastics materials is expected to increase year by year. With this increased production comes increased plastics material wastage, and thus it is clear that mechanical recycling processes alone are not sufficient to handle the increasing amounts of waste volumes. Alternatives to this process are the conversion of plastrics waste to fuel and the chemical recycling process.

Chemical recycling of plastics, also known as tertiary recycling or feedstock recycling, means converting plastics wastes into monomers, other chemical raw materials, or fuels with the help of catalysts, heat, or pressure.

Chemical recycling can be divided in two main groups of technologies, first one in which the polymers are dissolved as long polymer molecules and technologies that involve breaking of the chemical bonds between the atoms in the polymer chains.

Currently, plastics recycling is almost entirely carried out by the mechanical route that is suitable only for homogenous and contaminant-free plastics waste, which most of the plastics wastes are not. For example, end-of-life vehicles, construction and demolition wastes, all contain large share of plastics that cannot be recycled via mechanical routes.

SOCIETAL BENEFITS OF RECYCLING

Strong community recycling programs can contribute to a healthy, united community. Some of the many benefits of recycling are the prevention of greenhouse gases and supporting local economies by creating jobs and tax revenue. Recycling programs can also help to improve water and air quality and are building blocks for sustainable growing communities.

A clean environment and a prosperous economy combine to make for a healthy society. By investing time, energy, and resources into recycling, governments and communities around the world can deliver ample benefits for them self and also for the environment. A community's commitment to a cleaner environment often reflects its commitment to a higher quality of living. Strong local and regional recycling programs also attract companies that reprocess recyclables and the suppliers who reuse these materials in their products. Recycling industries not only offer higher paying jobs than the national average, but they also prevent communities from disposing of valuable commodities in landfills.

According to North Carolina's Recycling Means Business, recycling employs more people than the state's biotech industry and the agricultural livestock industry. In addition, recycling jobs have increased 40% in ten years, as a percentage of the state's total employment.

Recycling also plays a role in reducing greenhouse gas emissions, which are associated with chronic health issues such as asthma. By recycling, waste that releases greenhouse gases through anaerobic decomposition is reduced. Recycling also reduces the need for raw materials in manufacturing processes, which require larger amounts of energy to harvest and thus have a larger adverse air quality impact.

Finally, landfilling can be minimized by implementing recycling programs and dedicating time and resources to their development and success. The placement of proposed landfills often leads to strong opposition in the community. Landfill placement can lead to diminished property values and the potential for releases to the environment. The need for landfills and the concerns that come with them subside with higher recycling participation rates.

Developing advanced recycling programs creates pathways for collected commodities to be sold in the marketplace. Comprehensive and efficient recycling programs offer more opportunities for the community to benefit financially, while improving the aesthetic appeal of their neighborhoods. One way the recycling industry does this is through boosting tax revenues—revenues that can go back into community projects such as public parks, alternative transportation, and educational grants.



No credits Project of The Environmental Center of Deschutes County, Oregor















Alexander Mourant (Photographer), 2017 News - RAW Project



John Cancalosi (National Geographic Photographer) Trapped stork



Akash (Photojournalist), 2018 Born to Work

In 1945, Yarsley and Couzens imagined a future world where human life would be enveloped in plastics.

'This plastics man will come into a world of color and bright shining surfaces where childish hands find nothing to break, no sharp edges, or corners to cut or graze, no crevices to harbor dirt or germs.... The walls of his nursery, his bath...all his toys. his cot, the molded light perambulator in which he takes the air, the teething ring he bites, the unbreakable bottle he feeds from. As he grows he cleans his teeth and brushes his hair with plastics brushes. clothes himself with in plastics clothes, writes his first lesson with a plastics pen and does his lessons in a book bound with plastics. The windows of his school curtained with plastics cloth entirely grease and dirt-proof...and the frames, like those of his house are of molded plastics, light and easy to open never requiring any paint.'

> Yarsley & Couzens, Plastics, 1945

Today, this prediction has sadly been fulfilled as scientists, lawmen, and politicians begin to ponder the long-term effects of ubiquitous consumer products made from plastics that endanger both human health and the environment.

Products produced for use for mere seconds are polluting the environment for decades, as wastes enter the food chain with the ultimate destination sometimes being the descendants of those who disposed of it in the first place.

The average size of plastics particles in the environment seems to be decreasing, and the abundance and global distribution of micro-plastics fragments have increased over the last few decades.

As the collective realization of this omnipresence began in the early 2000s, researchers began to explore the impacts on the environment, wildlife, and eventually the human body, with the enumeration and characterization of microplastics representing an important aspect of this work.

Occurring at a size range of less than 5 mm, microand nanoplastics are small enough to be ingested by marine life potentially allowing for biomagnification of the particles and bioaccumulation of toxins adsorbed on the plastics surfaces.

Current environmental and health impacts related to plastics are still poorly understood but potentially far-reaching.

Environmental impacts include the entrapment and destruction of habitat for wildlife, hazard of ingestion, and plastics-facilitated transport of organisms to new eco-systems.

Health impacts include the respiratory, circulatory, and lymphatic system for transport with the ultimate fate and deposition in the liver, kidney, and gut. Interestingly, transport and deposition of plastics particles in the human body affects the endocrine system most notably causing endocrine disruption.

The effects on these systems may be vast with acute, long-term exposure; however, much is left to be determined for the impacts on the human population.













MICROPLASTICS



No credits Microplastics on the seashore

Despite occasional reports of small plastics in the environment from as early as the 1960s, it is only in the past 10 years that the scale and pervasiveness of microplastics pollution has become apparent.

Increasing awareness has resulted in almost exponential growth in the number of studies assessing the spread and impacts of microplastics in the marine environment, and the focus on freshwater and terrestrial habitats is similarly increasing.

Over the past decade, there have been a number of attempts to formally define the broad category of pollutants identified as 'microplastics' but classification and categorization of microplastics has been variable depending on discipline.

A framework for plastics definitions was recently suggested by a group of international scientists, considering biological impacts and endpoints and other important cross-discipline topics, suggesting that size is not the most important descriptive factor.

But for this issue, dimensions and source will be the considered characterisation factors.

Size should be considered later in the definition of particles. First, must be categorize the physiochemical properties; size, shape, color, and origin become subordinate characterization criteria.

Size is currently the most commonly used criterion to define plastics, and size classes are normally recorded as nano-, micro-, macroplastics. Particle size is of ecological relevance because size determines the interaction with biota and environmental fate.

The most frequently used upper limit is 5 mm, partially informed by the availability of small particles found in the stomach of marine biota.

The dimensions of particles are important and may greatly influence particle fate following ingestion.

In addition to size, macroplastics may be classified by their source.

Determining the origin of many macroplastics can be unmanageable, and this should only be applied when the origin of the plastics can be reliably determined. Broadly, primary macroplastics refer to those particles that have been intentionally produced within the macroplastics size range, whereas secondary macroplastics are formed through fragmentation in the environment or breakdown during use.

Those particles intentionally manufactured to be small include preproduction pellets, the feedstock for a large proportion of the plastics industry.

Other sources of primary macroplastics are plastics granules used for a range of functions including cosmetic exfoliation, cleaning products, and sandblasting media.

Secondary macroplastics originate from a range of diverse sources, both terrestrial and aquatic.

There are two distinct phases of secondary production in macroplastics, in-use fragmentation and postuse fragmentation.

In-use fragmentation may be typified by tire wear, the formation of microfibres during clothes washing, and the wear of fishing gear. Additionally, in-use plastics may be degraded through the action of organisms.

Postuse fragmentation may be categorized by the breakdown of lost and discarded plastics.

Plastics and macroplastics may also be further degraded following ingestion.



Fred Dott (Photographer), 2016 Plastics from the sea to the plate

EFFECTS ON ENVIRONMENT

Plastics debris has accumulated in natural habitats from the poles to the equator; it is a very conspicuous component of the debris that is present in the marine environment, and most of the literature on the accumulation of plastics in the environment and the associated problems for wildlife has come from marine habitats. Due to their buoyancy and durability, plastics may be transported for long distances on water and air currents. As a result of this extensive transport, microplastics have now been observed in all global environments.

Monitoring represents an important step towards quantifying spatial and temporal trends in the abundance of all types of debris, including plastics. Numerous national and international schemes have been initiated to record quantities and categories (uses, sources, material types, sizes), and in some cases to facilitate debris removal.

Many plastics are constructed with a high surface-a-rea-to-volume ratio, which enables them to be carried on air currents. Many airborne microplastics are assumed to originate from textiles, the degradation which produces fibrous particles that have been observed in atmospheric fallouts, as well as in indoor and outdoor environments.

Total atmospheric fallout was investigated at both an urban and suburban site finding higher results at the urban scale rather than suburban.

This research was expanded to investigate settled dust as well as indoor and outdoor air. The concentrations in indoor environments ranged from 1.0 to 60 fibers per cubic meter, and outdoor concentrations were significantly lower, ranging between 0.3 and 1.5 fibers per cubic meter.

The presence of plastics in terrestrial ecosystems is, as in air, comparatively understudied, although it is recognized that most marine microplastics pollution is of terrestrial origin. Plastics and microplastics on land are also often harder to detect due to the masking from vegetation and soils.

Wastewater treatment systems receive a range of microplastics starting from particles inside cosmetics to those generated during industrial processes. The large proportion of microplastics removed during wastewater treatment may be retained in sewage sludge. Following treatment, a large proportion of sludge becomes biosolids, transferred to terrestrial ecosystems through land application and also landfilling.

This presents a further problem; in repurposing sludge, microplastics are directly released to the terrestrial environment.

In addition to the release of microplastics in sewage and wastewater, sources on land include watersheds and riverine transport, industrial outlets, littering, and dumping, and despite their accessibility, microplastics have now been found in remote and unexpected regions of the environment.

Microplastics, those pervasive relics of modern times, have invaded seemingly every part of the planet to-day, including rain over the Rocky Mountains and the most remote reaches of the Arctic. Scientists have been puzzling over how this flood of pollution makes its way to such distant locations far from the urban centers where it's generated. A new study finds a surprising route for the tiny particles.

Melanie Bergmann, a marine ecologist with the Alfred Wegener Institute, had been studying plastics on the Artic sea floor since 2002 finding out that the

Timo Lieber (Photographer), 2017 The Scott Polar Research Institute from Cambridge working on the ice cap.



Arctic is far from pristine, with much of the world's pollution eventually making its way there. Over the past decade or so, they noticed huge increases in the amount they were seeing, including a tenfold rise at one station. So they started to look for microplastics in the Arctic water column. Copious amounts turned up everywhere they looked. In deep sea sediments, they found about 6'000 particles in every kg of mud. Other researchers found that Arctic surface waters had the highest microplastics concentrations of all the world's oceans.

Then the question is coming, how this flood of pollution makes its way to such distant location far from the urban center where it's generated?

Uncountable researchers have conducted studies all over the world and the common output was that basically microplastics are everywhere and aerial transport is their pathaway to the remotes parts of the planet. This also means the atmosphere may be a key source of exposure for humans and animals which undoubtedly inhale some of them.

'The message I'm often trying to communicate to people [...] is that there's so much information about, you know, garbage patches and turtles with straws up their nose, all of that stuff, that people think that plastics pollution is a middle-of-the-ocean problem. But the more we work on this, the more we are learning that it's not a middle-of-the-ocean problem. It's a water body problem. It's a terrestrial problem, it's an air problem, it's a tropical problem, it's an Arctic problem. It involve the whole ecosystem.'

Jennifer Provencher, Canadian Wildlife Service resercher 'Tiny pieces of plastic found in Arctic snow', 2019

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As lakes are transitory features in the aquatic environment, they can act as reservoirs for microplastics particles and also sinks, especially in areas with limited water movement. Lakes can represent catchment-scale sinks for microplastics, and it appears that urbanization, industrial activities, and wastewater input influence the composition and quantity of microplastics.

River systems are considered one of the primary routes by which plastics and microplastics enter the marine environment, these sites are highly susceptible to plastics pollution due to their proximity to urban and industrial sources and may demonstrate notable levels of microplastics in their own right.

The marine environment represents the main repository for plastics pollution, with minor exports back to the terrestrial environment in the form of buried beach debris, sediment extraction, and the capture of marine species for human consumption.

The marine environment is highly complex three-dimensional system, and the transport and aggregation are affected by numerous processes including global thermohaline circulation, gyres, wind-driven currents, and tidal patterns

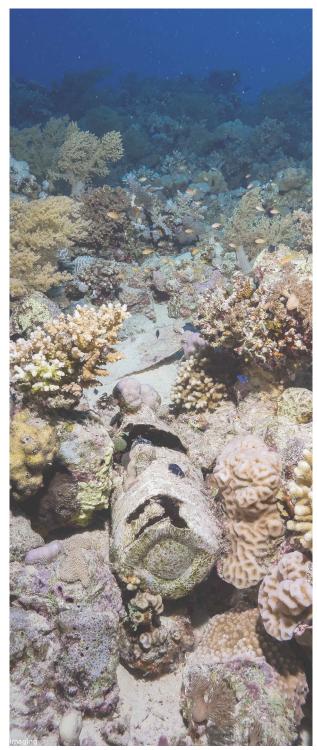
With such vast volumes of plastics in the environment, wildlife interaction is commonplace. Issues such as entrapment and destruction of habitat are well understood, while the impact of ingestion is much more complex. Plastics are documented to contribute to the destruction of habits.

Plastics-assisted migration of pathogens and invasive species to a vulnerable habitat may also present a cause for displacement of native populations.

Transport of microbial species has been documented as self-fertilizing corals were found in the Netherlands near plastics debris. Proliferation of less desirable species such as microalgae has been recorded as well. Plastics is a desirable raft for species due to its abundance and durability.

Not only those plastics provide a hospitable harbor to invasive species but oceanic plastics samples have also been found to adsorb environmental pollutants from the surrounding ocean water at high concentrations.

Different characteristics influence the selective adsorption of compounds onto the surface of microplastics with increased hydrophobicity with competitive adsorption of toxins. Compounds may more effectively sorb to deteriorated rather than virgin plastics debris, due to higher surface-area-to-volume-ratios or the presence of stronger binding sites on deteriorated plastics.



David Jones (Photographer)
Plastics bottle on the reef

EFFECTS ON BIOTA

Substantial quantities of plastics debris already contaminate marine habitats from remote shorelines and inaccessible areas of the deep sea to heavily populated coastlines. The ubiquity of these debris in the marine environment has resulted in numerous amounts of species ingesting and becoming entangled in plastics. As a consequence of the durability of plastics, these conflicts typically result in trauma or damaged movement and can ultimately result in death.

Due to the prevalence of plastics waste in the oceans, the incidence of ingestion has increased dramatically. Recent works concluded that '44% of seabirds were found to have ingested plastics wastes and 267 species are affected by garbage'. It is predicted that 99% of seabirds will have ingested plastics wastes by 2050.

The consequences of ingestion that can affect the health of the animals that have consumed plastics include physical obstruction of digestive tracts, bio-accumulation of the plastics particles, and biomagnification of adsorbed toxins. The physical obstruction of the digestive tract is a documented cause for morbidity among larger marine species. Seabirds are commonly known to ingest plastics waste and die of digestive tract obstruction as well.

Morbidity involving marine and maritime species may occur at various ingested volumes and is species-specific. Bioaccumulation is the process of the physical accumulation of particles resulting from the ingestion of previously contaminated organisms. For example, zooplanktons consume micro and nanoplastics followed by mollusks or shrimp.

The case may be similar for the smallest terrestrial species but there is currently insufficient evidence to

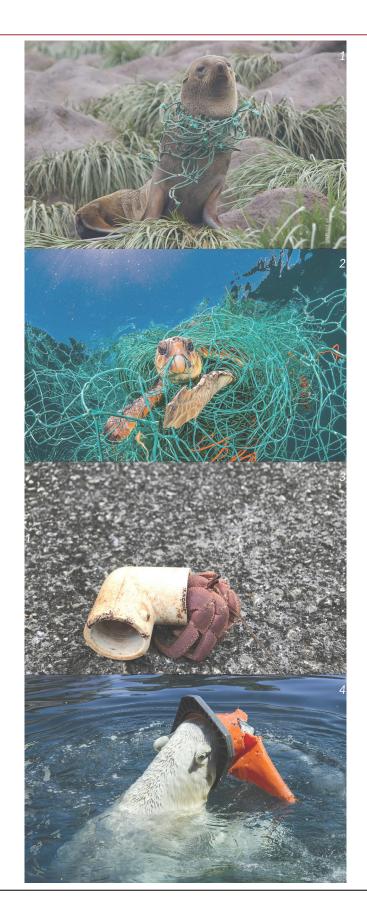
draw compelling conclusions. Larger terrestrial fauna, such as ruminant livestock, may encounter microplastics in the soil due to their feeding behavior or feedstock but are unlikely to experience significant negative impacts resulting from ingestion due to the small particle sizes.

Other terrestrial species like insects also interact with microplastics. Ingestion and transfer of very small microplastics has been shown for different life stages of mosquitos, which has also been proposed as a potential aerial dispersal mechanism for propagating microplastics contamination across wider spatial scales.

Plastics waste may also interact with terrestrial and aquatic flora, in addition to abiotic factors affecting ecosystem functioning. While plastics are often used specifically in agriculture to promote crop growth, there is some preliminary evidence that small plastics particles in the soil may negatively impact upon the health of wheat and cress plants. Some initial effects from micro- and nano-plastics contamination have been observed for aquatic plants, including impacts on shoot and root length. Although, the studies point out also dangerous impacts of microplastics on the biophysical environment of soil systems, where micro- and nanoplastics may influence soil microbiota and physical properties of soil quality.

One of the numerous effects of large plastics debris, particularly in soft aquatic sediments, is the creation of an artificial substrate for colonization. A range of organisms, require a surface for attachment.

The colonization of floating plastics, whether initially fixed in the marine environment or colonized in transport, also results in the movement or organisms that



may otherwise have not been able to span the vast ocean basins. Rafting animals may also include microbial organisms which could present a risk to human or environmental health. Observations of plastics along the Catalan coast have demonstrated the colonization of plastics by potentially harmful organisms such as the pathogen that have also been associate with plastics debris.

A key effect of marine plastics debris is that of entanglement, whereby a species is wrapped up in marine debris. These interactions may result in damage to the organism, reduced mobility (due to carrying a piece of debris), and direct or indirect mortality. These effects are seen throughout the world's oceans, as well as in freshwater and terrestrial habitats.

The number of marine animals recorded as affected by entanglement is constantly rising, and currently includes all species of turtle, around two-thirds of the world's seal species, approximately one-third of the world's whales, and a quarter of its seabirds.

One well-studied form of entanglement is ghost fishing, mortality as a result of interaction with abandoned, lost or discarded fishing gear. Modern fishing gear is predominantly composed of synthetic materials that persist for extended periods in the environment. As a result, lost traps, pots, and nets continue to attract and trap for a long time after their initial loss, resulting in the mortality of a range of organisms including protected and sensitive species.

- 1_Claire Waluda (Photographer), 2018 Antarctic fur seal
- 2_Jordi Chias (Photographer), 2020 Planet or plastics?
- 3_Hexen Zirkel (Photographer), 2017 Pipe turned in home
- 4_No credits
 Polar bear entanglemed in a traffic cone







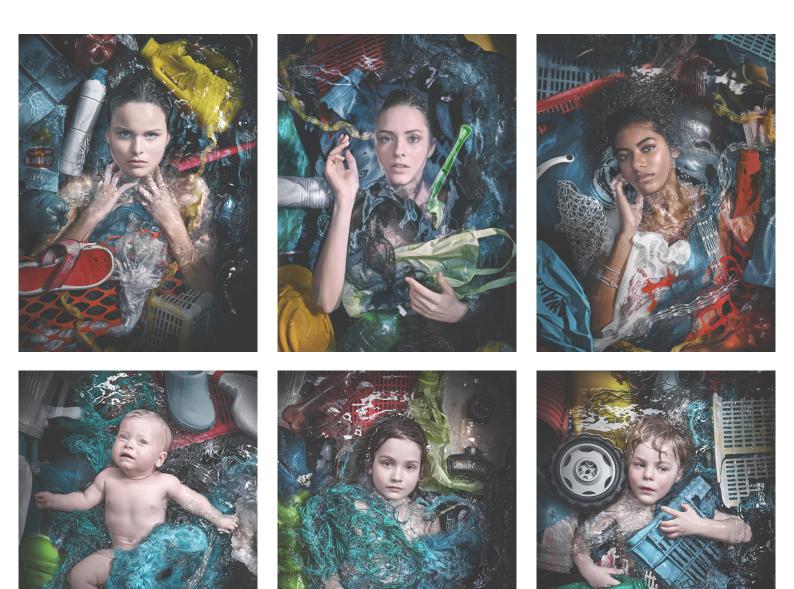








EFFECTS OF PLASTICS



Picture first line Staudinger + Franke (Photographer), 2019 Plastics Ocean

Picture second line Staudinger + Franke (Photographer), 2019 Plastics Ocean Underwater Exhibition

EFFECTS ON HUMANKIND

In parallel with concerns for wildlife, there is a rapidly growing body of evidence relating to public health issues arising from current use of plastics.

A range of chemicals are added to plastics during manufacture, to enhance the performance of plastics. These additives can be referred to as plasticizers and also include flame retardants, stabilizers, antioxidants and other chemicals such as antimicrobials that give each type of plastics unique properties.

There is concern that potentially harmful chemical additives including phthalates, bisphenol A (BPA) and polybrominated diphenyl ethers (PBDE) could be transferred to humans directly from plastics, for example from flexible toys mouthed by toddlers, or indirectly, for example via food and drink that is packaged or transported via tubing in plastics containing these additives.

Certain polymers and the associated polymer additives are correlated to carcinogenicity and endocrine disruption and may cause neurological, cardiological, hepatological, and renal issues upon acute chronic exposure.

The primary mechanisms for plastics exposure to humans and similar mammals are through ingestion and inhalation. Following exposure to microplastics, transport and deposition or excretion of the particles follows. Transportation of micro and nanoplastics involves the respiratory system, lymphatic system, and circulatory system. Deposition has been shown to occur in the liver, kidney, and gut of mice.

Three primary routes of exposure to P&PA* have

*P&PA: Program & Project Assessment

been established: inhalation, ingestion, and dermal absorption.

For inhaled polymeric particles, respiratory-related illnesses have been epidemiologically linked, including nasal cavity cancer, airway impaction, respiratory disease, lung cancer, and lung deposition.

Ingested P&PA* in food products may result in neurological and psychological effects such as decreased maternal behavior, self-reported sexual dysfunction, neurotoxic response, and sex-dependent brain restructuring. Reproductive effects of plastics have been documented, for example, for the monomer, polymer and plastics additive bisphenol A, which was found to act as an estrogen agonist and androgen protagonist, with known or postulated exposure effects including breast cancer, prostate cancer, sperm count decrease, ovarian cancer, and affected fetal development overall.

Lastly, ingestion may lead to metabolic disease, bladder cancer, large bowel cancer, diabetes, liver disease, and more.

Dermally applied P&PA* are linked to irritation primarily with no major indications; however, high dose scenarios are rare.

Size range directly correlates with toxicity of microplastics as they approach a nanometer range. Particles measuring less than 135 μ m can pass through the human airway unperturbed resulting in persistent irritants to the alveoli.

Particles measuring less than 130 µm can enter the

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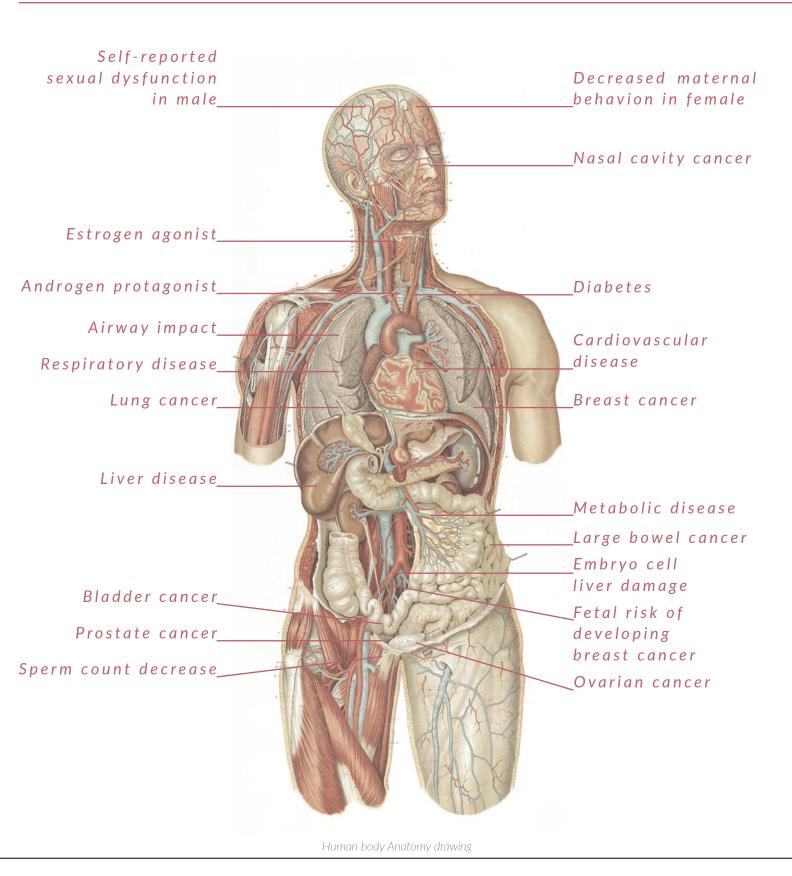
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EFFECTS OF PLASTICS



lymphatic system in model mammalian systems to be trans- ported or deposited in lymph nodes.

At 110 μ m, particles enter the blood, urine, and cerebrospinal fluid in dog studies.

Lastly, deposition in the liver, kidney, and gut is documented to occur at particle size of <20 µm.

The size range of particles which have been found to impact the human body the most, like particles measuring less than 135 μ m, are being found in much higher quantities in the environment than previously believed.

Several routes for exposure exist including contaminated food, food packaging leachate, occupational exposures, age-specific exposure such as children chewing on plastics toys, atmospheric fallout and urban dust, toothpaste or other personal care products, and synthetic clothing shedding.

Unfortunately, a large portion of these sources remains unregulated.

To avoid contamination of food products with plastics components, like wrappers, resealable bags, and food storage containers, the most reliable strategy is to avoid plastics products when possible.

Most importantly, avoiding the heating of plastics products or unnecessary abrasion of plastics coatings are effective strategies of limiting exposure.

Plastics pollution may be addressed in multiple ways, with the concept of reduce, reuse, and recycle representing a helpful but imperfect solution.

Through the reduced consumption of single-use plastics, individuals can decrease their exposure to harmful plastics constituents and promote a more sustainable chemistry at the same time.

Reducing the use of plastics food packaging is one way for consumers to decrease uptake of potentially toxic plastics leachate.

Similarly, exposure to microplastics fibers from synthetic fabrics is avoidable. However, natural textile also shed fibers, and robust studies comparing the health impact of these two different classes of microfibers are thus far lacking.

Multiple health conditions have been epidemiologically linked to human exposure to polymers and their various associated additives, taken up by humans through contaminated food products, food packaging leachate, and the inhalation of airborne microplastics as well as the ingestion of microplastics-containing dust. Following ingestion, microplastics may be subjected to excretion or uptake into the blood stream, with deposition in the liver and kidney, as rodent studies suggested. Some anecdotal evidence points to a potential link between exposure to microplastics particles and the development of diabetes and cancer of the liver and the large intestines. However, conclusive evidence for such human health outcomes is still lacking. A better documented and more pressing human health concern is endocrine disruption in animals and humans from plastics and plastics constituents. Additionally, neurotoxic responses, metabolic disease, and decreases in cellular levels have been observed and constitute potential reasons for concern.





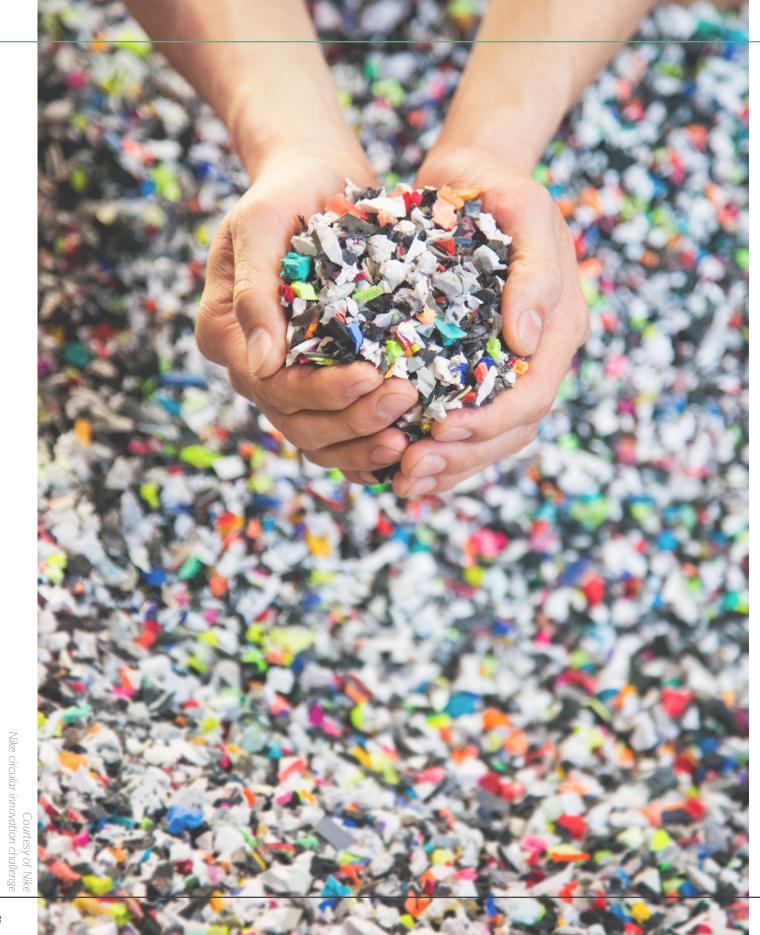












The supply of recyclables has grown more quickly than the demand for recycled products. The process of recycling cannot be successful unless the collected materials are turned into products that will be purchased. Hence, creating a market for recycled materials is a crucial part of supporting the environment.

'Consumers may participate in the sorting and collection of household materials for recycling, but unless the materials are then converted into recycled products and purchased by consumers, there is no environmental benefit.'

Guagnano, G.A. (2001).

Altruism and market-like behaviour

The increasing environmental concern has led to a greater demand for sustainable products.

Consumers express their increased interest to ethical production in their choice of products: there is a rising preference for products that are more durable, contain reusable materials and are less toxic, and a greater acceptance of recycled materials.

The market for sustainable products grows but there is a challenge for companies in balancing consumers environmental concerns, profitability and the competitive dynamics of their target markets.

Researchers have shown that people who are more concerned about the environment are more likely to purchase sustainable products, while people who are less interested in the environment are more likely to evaluate the quality of a sustainable product negatively and prefer to purchase a comparable conventional product.

These individual differences are important to keep in mind when addressing a target group for recycled products. Besides individual differences, there are many other factors that influence the consumer evaluation of sustainable products.

In fact, there is a wide gap between consumers expression of sustainability support and the low level of actual consumption of sustainable products.

When companies communicate that they intentionally made a sustainable product, consumers might evaluate the product quality more negatively compared to when they communicate that the sustainable aspects are a side effect.

This is due to the Zero-Sum* inferences consumers make, which implies the superiority of one product compensated by inferiority in another one. This is the case when the sustainability aspect is inherent to the product itself and leave the production method aside.

For the companies which will be described on the following pages, the recycled material aspect is completely inherent to the product, in fact the product exist because of the plastic waste are generated.

But generation of wastes for recycle and gave those materials another life, does not mean leave them floating on the great garbage patches available in the most of the oceans.

Catching floating plastics is the main goal of TheO-ceanCleanUp which researchers developed unique intruments for taking advantages from river flow but also running against tide.

On the other hand, uncountable number of companies are working on the refinement of those plastics wastes catched on the ocean, on the following pages there will be the exposition of some of them.

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^{*}Zero-Sum: relating to denoting a situation in which whatever is gained by one side is lost by the other.

The Ocean Cleanup is a non-profit organization developing and scaling technologies to rid the world's oceans of plastics.

At 16 years of age, Boyan Slat, founder and CEO of the organization, saw more plastics bags than fish when scuba diving in Greece. He thought: 'Why can't we just clean this up?' This question led him to research the plastics pollution problem for a school project. He learned about plastics accumulating in five large oceanic gyres, the largest one being the Great Pacific Garbage Patch. In 2012, Boyan held a TedX talk about how to rid the world's oceans of plastics using technology. The video went viral, and the momentum that followed allowed him to drop out of school and found TheOceanCleanUp.

The initial design consisted of long, floating barriers fixed to the seabed, attached to a central platform

shaped like a manta ray for stability. The barriers would direct the floating plastics to the central platform, which would remove the plastics from the water.

In 2014, the design was revised, replacing the central platform with a tower detached from the floating barriers. This platform would collect the plastics using a conveyor belt. The floating barrier was proposed to be 100 km long. They also conducted and published their feasibility study. In 2015, this design won the London Design Museum Design of the Year and the INDEX: Award.

In 2015, scale model tests were conducted in controlled environments. Tests took place in wave pools at Deltares and Marin. The purpose was to test the dynamics and load of the barrier, when exposed to currents and waves, and to gather data for continued computational modeling.



The Ocean Clean Up official website, Boyan Slat, founder and CEO of The Ocean Cleanup

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A 100 m segment went through a test in the North Sea, off the coast of the Netherlands in the summer of 2016.

The purpose was to test the endurance of the materials chosen and the connections between elements. The test indicated that conventional oil containment booms could not endure the harsh environments the system would face.

They changed the floater material to a hard-walled high-density-polyethylene pipe, which is flexible enough to follow the waves, and rigid enough to maintain its open U-shape. More prototypes were deployed to test component endurance.

On May 2017, TheOceanCleanUp announced new design changes and their plan to test their new drifting system in the North Pacific in 2017.

At the end of the same year, significant changes to

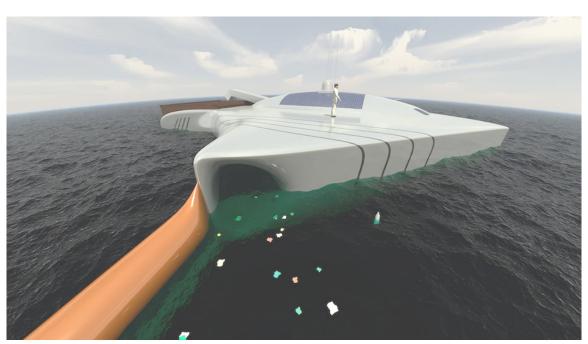
the design were made: the dimensions were drastically reduced, from 100 km to 1–2 km; theOcean-CleanUp suggested using a fleet of approximately 60 such systems.

The seabed anchors were replaced with sea anchors, allowing it to drift with the currents, but moving more slowly. This allowed the plastics to 'catch up' with the cleanup system. The lines to the anchor would keep the system in a U-shape.

This design allows the system to drift to locations with the highest concentration of debris.

An automatic system for collecting the plastics was dropped. Instead, the system would concentrate the plastics before removal by support vessels.

TheOceanCleanUp performed more scale model tests in 2018. The sea anchors were removed because the wind moved the system faster than the plastics. The opening of the U-shape barrier would face the



The Ocean Clean Up official website, Interceptor 001, initial design

direction of travel, which would be achieved by having the underwater screen deeper in the middle of the system, creating more drag.

On September 2018, System 001 (nicknamed Wilson from the Cast Away (2000) volleyball) deployed from San Francisco.

The ship Maersk Launcher towed the system to a position 240 nautical miles off the coast, where it was put through a series of sea trials.

It consisted of a 600 m long barrier with a 3 m wide skirt hanging beneath it. It is made from HDPE, and consists of 50 m per 12 m sections joined.

It was unmanned and incorporated solar-powered monitoring and navigation systems, including GPS, cameras, lanterns and an automatic identification systems (AIS).

The barrier and the screen mounting were produced in Austria by an Austrian supplier.

When the tests were complete, and the organization deemed it okay to move forward, it was towed to the Great Pacific Garbage Patch for real-world duty. It arrived on October 16, 2018, and was deployed in operational configuration.

System 001 encountered difficulties retaining the plastics collected. The system collected debris, but soon lost them because the barrier did not retain a consistent speed through the water.

In November, the project attempted to widen the mouth of the U-shape by 60 m / 70 m but failed.

In late December, mechanical stress caused an 18 m section to detach. Shortly thereafter, the rig began its

journey to Hawaii for inspection and repair.

During the two months of operation, the system had captured some 2,000 kg of plastics.

In anuary 2019, the Wilson system completed its 1300 km journey and arrived in Hilo Bay, Hawaii. TheOceanCleanUp planned to return the repaired system to duty by summer. In mid-June, after four months of root cause analyses and redesign, a new revamped testing system (001/B) was deployed.

In August, the team announced that after trying multiple alternatives, a water-borne parachute attached to slow the system, and expanding the cork line used to hold the screen in place would be tested.

In October they announced that the new system successfully captured and collected plastics, and even microplastics. The model was also more efficient and smaller, making offshore adjustments possible.

In June 2019, they deployed System 001/B, a smaller test system. They tested speeding up the system with a string of inflatable buoys installed across the system's opening, and slowing down the system with a parachute sea anchor. The sea anchor was found to best capture plastics. This edition used simpler connections between the barrier and skirt, eliminated stabilizing structures and reduced the barrier size by two-thirds.

In October, TheOceanCleanUp unveiled their new river cleanup technology, The Interceptor, the first scalable solution to intercept river plastics and prevent it from reaching the ocean. Two systems were deployed in Jakarta (Indonesia) and Klang (Malaysia).

In January, extreme flooding broke the barrier of Interceptor 001 in Jakarta. Although this was part of the design to reduce the force on the whole structure, the barrier was replaced with a newer model that has a stronger screen, simpler design, and an adjustable better-defined weak link.

In August, the third Interceptor was deployed in Santo Domingo, in the Dominican Republic.

In December, TheOceanCleanUp announced that production of the Interceptor series was to begin for global scale-up.

On October, they launched their first product made from plastics from the Great Pacific Garbage Patch, TheOceanCleanUp sunglasses, with funding going to their continued clean up. They worked with DNV GL (a Norwegian classification society) to develop a certification for plastics from water sources and the sunglasses were certified to originate from the pacific patch.

In July 2021, a new design called System 002, also known as 'Jenny', was deployed in the Great Pacific Garbage Patch for testing.

In October, the organization announced that the system had gathered 28'000 kg of trash.

In October, the project announced plans for System 003, which will span 2.5 km.

In July 2022, TheOceanCleanUp announced that an Interceptor Original will be deployed near the mouth of the Ballona Creek in southwestern Los Angeles County, California. This will be the first Interceptor



The Ocean Clean Up official website, The Ocean Clean Up team (2020)

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Original installed in the United States, and the second of the 3rd generation Interceptor Original to be deployed globally. Until the system is put into place, it will be docked with the United States Coast Guard in the Los Angeles area.

On July 2022, TheOceanCleanUp announced that it has removed more than 100'000 kg of plastics from the Great Pacific Garbage Patch using its 'System 002' and announced the beginning of its transition to the new 'System 03', which is purportedly 10 times as effective as its predecessor.

After many years of research, development, testing, and iteration, TheOceanCleanUp now has technologies to intercept plastics in rivers before it reaches the ocean, and technologies to remove the plastics that is already out there debris that has been building up for decades.

TheOceanCleanUp's team today consists of 120 engineers, researchers, scientists, computational modelers, and supporting roles, working daily to rid the world's oceans of plastics.



The Ocean Clean Up official website, The Ocean Clean Up first batch of marine plastics waste



The Ocean Clean Up official website, Retention zone filled with plastics during the System 002 compaign

THE INTERCEPTOR

To rid the oceans of plastics, the need is not only to clean up what is already out there but also stop new plastics from entering the ocean, main need is to close the tap. Working together with government leaders, individuals, and private corporations, TheOceanCleanUp goal is to tackle these 1000 most polluting rivers all over the world.

Every single year, marine plastics costs the economy (6 to 19) billions of dollars – impacting tourism, fisheries and aquaculture, and (governmental) cleanups. And that doesn't include the impact on people health and on the marine ecosystem.

Intercepting plastics in rivers is much more cost-effective than dealing with the consequences downstream. But each river is different from others. Factors like river width, depth, flow speed, debris composition, seasonality, and tides all have a major influence on the success of a river intervention.

To tackle different types of scenarios, the organization has a family of technology solutions to choose from, ranging from high tech to low tech.

Besides the ones listed below, researchers investigate the most suitable and effective ways to intercept plastics in other rivers on a case-by-case evaluation, and more solutions will be added to portfolio.

The Interceptor Original is the first river cleanup technology. It is a high-tech solution with solar-powered mechanics, smart processing, and connectivity for easy performance tracking. It is designed for series production, and in December 2020, TheOceanCleanUp entered a partnership with Konecranes was signed to begin manufacturing for more locations and to handle manufacturing at higher scale. Due to its

autonomous and large cleaning capacity, this is the primary technology researchers evaluate for feasibility in any new river which is planned to tackle.

Interceptor presents a catamaran structure built from the ground up. The modular design is specifically designed to facilitate containerization and swift deployment globally. It is also powered by monocrystalline solar cell panels and a smart energy storage system, which meets the 100% solar energy demand required to operate the Interceptor.

Latest version of continuously developing Interceptor, floats and works throught different machine:

BARRIER

The first thing that debrids encounter is the barrier. River waste flowing with the current is guided by the barrier towards the opening of the Interceptor. Thanks to the Interceptor's catamaran design, the water flow path is optimized to pass through the system, carrying the plastics onto the conveyor belt.

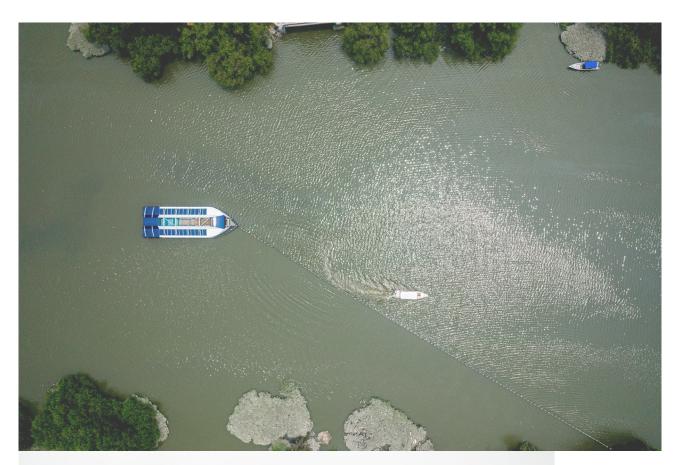
CONVEYOR BELT

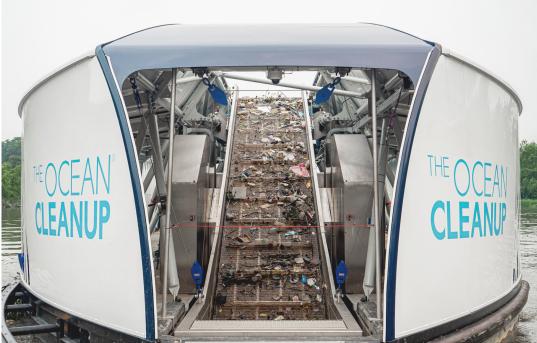
The current moves the debris onto a conveyor belt, which continuously extracts the debris from the water and delivers the waste to the shuttle.

In the latest version it is 2.50 m longer and 1.60 m wider. The expanded width allows for a less obstructive flow and better distribution to the dumpsters. It collects floating garbage drived by the barrier.

SHUTTLE

A shuttle automatically distributes the debris across six dumpsters. Using sensor data, the containers are filled equally until they reach full capacity.





The Ocean Clean Up official website, Interceptor 002 in Klang river, Selangor, Malaysia

DUMPSTERS

The Interceptor can store up to 50 m³ of trash before needing to be emptied. This means it's capable of operating even in the most polluted rivers all over the world.

BARGE

When the interceptor is almost full, it automatically sends a text message to the local operators to come and collect the waste. Operators then remove the barge, bring it to the side of the river, empty the dumpsters, send off the debris to local waste management facilities, and return the barge back into the

interceptor.

To adapt to the new conveyor belt width, the barge and the six dumpsters inside the Interceptor are now widened as well, which makes transfer from conveyor to dumpster easier and more effective.

Nowadays they have deployed this technology in five locations: Indonesia, Malaysia, the Dominican Republic, Vietnam and Jamaica.



The Ocean Clean Up official website, Barnes Gully barrier and tender, Kingston Harbour, Jamaica



Not only the catamaran structure works for stop plastics entering in the oceans, other stand alone machine operate before Interceptor during the floating of garbage.

INTERCEPTOR BARRIER

The Interceptor Barrier is a solution that consists of a standalone floating barrier anchored in a U-shape around the mouth of a small river. This intercepts the trash and buffers it until it is removed from the water. It is a variation of the barrier used to concentrate trash toward the mouth of a standard Interceptor. The main difference is that, in this case, most of the barrier is permeable and is thereby optimized to efficiently buffer trash in the water.

INTERCEPTOR TENDER

The Interceptor Tender was developed to work alongside Interceptor Barriers. This small powered barge uses a conveyor belt to scoop up the trash from a barrier and offload it into a dumpster onshore. While the Interceptor Barrier is a tool to intercept trash, it's

not capable of extracting and offloading on its own. This is where the Interceptor Tender comes in. This mobile extraction and offloading unit is capable of servicing multiple barriers, this means that the cost of extraction/offloading equipment is shared over multiple Interceptor sites.

INTERCEPTOR TRASHFENCE

The Interceptor Trashfence is a waste-capturing chain-link fence inspired by avalanche protection systems and specialized for flash flood environments. The structure is anchored to the banks and bed of a river and captures plastics and other waste along its length for extraction later. Designed for maximum impact in highly polluted and hard-to-reach locations, the Interceptor Trashfence is currently being piloted in Guatemala in one of the world's most polluting rivers, the Rio Las Vacas, where unique seasonal challenges including huge quantities of river waste and massive water pressure during the rainy season require a custom-engineered and experimental solution.

SYSTEM

Trash accumulates in five ocean garbage patches, the largest one being the Great Pacific Garbage Patch, located between Hawaii and California. To solve it, people not only need to stop more plastics from flowing into the ocean, but also clean up what is already out there. Floating plastics trapped in the patches will keep circulating until they break down into smaller and smaller pieces, becoming harder to clean up and increasingly easier to mistake for food by sealife. If left to circulate, the plastics will impact ecosystems, health, and economies for decades or even centuries. The fundamental challenge of cleaning up the ocean garbage patches is that the plastics pollution is highly

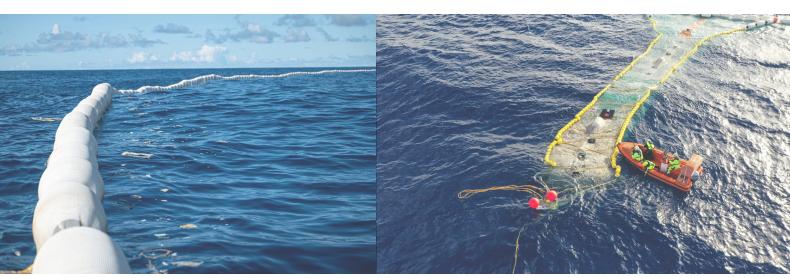
TARGET PHASE

The circulating currents in the garbage patch move the plastics around, creating natural ever-shifting hotspots of higher concentration. With the help of computational modeling, researchers predict where these hotspots are and place the cleanup systems in these areas. diluted, spanning millions of km². Company's cleanup solution is designed to first concentrate the plastics, allowing cleaners to effectively collect and remove vast quantities.

To clean an area of this size, a strategic and energy-efficient solution is required. With a relative speed difference maintained between the cleanup system and the plastics, System create artificial coastlines, where there are none, to concentrate the plastics. The system is comprised of a long U-shaped barrier that guides the plastics into a retention zone at its far end. Through active propulsion, ships maintain a slow forward speed with the system.

CAPTURE PHASE

By maintaining a relative speed difference to the plastics, the plastics can be caught in the retention zone of the cleanup system. The wingspan, speed and direction are corrected and maintained by the vessels.



Plastics accumulated along the barrier of System 002

Offshore crew investigating the retention zone of System 002

The Ocean Clean Up official website, System 002 deployed for testing in the Great Pacific Garbage Patch

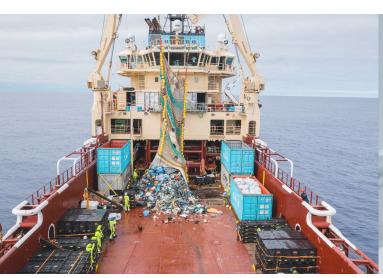


EXTRACTION PHASE

Once the system is full, the back of the retention zone is taken aboard, sealed off, detached from the system, and emptied on board the vessel. The retention zone is then put back in place and the cleanup continues.

RECYCLING PHASE

Once containers are full of plastics onboard, they are brought back to shore for recycling. For each system batch, the plan goal is on making durable and valuable products. Supporters getting the products will help fund the continued ocean cleanup. Catch, rinse, recycle and repeat - until the oceans are clean. The sunglasses are a proof of concept for this.



System 002 extraction zone emptied on deck



Granulate created from the catch from the system 001/B

THE OCEAN CLEAN UP



Ocean Garbage Patch



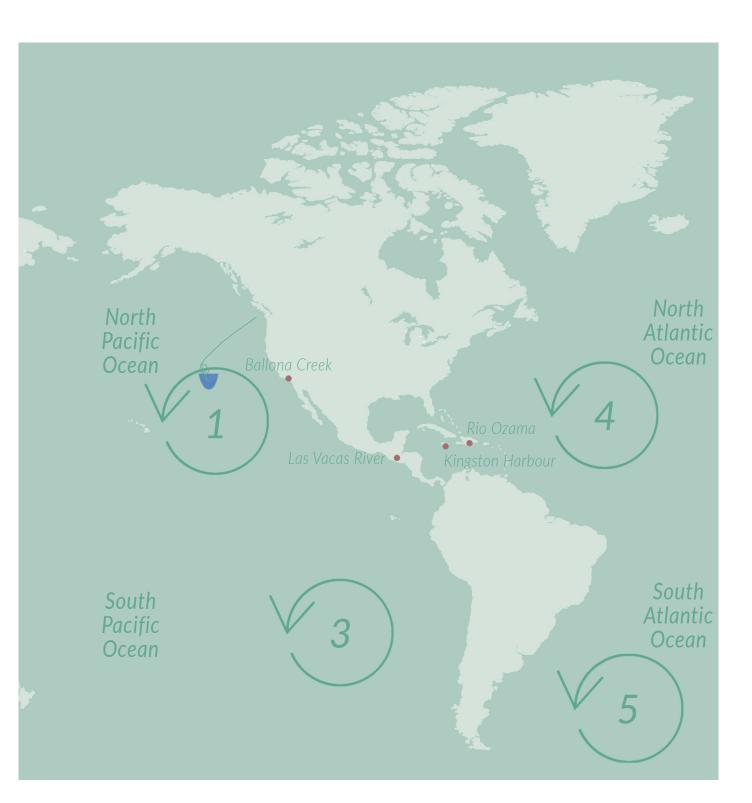
Working Interceptor



System 002 campaign



The Ocean Clean Up official website, map of the campaign taken by The Ocean Clean Up since 2015



WASTE MANAGEMENT

Since the beginning of TheOceanCleanUp, Boyan Slat and his researchers have always planned to do something valuable with the plastics they clean up.

Their main goal is keep this plastics from entering the environment again – either by creating durable new products or processing it otherwise. By giving ocean plastics a new purpose, they always work on how to turn the problem into a solution, and the funds they manage to raise this way will always go straight toward further cleanup.

TheOceanCleanUp is currently conducting cleanup operations in the Great Pacific Garbage Patch and some of the world's most polluted rivers.

The composition of trash extracted from the ocean differs from what cought in rivers, as does the ownership of the catch. Due to these factors, company's role in creating value for these two streams also differs and the main differences are exposed below.

COMPOSITION

Only certain types of plastics make their way out to the middle of the ocean. Compared to plastics retrieved from rivers, ocean plastics is also much more degraded due to decades of exposure to seawater and UV radiation from the sun.

The diversity of trash in rivers is much more signifi-



The Ocean Clean Up official website, Boyan Slat standing with plastics caught during the System 001/B campaign

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cant than for oceans. Here, it's not only cought different types of plastics but also other types of waste.

OWNERSHIP

The plastics cought in oceans is located in international waters, making the company its legal owner.

Trash caught in rivers is mainly owned by the operators of the Interceptor.

WASTE MANAGMENT

As legal owners, researchers of the campaign ensure the ocean catch is processed in accordance with USA waste management policy, overseeing the entire value chain as they go.

Working closely with the local operators of the Interceptors, TheOceanCleanUp researchers review waste management plans, helping to identify and mitigate potential risks. Together, the aim is to ensure a positive environmental impact.

FUNDING AND BUSINESS MODEL

They recycle the majority of plastics, after which

company's partners process to make durable new products while constantly looking for the best way to process any remaining waste.

TheOceanCleanUp supports Interceptor solution operators in developing business models for the extracted waste by sharing knowledge, experience, and access to network.

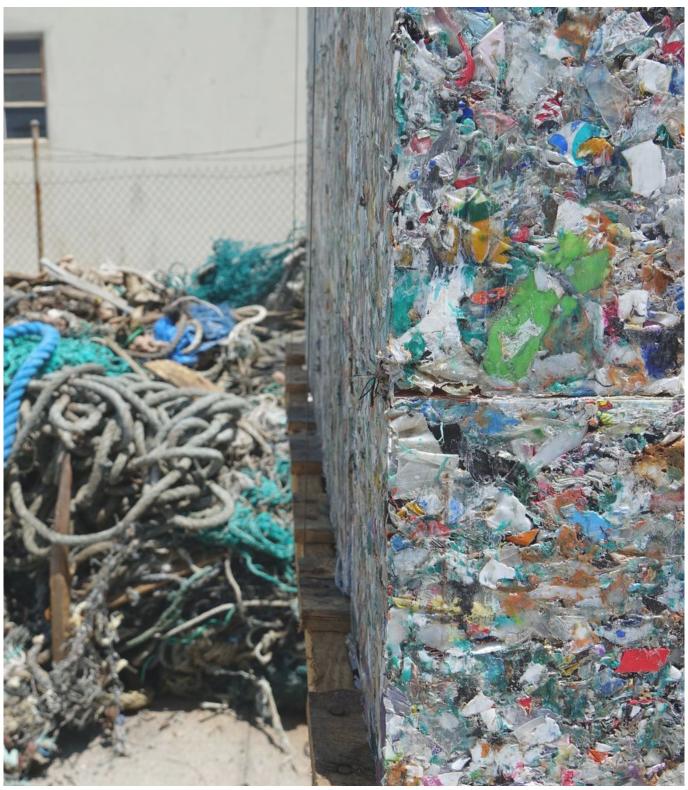
In October 2020, TheOceanCleanUp launched the first product made with plastics caught in the ocean: TheOceanCleanUp Sunglasses. This served as the proof of concept that it's possible to unlock the value in the ocean plastics catch: the material can be recycled into high-quality consumer products, giving people a tangible way to support researches, so they can raise funding to clean more ocean.

But there is no future for their products, they said. Main goal of TheOceanCleanUp is to work with partners to develop products and this will allow them to focus on the core mission of cleaning up: scale up missions quickly and catch exponentially more plastics the more ocean systems they deploy.



The Ocean Clean Up official website, Crew sorting plastics on deck after System 002 extraction, 10/2021

The Ocean Clean Up official website, Dominican Republic sorting



ByFusion Website Blog,
This marine debris was collected during a cleanup in the Great Pacific Ocean and will get repurposed into constructon-grade building material

2

ByFusion is a waste to infrastructure company dedicated to providing innovative solutions to address the global plastics crisis: a part of the larger movement working to combat climate change through innovative uses of technology.

ByFusion was founded in 2017 by Heidi Kujawa. Grown up swinging a hammer, she rooted around her grandfather's factory looking for scrap metal and wood to string together to figure out something to make. But slowly she realized, as a young girl, that girls weren't supposed to do that. And so she led herself into technology, as a career. Years of cyber security for Hollywood filmmakers and Sony Pictures, led her to found ByFusion Company.

The name ByFusion derives from the main technology they use: they actually fuse the plastics together. Their patented process is a kind of thermal reset. Melting plastics is not a good thing, so they actually don't melt plastics, they fuse it together using their patented system.

Los Angeles-based company has developed a machine, the Blocker, that turns plastics into plastics bricks called ByBlock. Similar in size and shape to the

concrete blocks commonly used in construction, ByBlocks are made entirely of reclaimed plastics waste the one which can't be recycled or is very, very difficult to recycle, which includes marine debris and agricultural plastics.

Marine debrids includes, for the most, fishingnets, bottles, straws and a lot of other objects highlighted in the previous chapters.

But what about agricultural plastics?

There are a lot of plastics that the farming and agricultural industry uses to grow crops. Everything from creating fumigation domes to preparing the soil for planting, to humidity control once seeds are planted to help those seeds get a jumpstart, all the way down to the drip lines. A lot of advanced drip line technologies that enables them to have better control over water. And so drip lines are used a lot these days in agriculture, and that's all plastics which go directly to the landfill.

After years of development for industrial mass production, the patented Blocker systems can consistently convert all types of plastics wastes into a high-performing, advanced building material called ByBlock.

Leading mission of the company isn't necessarily to



RECYCLES THE UNRECYCLABLE WITHOUT SORTING OR PREWASHING



REDUCE STRESS ON WASTE MANAGEMENT AND RECYCLING INFRASTRUCTURE



SCALES TO MEET THE VOLUME DEMANDS OF ANY RECYCLING FACILITY



DOES NOT REQUIRE ANY CHEMICALS, ADDITIVES, ADHESIVES, OR FILLERS



PROTECTS OUR PLANET, OCEANS, WATERWAYS, AND WILDLIFE

build a bunch of ByFusion brick-and-mortar facilities around the world but enable communities and corporations to be able to take control of their own plastics wastes, to convert their wastes into a building material that can then be used within local communities to serve and service those local communities.

And so they would offer themselfes like a platform that enables change, to enable cities to take more responsibility, accountability, and more transparency in the wastes management processes. They don't necessarily source plastics, because the company provides the hardware and infrastructure required for cities and corporations to do that themselves, to process their own wastes.

ByFusion enables communities, corporations, and governments to make use of their plastics wastes while cleaning up the planet. Blocker systems create jobs, improves infrastructure, and revitalizes neighborhoods everywhere.

'Driven by a desire to end plastics waste, we launched ByFusion, which has developed the first construction-grade building material made entirely from recycled (and often unrecyclable) plastics wastes'.

Heidi Kujawa, CEO and founder of the ByFusion company

Through steam and compression Blocker converts all types of plastics waste into ByBlock.

ByFusion diverts trash destined for the landfill, repurposes the mixed materials into a consolidated building block, and gives plastics wastes a long term, sustainable purpose.

The system works with virtually any kind of plastics, but excluding styrofoam and it doesn't require an ounce of adhesive, glue, or mortar.

As a result, the process yields no waste whatsoever: 10 kg of plastic makes a 10 kg block.



ByFusion Instagram profile, Plastics waste arrival

ByFusion Instagram profile, ByBlock section

2

You can literally eat your lunch, throw in the leftover plastics, make a block, then stick it in the wall.'

Heidi Kujawa, CEO and founder of the ByFusion company

The project is focused on creating a partner network that solves the global plastics crisis by: empowering communities to block their waste in place, advantage communities to solve increasing challenges around job creation, affordable housing and crumbling infrastructure, support aggressive wastes reduction goals, and supply the local market with an incredibly cost effective, 100% recycled advanced building material.

The company is working with several cities across the United States including Boise, Idaho, and Tucson, Arizona, and has already recycled 103 tons of plastics. It hopes to reach 100 million tons by 2030.

ByFusion also recently announced its collaboration with the Hefty Trash bags to launch a pilot program in Boise, Idaho that will give the community access to ByBlocker technology.

The Hefty EnergyBag Recycling Program initiative hopes to remove up to 72 tons of plastics wastes from local landfills and turn them into ByBlocks to build city park benches, and plans for more building initiatives in the coming years.

The ByFusion pilot projects demonstrate how communities of all sizes can innovate solutions to environmental challenges and put their hard-to-recycle plastics wastes to good use by converting it into a building material that supports their community.

The current project leverages public-private partnerships and will divert up to 72 tons of hard-to-recycle plastics from the Ada County Hidden Hollow landfill, which helps decrease its environmental impact.



ByFusion Instagram profile, In construction

ByFusion Instagram profile, Los Angeles installation

THE BLOCKER

The ByFusion Blocker is a machine which can process nearly all forms of plastics, without the need for intense cleaning and sorting. It's scaled to meet the volume demands of the city or the operation where it was going to be installed.

The Blocker base model is suitable in a shipping container, so it can be dropped and plugged in virtually anywhere that has the right power resources, it is a modular containerized version. Also the company has an industrial line of equipment that, like a kind of serial connections, work together to meet the volume demands of the operation.

The Blocker is designed to be placed and operated in recycling centers and plastics producing facilities as their purpose is to maximize the quantity of recyclables processed, while producing materials that will generate the highest possible revenues in the market. Because copious amounts of plastics are being sent to recycling centres already, ByFusion de-

veloped the ability to significantly increase the plastics cs being processed by allocating unrecyclable plastics to the Blocker which then produces the ByBlock without the costs of sorting and prewashing, a product able to generate increased revenue.

ByFusion call the Blocker the 'ultimate environmental diversion solution'. To explain it simply, this machine takes plastics wastes and converts it into construction-grade building blocks, the ByBlocks. Each ByBlock, while streamline in function, is unique to the plastics wastes recovered from that particular community.

'It is essentially like an adult Lego. Anybody can stack these blocks, which enables more people to participate in construction, do construction work. And so it enables communities to tap into a whole other labor pool to help satisfy construction demands for their communities.

Heidi Kujawa, CEO and founder of the ByFusion company



One of the main goal of the company is not to be a transaction or a business, the focus is to be a service provider to cities.

Services actually can vary in two different ways.

Hardware-only service where technichian come in, plop the system down, help train local operators to run the operation, as well as work with local builders on how to build with the material. It works like professionists come in and do all the quality inspections, make sure the building material continues to live up to the standards that were required, and then also provide services and upgrades along the way.

On the other hand if the city does have a surplus or makes enough blocks that they can't use, then sellers come in and help move that material into the market. Doing that with either a guaranteed buyback program or a revenue split.

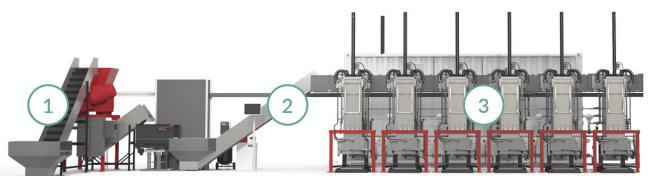
So there's a couple different ways to think about the services that the company can provide.

The base service provided by the company starts at a really affordable price of equipment that enables companies or communities to take control of their wastes and create their own building materials. So there's a lot of upside from a cost perspective.

The Blocker takes any plastics wastes, then shreds, superheats and fuses it into construction-grade building blocks. ByFusion uses a steam-based compression process that does not melt or degrade the polymers. This process, while cost effective, also generates significantly less greenhouse gas emissions than processing plastics for the landfill or recycling, as well as the production of other construction materials such as concrete.

HOW IT WORKS

Using only steam and compression, ByFusion's zero-waste process repurposes unsorted commingled plastics wastes into ByBlock without secondary additives or fillers: 10 kg of plastics create a 10 kg ByBlock.



PLASTICS IS LOADED ONTO A
CONVEYOR OR FED DIRECTLY
INTO THE SHREDDER FROM THE
FACILITY'S SORTING LINE

THE BLOCKER'S AUTOMATED
SYSTEM THEN DELIVERS THE PLASTICS INTO THE BLOCKER CELLS
TO PRODUCE BYBLOCK

BYBLOCK IS EJECTED FROM THE
BLOCKER CELL AND PALLETIZED
FOR SALE, SHIPMENT, AND BUILDING APPLICATIONS











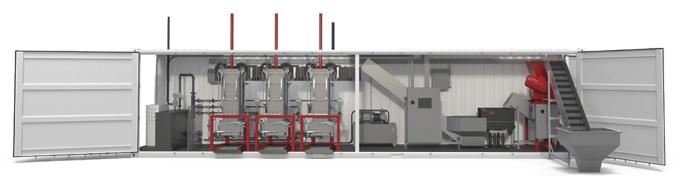


The Blocker comes in two primary sizes: Community and Industrial.

S40 BLOCKER

The Community Blocker is geared toward small recycling operations, community projects, disaster

relief/clean-up efforts and mobility, with the capacity to process up to 30 tons of plastics per month.

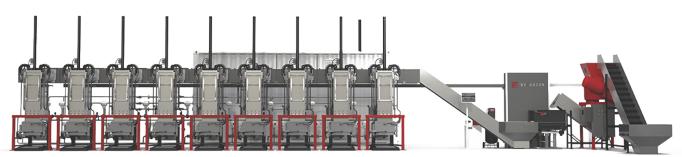


- Designed for smaller material recycling facilities, waste management operations, municipalities, and corporate partners
- _ Processes up to 100 tons per month

- _ Conforms to California emissions standards
- _ Modular installation
- _ Ships standard shipping containers

LI120 BLOCKER

The Industrial Blocker is intended for large scale, industrial installations and can be scaled up or down to meet venue space limitations and almost any plastics volume requirement, processing 90 tons per month.



- _ A customizable system, engineered to scale for large scale material recycling facilities
- _ Floor mounted installation

- _ Entry level industrial system process up to 320 tons per month
- _ Conforms to California emissions standards

Jason Feifer (photojournalist), 2022 'This Company Turns Plastics Garbage Into Construction Materials' (article)

But who is the consumer for the Blocker?

ByFusion's plan isn't just to sell blocks of plastics. It sells the machines that make the blocks, and has designed them modularly so that a broad range of clients, from waste management companies to municipalities, can utilize them to fit their needs.

MATERIALS RECOVERY FACILITIES (MRFs)

Reduce the cost burden and headaches of the low to no-value plastics and improve bottom line.

ByFusion allows MRFs* to create saleable construction- grade building products, ByBlock, thus creating a new revenue stream and decreasing the overall cost associated with currently sending this plastics to landfill and paying tipping fees.

Contamination in recycling is a major issue for all MRFs*. ByFusion creates systemic incentive to sort what is currently considered a contaminant, bound for the landfill and recovers it as valuable material for construction-grade building blocks.

Blockers systems are designed to plug into existing sort lines, reducing expensive transportation costs and gate-fees, while increasing the throughput of the balers for high-value materials. Proving to their customers they have a solution to address the plastics crisis that doesn't involve landfilling or incineration and doesn't hurt either on green house gasses emissions. MRFs* have the challenging position of meeting regional or statewide waste diversion requirements, yet are subject to the vagaries of national and international waste markets. Blocker offers them the opportunity to locally divert a community's plastics wastes and turn it into a product for building local facilities and structures.

*MRFs: Material Recovery Facilities



BYBLOCK



ByFusion Website Blog, ByBlock

ByFusion invented a way to convert plastics wastes into a building material called ByBlock, rather than it ending up in landfills. The best part, it can be done without having to sort, process or clean the plastics first, and it can be shaped into the size of a cinder-block (by using steam and pressure) that doesn't crack or crumble. Once shaped, it can be used to build and can be similarly covered with paneling or stucco.

But the best thing to think about is that ByBlocks can be used wherever lumber is used hence fall in the category of a general utility type-five construction application. Type five is where all of the lumber applications live. General utility encompasses anything from garden sheds storage, single-family residential projects, landscaping, fencing, kiosks, uninhabitable spaces, walling applications, a whole slew.

It's general utility, but it does include some residential applications, as well as commercial, but generally uti-

lity across the board.

ByBlock is a multi-purpose, high-performing insulating building material made entirely out of plastics waste without additives or fillers added.

ByBlocks are designed to integrate harmoniously with traditional building materials such as lumber, steel and cement to meet the structural requirement of the project; offering excellent dimensional stability, water-resistant properties, and handles high-pressure load without cracking or crumbling.

ByBlock helps constructors build faster, cleaner, and greener than any construction block on the market. Made of recycled and often unrecyclable plastics wastes, ByBlock gives builders, architects, weekend warriors, and DIY* makers alike a sustainable, high-performing construction material usable for anything from walls to sheds and furniture to fencing.

The qualities that make plastics such a valuable material for packaging are exactly what make it one of the

*DIY: Do It Yourself



ByFusion Website Blog, BvBlock

most powerful building materials around: it's malleable, insulative, and doesn't degrade easily.

Using ByFusion proprietary system, technology maximizes these traits by processing recovered plastics wastes of any sort into ready-made building materials, thus offering builders around the world an easy-to-use, eco-friendly, and inexpensive product to use in residential or commercial settings.

ByFusion's ByBlock offers one of the most intriguing construction products the building industry has seen in years.

ByBlock is similar in dimension to standard concrete cinder blocks: approximately 40 cm wide, 20 cm deep, and 20 cm tall.

Although they are made from 100% plastics wastes, their strength is not to be underestimated. Weighing 10 kg per block, final structure will be sturdy, reliable, and well insulated.

Each ByBlock has two clearance holes both extending

completely through the product, two pins located on the top, and two dimples located on the bottom. The clearance holes are used to run metal rods through each ByBlock to reinforce structure strength, while the pins and dimples are designed to connect to one another while stacking ByBlock, just like Lego bricks.

ByBlock's user-friendly build, coupled with its ecofriendly footprint, make it a unique building material. Rob Brower, sustainable builder and ByFusion advocate, has positive things to say after spearheading the installation of one of the project at the Island School in Lihue, Kauai.

'The ByBlocks went up fast and easy. When you see how the finished product looks, it's clear that ByBlock is a great way to give plastics wastes a responsible end use. They seem to have great R value and sound proofing qualities.'

Rob Brower, sustainable builder and ByFusion advocate

ByBlock saves time, money, and energy but some other technical datas are shown below, most of them derived from frequently consumers asked question.

What about the potential of pesky termites and water damage?

ByBlock's plastics composition renders it both insectand water-proof. In fact, because plastics does not absorb moisture, ByBlock will actually float.

What if household move and want to take ByBlock structure with himself?

Any project made from ByBlock can be disassembled and repurposed with the same strength and quality, easier than any other building material.

ByBlock will not crack under pressure nor break if dropped, so consumers don't have to worry about replacing materials. If somebody do somehow manage to break a ByBlock, but it's found not to be easy, any waste material can always be sent back and remade into a new fully functioning ByBlock.

Does ByBlock contribute to LEED certification?

Yes, ByBlock will contribute to LEED credits.

The low emission process, high rate of plastics wastes diversion, and minimal materials required for installation make ByBlock the most eco-friendly building block to choose from.

Will ByBlock leach or put microplastics into the environment?

ByBlock is a high-performing, insulating building material and is not intended to be exposed to the elements without an exterior covering. This could be one of any readily available products in the market; weatherboard, stucco, paneling, etc. This will protect ByBlock from weather, UV and any environmental degradation.

Every ByBlock purchase comes with a collection bag for construction debris. Because ByBlock is realized using only steam and compression, no melting or extrusion, it is normal to have some pieces fall away when rough handling the material.

These can be collected and sent back to ByFusion and Blocker can use the debris to make more ByBlock.

What about fire?

Like timber building materials, ByBlock is a Class 5 product. This means it will require a fire retardant in certain applications. These retardants are readily available in the market and are used in everyday building projects.

Upcoming testing strategies include a full array of fire rating tests based on internationally-accepted standards.

Can ByBlocks be cut?

Yes, ByBlocks can be cut using standard tools like band saw, reciprocating saw, radial arm saw, chainsaw, etc. with a high tpi count. Consumers can also cut them with a handsaw.

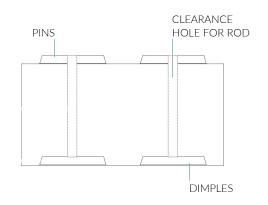
Can ByBlocks be painted?

Yes, ByBlock can easily be painted using a sprayer or roller application. A specific primer will be required to ensure proper adhesion to the plastics substrate.

BYBLOCK DATA SHEET

DESCRIPTION

ByBlock is a multi-purpose, high-performing insulating building material made entirely out of plastics wastes no additives or fillers. ByBlocks are designed to integrate harmoniously with traditional building materials such as lumber, steel and cement to meet the structural requirement of the project; offering excellent dimensional stability, water-resistant properties, and handles high-pressure load without cracking or crumbling.



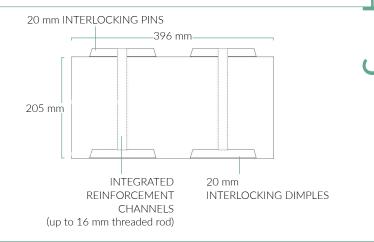
SIZE AND DIMENSIONS

STANDARD BYBLOCK

Total height of ByBlock includes the 'pins' on top of the product which recess into the ByBlock above. Actual finished height of ByBlock is 205 mm.

WIDTH	DEPTH	HEIGHT
396 mm	198 mm	227 mm
	DENSITY	

Standard 10kg Customization densities 8 kg - 12 kg

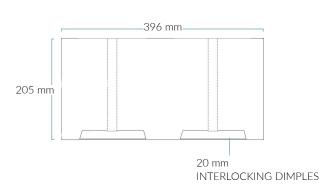


FLAT BYBLOCK

Flat ByBlock is intended to be used for the top course to make finishing easier. Actual exposed/finished height of ByBlock is 207 mm.

WIDTH	DEPTH	HEIGHT
396 mm	198 mm	207 mm
	DENSITY	
	B 2. 10	

Standard 10 kg Customization densities 8 kg - 12 kg



ADVANTAGES

Project Savings

ByBlocks are highly-durable and easy to handle, mid-weight material that stack in place without additional glues, adhesives, additives, or mortars. Specialized trade skills are not required for installation of ByBlock which translates to approximately 54% project savings between materials and labor costs when compared to concrete block construction.

Environmentally Friendly

100% repurposed plastics wastes. No additives or fillers.

Zero Breakage

Does not crack or crumble. Minimizing unnecessary construction waste.

Water Resistant

Since ByBlocks are made with plastics, they are able to resist water without additional products.

Insect Resistant

Plastics is not consumable by termites and carpenter ants.

Workability

ByBlock can be used alone for many applications, but also integrate easily with all other building materials to fit the demands of the project. They can be screwed, nailed, stapled, sawed and drilled through using standard, readily available tools and hardware.

Finishing

ByBlock can be finished with any readily available finishing material including but not limited to stucco, sheet rock/drywall, plaster, siding, paneling and some specialized paints to meet the demands of any project.

COLOR

Colors vary due to the nature of the material. No two ByBlock are alike.

FIRE RESISTANCE

ByBlock are categorized as Type 5 construction. Approved thermal barriers must be applied as part of finishing to conform with the building code for fire safety as required for the application. Secondary fire retardants (spray, wraps or panels) can be applied.

PERFORMANCE

Standard, single unit un-reinforced 10 kg ByBlock offers unique performance and strength.

ByBlocks are intended to be reinforced using threaded rod (10 mm - 16 mm) for assembly and added strength. They can be integrated with other structural building materials such as wood, steel and concrete depending on the application and as directed by engineering.

ByBlock is not intended as a sole component of a wall assembly in thermal applications. They will serve as an insulating, structural component; utilizing standard building materials to the interior and exterior of the wall assembly as per project design specifications.

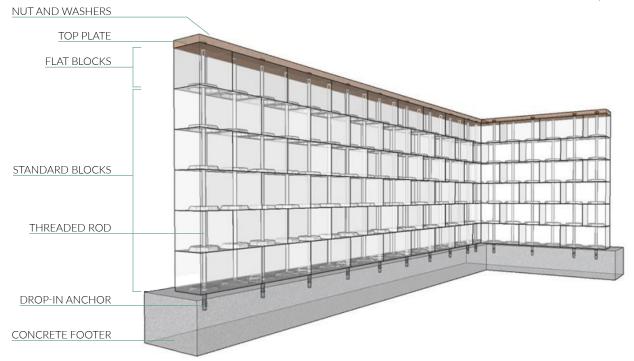
CLEANING

ByBlock walls do not require special cleaning. ByBlock structures/surfaces can be cleaned using an air gun to blow debris free from the product.

C H A P T E

HOW TO BUILD WITH BYBLOCK

ByFusion Website Blog, Build with ByBlock



Building with ByBlock is fast and easy.

The primary materials required for ByBlock construction include the ByBlock itself, threaded rod, washers and nuts, lumber or steel top plates, base mounting hardware, and covering; but also tools are needed like standard torque wrench, rubber mallet, standard level, band saw, table saw with fence and chainsaw.

REINFORCEMENT ESTIMATES AND PREPARATION

ByBlock does not require glues or mortars during construction but, glues and adhesives can be applied if needed. ByBlock's strength is further enhanced from the use of threaded rod or rebar and post-tension. Instead, the rods are secured within the base and extend through each ByBlock with the pins and dimples

locking together.

ByBlocks are manufactured with an integrated reinforcement channel for speedy construction. The reinforcement channel can support 10 mm – 16 mm threaded rod without drilling.

Threaded rod may be used every 200 mm to provide additional support depending on the application.

If project includes windows, door or other openings, a rod should be placed on either side of the opening for additional support.

PREPARING FOUNDATION

ByBlock requires a level footing which can be concrete, steel bases, or lumber.

With concrete, there are a few options for anchoring the metal rods: place rods in cement when it is poured, drill holes in concrete, and either install drop-in anchors or use epoxy. Using drop-in anchors afford constructor the quickest installation with the most precision.

Regardless of new or existing construction, insert the first threaded rod 100 mm from the edge of the first wall then every 400 mm thereafter.

Rebar can be added every 200 mm for additional support if required.

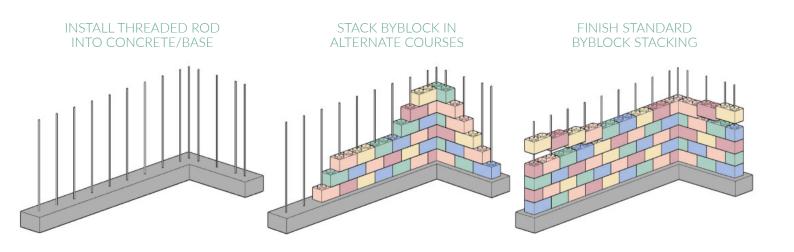
BYBLOCKS CUTTING

Best results are achieved using a fine-tooth blade band saw or radial saw. As the product is created using varying types of post-consumer waste, it is an irregular material and may grab during the cutting process. Ensure the ByBlocks are properly secured in position using fences or guides to hold the block firmly in place. Do not cut while trying to hold with bare hands. Hand saws and grinders can be used for minor adjustments or material removal if required.

INSTALLING

Install ByBlock as any other 'brick' type of application–staggering each course. One of the important thing to remember is that during the planning phase of the project, at least one rod must run through each ByBlock. Slide the ByBlock down the threaded rod and into position; continuing the process until the wall unit is at finish height. Use a rubber mallet to tap ByBlocks over threaded rod if needed. Once wall height is achieved, install top plate or beam, washers and lug nuts, and tightened to the desired wall height. Post-tensioning will lock ByBlocks in place and add integrity and strength to the wall unit.

At this point, tightening the nuts will draw the ByBlock courses together and lock them tightly into position. This is where a ByBlock wall assembly gets its strength. Then, once the nuts are tightened and the walls are compressed together and levelled, the excess rod can be cut back using a grinder or reciprocating saw.



FINISHING

Lastly, because ByBlock is designed to be covered and protected from the elements, the final step is to add a finish like stucco, sheetrock/drywall, plaster, siding, paneling or even specialized paints.

If it's an outdoor project and is designed to feature ByBlock visually, a clear UV coating will need to be applied. UV protective products are readily available in the market today.

Now a perfectly-functioning, durable structure made almost entirely out of post-consumer plastics is done.

JOINTING

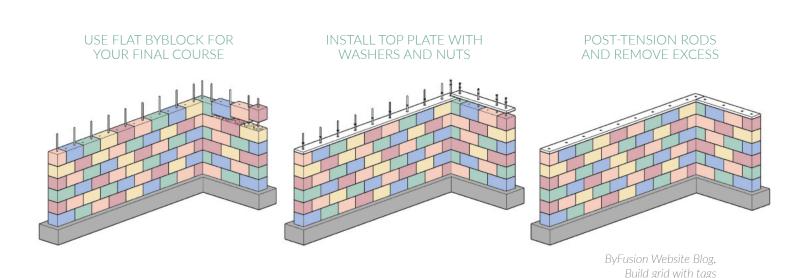
No adhesives, mortars, or solvents are required for jointing. ByBlock is designed to hold firmly to the blocks above and below, creating one complete unit. The post-tension adds enhanced strength to the system.

I FVFI ING AND SETTING

A ByBlock structure gets its strength from compressing the blocks together by tightening the top plate down; using post-tension.

For time savings, pre-drill the top plate or beam to match the measurements of the rods at the footing. It is not uncommon for slight movement in the rods during the installation of the ByBlock, but the rods need to be fastened in direct vertical alignment with their attachment point in the footing for maximum strength and sizing. Over tighten is not reccommended. Refer to the maximum loads on the threaded rod when in question. Tighten each wall down in equal increments until the ByBlock wall locks into place and the desired level height is achieved.

Ideal tensioning results in 2-3 mm compression per ByBlock. Use a standard carpenter's level to keep the work you are doing plumb. If at any time ByBlock slips out of place, simply knock it back into place using a rubber mallet.



WEEP HOLES AND VENTS

Because the material is not bound together with adhesives, there is no need for additional ventilation. The material will allow for some ambient air to pass. For most residential and commercial purposes, most of external walls will be covered and finished with an external covering/application which will prevent any water or liquid from penetrating into the internal structure of the ByBlock, negating the need for weep holes.

INSPECTION

The final surfaces of any ByBlock wall using standard applications will present true, level and flush. To maintain plumb, additional metal bracing can be applied.

DELIVERY, STORAGE AND HANDLING

ByBlocks are delivered on pallets. Store pallets on level ground and keep dry. Avoid sitting in pooled water. While ByBlocks do not demonstrate capillary action, they can accumulate water adding to weight. Saturated ByBlocks will require additional drying time before interior/exterior wall coverings can be applied.

MAINTENANCE

ByBlock requires no maintenance. Plastics will not deteriorate when covered and protected from the elements. If left exposed to sun, some surface color may bleach out.

LIMITATIONS

1st

ByBlocks are intended to be reinforced and assembled by means of post-tensioning.

2nd

ByBlocks are fused together using ByFusion proprietary process. When cut in half, it is common for some particles of plastics to become loose. Use the collection bag that comes with every pallet to collect ByBlock construction debris and send back to ByFusion to make more ByBlock and get zero waste.

3rc

If the application requires ByBlock to be exposed to the sun, a UV sealer/protectant should be applied to limit the effects of UV as it will bleach out colors over time.

_4th

ByBlocks are not intended to be used in environments where they are exposed to temperatures exceeding 60°C over extended periods of time without a finished covering.

WHAT BUILD WITH BYBLOCK

ByBlock is designed for a wide variety of residential, commercial, and institutional projects.

From landscaping and gardening, to flooring and fencing, to small buildings like sheds or offices.

Thus far, ByFusion has completed two official pilot projects: an athletic pavilion on the sports field of Island School in Lihue, Kauai and a lifeguard tower on Bruce's Beach in Manhattan Beach, California.

In both cases, the community was elated with the quality of the structures and their waste diversion function, while the construction team raved about ByBlock's simple assembly, inspiring ideas for additional projects in both locations.

The ByBlock can be utilized to improve infrastructure by anyone, eliminating the need for highly skilled, indemand construction tradesmen/women, opening up a whole new labor field to support construction needs.

ByBlock's are versatile, tested and ready for deployment in projects including:

landscaping and walling like privacy, sound and retaining; infrastructure and utility like sound walls, kiosks, storage sheds, security; parks and recreation like pavilions, benches, planters, open space projects; commercial, residential and consumer like accent walls, furniture, modular structures such as sheds, detached office spaces and various other residential projects.





IN THE WORLD

ISLAND SCHOOL ATHLETIC PAVILION IN LIHUE, KAUAI, HAWAII

There isn't a day that goes by that people don't hear about plastics and the damage it is doing to oceans and communities. Plastics wastes can be found in just about every corner of society, whether it's from blatant disregard, leaked during transit, or natural disasters that wash waste out to sea. Studies have found that approximately 9 million tons of plastics enters oceans each year, significantly impacting sea life and coastal communities.

The beautiful beaches of Hawaii and surrounding oceans are not immune from the scourge of plastics wastes. Below is the story of a school, a nonprofit, and ByFusion which coming together to take trash and turn it into treasure for a small island community.

In April 2017, Rob Brower reached out to ByFusion and described the challenges the island of Kauai, Hawaii was facing due to marine debris.

Rob is a 45-year veteran surfer and diver who serves on the board of Surfrider Foundation – Kauai Chapter as well a luxury home builder with an emphasis on sustainability.

Since then, Rob's commitment to protecting Hawaii oceans accelerated marine debris research when he introduced ByFusion team to Surfrider Kauai's Senior Scientist, Dr. Carl Berg.

A few years and Blocker generations later, ByFusion reached a big milestone and successfully produced the world's first construction-grade ByBlock made of plastics marine debris and abandoned fishing nets. While researchers were busy in the Innovation Lab, Dr. Berg and Rob Brower were scouring Kauai in search of the ideal construction project for these new ByBlocks when they learned Island School in Lihue, Kauai needed a new athletic pavilion.



ByFusion Website Blog, Pavilion skelethon

ByFusion Website Blog, Constructors took one day to stack the blocks that of the walls of the pavilion

Dr. Berg enlisted the help of Schmidt Marine Technology to help fund the project and Rob's construction company, Brower Construction, tapped his network of industry specialists including; Architects Kauai, Island Truss, Kick Ass Concrete, Mahelona Sheet Metal Fabrication, and Pacific Plaster and Stucco and got to work building a valuable new structure for local students to enjoy.

Heidi Kujawa, ByFusion CEO, shared how invaluable these two have been to ByFusion's success, noting that

'Rob and Dr. Berg have become a part of ByFusion's family. Their support over the years has enabled us to achieve several major milestones. We are forever grateful for their contributions and looking forward to continuing to partner with them on many more projects.'

In the Summer of 2019, ByFusion team travelled to the island community of Lihue, Kauai to build an athletic pavilion on the grounds of Island School, using ByBlock in conjunction with standard building materials including threaded rod, hardware and lumber, and concrete slab.

In this case, to create the athletic pavilion using ByBlocks, volunteers first collected marine debris on the local beaches of Kauai.

This was then mixed with a collection of post-consumer waste, called 'pre-marine debris'.

ByFusion coined this term due to the fact that most plastics wastes starts out as post-consumer wastes before making its way into oceans.

Testing was then employed to identify the highest ratio of marine debris to plastics wastes that would result in a ByBlock meeting ByFusion quality standards. Surfrider hosts community beach cleanups and targe-



ByFusion Website Blog, ByBlock texture of the pavilion

ByFusion Website Blog, Finished athletic pavilion structure on the Island School field



Jessica Else (ByFusion's journalist), 2019 Inauguration day

ted net patrols, collecting an average or approximately 4.5 tons per month. Without a means to recycle or repurpose this waste, the Honolulu H-Power incinerator is their only option, resulting in the production of toxic greenhouse gas emissions.

The Island School project alone has utilized 2.4 tons of plastics wastes which was previously burdensome on the island community, making a significant stride in the fight to solve the global plastics wastes issue.

The blocks form the walls of the pavilion, and the spaces in between are filled with traditional building materials like rebar, stucco and trusses. The building is about 6 m in length and is situated by the school's soccer field.

Each block is made out of shredded, cleaned plastics wastes compressed into a solid rectangle at ByFusion's only processing facility in New Zealand.

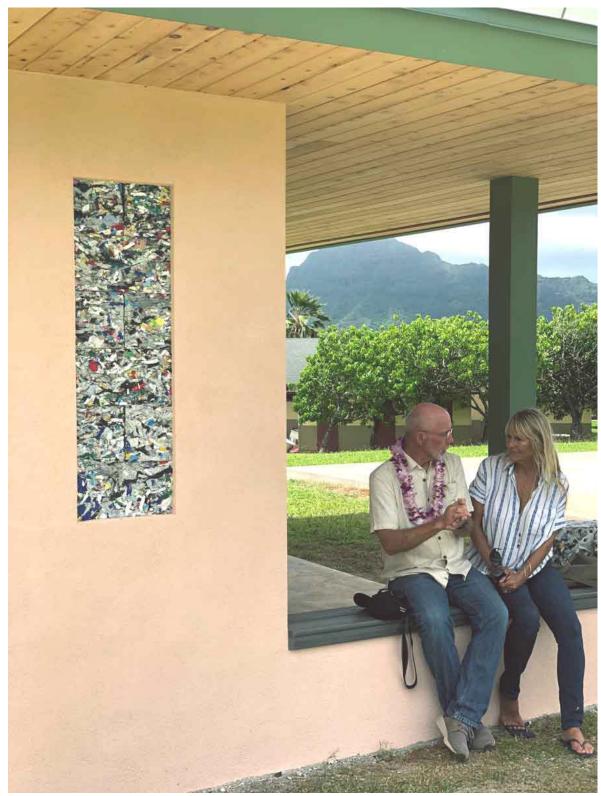
They're touted as a cheaper form of construction because they're lighter and require fewer materials for building.

Stucco covers the plastics blocks, sealing them and the gasses they produce should they decompose.

Dr. Carl Berg as well as other key players in this project have expressed interest in obtaining a Blocker on the island which can facilitate a community run, closed loop cycle for plastics wastes and marine debris. Local plastics wastes, transformed into construction-grade building material, used for local projects, eliminating plastics wastes pollution, creating jobs, and improving community infrastructure, all in one.

It's a pilot project that's brought together the County of Kauai, Surfrider Foundation, Island School, ByFusion and the island's construction community.

With contractors building with ByBlock and community members collecting plastics wastes, this project brought together a unique set of people, working together to better their home island and the environment in a tangible way.



ByFusion Website Blog, Kauai Surferider Senior Scientist, Dr. Carl Berg and his wife during the inauguration day of the pavilion



ByFusion Website Blog, Lifeguard tower

LIFEGUARD TOWER IN MANHATTAN BEACH, LOS ANGELES, CALIFORNIA

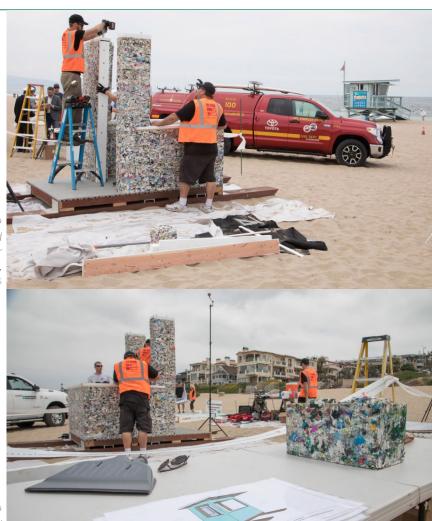
The lifeguard tower in Los Angeles and the school pavilion in Kauai will be the first-ever structures built with ByBlocks in the United States, collectively diverting 3.5 tons of plastics from landfills and oceans.

To demonstrate how it works, and in honor of World Oceans Day, ByFusion partnered with Sustainable Surf and Channel Islands Surfboards to create a lifeguard tower made from 0.6 ton of disregarded plastics, as well as foam waste from shaping surfboards. It's all happened in the summer of 2019 in Manhattan Beach, Los Angeles, California.

A ByFusion press release announced they'd used boards donated by Channel Islands Surfboards and Sustainable Surf as part of a partnership to start incorporating waste from the surfboard manufacturing process into their ByBlock product.



ByFusion Website Blog, Lifeguard tower 'how to make'



Chuck Bennett (Photographer), 2019 Morgan Sterling, Michael Kujawa and Dave Gnadt build a lifeguard tower in Manhattan Beach on Saturday, June 8, 2019, with plastics bricks

Chuck Bennett (Photographer), 2019 Morgan Sterling, Michael Kujawa and Dave Gnadt build a lifeguard tower in Manhattan Beach on Saturday, June 8, 2019, with plastics bricks



Chuck Bennett (Photographer), 2019 Michael Kujawa grinds through a tension bar

The city of Nairobi generates more or less 500 metric tons of plastics waste every day. Much of it ends up in landfill or worse, dumped in rivers and roadsides across the country. To help combat the deluge, 29-year-old materials engineer Nzambi Matee started experimenting with ways to turn this waste into a resource. The result is Gjenge Makers: a community-oriented organization whose aim is to address the need for sustainable and affordable alternative construction materials in Kenya, tackling two problems, plastics pollution and the housing crisis, with one solution.

Nzambi Matee is a Kenyan trained mechanical engineer, environmentalist, hardware designer, inventor and serial entrepreneur.

Through trials and errors, she and her team learned that some plastics bind together better than others. Her project was given a boost when Matee won a scholarship to attend a social entrepreneurship training programme in the United States of America. With her paver samples packed in her luggage, she used the material labs in the University of Colorado

Boulder to further test and refine the ratios of sand to plastics.

With this process, Matee also developed the machinery she would use to make the bricks.

In 2017, she decided to quit her job of a data analyst for a Kenya's oil industry in order to focus on sustainability and waste management, this was the starting point for made arrangements to set up a small laboratory in her mother's backyard and here began creating and testing pavers.

But she waited for about a year in order to develop the right ratios for her paving bricks, then the first brick from a plastics waste was developed in 2018 and a year later in 2019 she made her own self made machine in order to convert plastics waste to bricks in a large scale. For over 8 months, Matee and the team sat down with 52 different investors and pitched their product. And 52 times they and their bricks had to get up and leave. But all of them cannot refuse this worthwhile mission.

The initial output is innovations derived from recycled plastics to produce paving blocks, paving tiles, and



Credits: Gjenge makers official website

manhole covers.

The startup company has now established a lightweight and low-cost building material that is made of recycled plastics with sand to make bricks that are stronger than concrete material and, depending on thickness, yet lighter in weight, which reduces shipping costs: the Pavers.

So far, Gjenge Makers has recycled more than 20 tonnes of plastic and created 112 job opportunities in the community. This is exciting, especially considering Matee's ambitions to educate and empower other youths in Africa to take on local waste issues.

With her initiative, Matee has recently been named a Young Champion of the Earth 2020 Africa winner at the United Nations Environment Programme (UNEP). The award 'provides seed funding and mentorship to promising environmentalists as they tackle the world's most pressing challenges'. Her sustainable efforts have also been hailed as one of the successful strategies to curb the plastic pollution in Kenya.





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PAVERS

Credits: Gjenge makers official website



The company's pavers are fully certified by the Kenyan Bureau of Standards.

Explaining the process in detail, company gets the plastics waste from packaging factories or buys it from other recyclers. But also they've created an app by which homeowners can let them know when they have available plastics and be rewarded for it.

They used high-density polyethene, used in milk and

shampoo bottles; low-density polyethene, often used for bags for cereals or sandwiches; and polypropylene, used for ropes, flip-top lids and buckets. But they don't work with polyethene terephthalate or PET, commonly used for plastics bottles.

The plastics waste is mixed with sand, heated and then compressed into bricks, which are sold at varying prices, depending on thickness and colour.



Gjenge Makers use plastics waste shredded into small pieces and mix it with sand. The mix is then transferred into an extruder (heating machine). At 367°C, the materials are heated and mixed further, slowly turning into a gelatinous blob.

As it comes out of the machine the texture looks a little like ice cream. It's split by hand and weighed for the size of brick they're making that day, and then dropped into the lego shaped holes in the press.

The hydraulic press squashes the mixture into the perfect brick shape which is then dropped in a cool bath to help the solidification process. And there is born the pavers: a stronger than concrete, totally recycled plastics brick. All it takes is two machines, a bath of water, and a willing team.

They make three types of bricks; the lightest is for foot traffic, the medium is for light vehicles, and a heavy brick for trailers and their like. Even the lightest holds three times the weight than the same amount of concrete.

They're lighter which translates into savings on tran-

sportation costs, and a reduction on ${\rm CO_2}$ emissions. This was achieved through three years of trials and errors, in which Matee and her team tested different combinations of plastics and sand, and developed the machinery needed to process them.

Their common grey bricks cost 850 Kenyan shillings (6.67 €) per square metre, for example.

The company has three machines, the extruder does the mixing of plastics waste, with sand, at very high temperatures and then the press compresses it.

Now, Gjenge Makers have a capacity of producing 1'000 to 15'000 bricks a day. Much of the raw plastics is sourced directly (and sometimes for free) from factories and recyclers, allowing the company to reduce the price of the product. This makes it affordable for schools and homeowners, including those in Nairobi's slums, where wood and other building materials are often scarce and expensive.







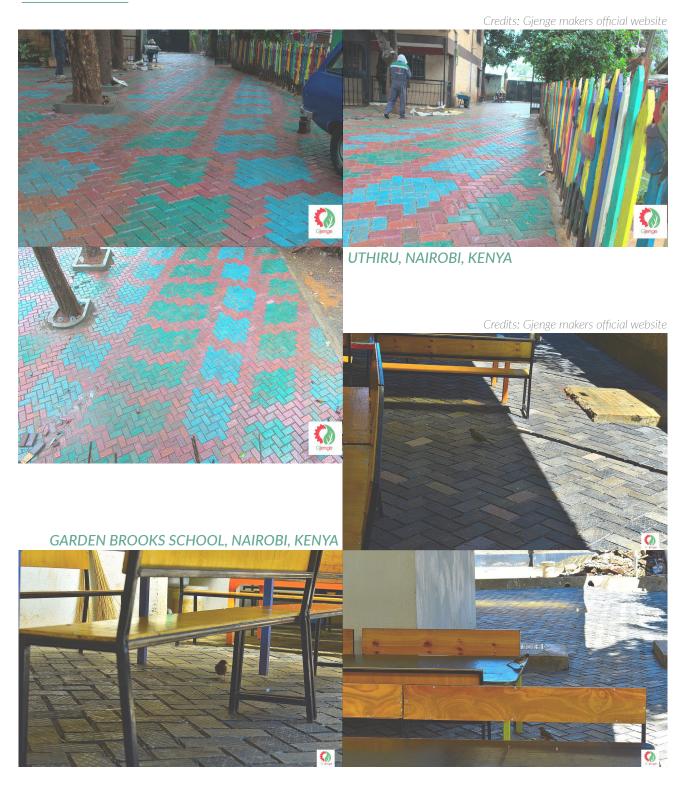








PROJECTS





Successful product design requires knowledge, intelligence and flair.

The knowledge requirement may be subdivided into: knowledge of the requirements of the product, knowledge of the behaviour of plastics materials, knowledge of recycled plastics processes, and knowledge of all relevant economic and psychological factors. Intelligence is required to relate these knowledges, and flair to bring the design to a successful reality.

Some researches show that presenting an object as sustainable (having positive social and/or environmental attributes) is not always beneficial from a marketing perspective. Even if sustainability increases preference for a products, it depends on what kind of qualities people are looking for in a specific product category.

Another point of view also show that there is a higher purchase intent and quality rating when the benefits are reflected on social responsibility or when the company takes sustainable actions that are not related to the functionality of the product itself, but for example on the production methods.

Although the sustainability aspect might be valued as a positive aspect in itself, it can also negatively affect the way people perceive other attributes of the product. People tend to associate sustainable products with gentleness, health and safety. On the other hand, sustainable products are likely to be perceived as less strong, effective and powerful.

This means that for a product category where the strength and long lasting aspects of the product are important, presenting the product as sustainable makes it less attractive.

The insecurity about how it can be used, how you can clean it and how long it will last for instance, increases consumers feelings of unconfidence towards the product.

A main barrier for consumers to buy a sustainable products is that they are unable to assess the product performance at fore hand. This is especially the case for products containing recycled material because consumers are not familiar with the use of this material for certain products.

The category of the product plays an important role in consumers evaluation of the product. The category in which a product is presented by a company affects how the qualities of a product are perceived by consumers.

The use of existing label supports consumers to think about the object as a whole. This means that, using this type of category consumers are likely to transfer information (qualities, properties, applications) from the existing material to the new one maximizing the perceived similarities. Labels override feature similarity as a factor predicting the type of inferences made about missing information.

Moreover, one label only discourages consumers to look at features of other categories which the product may be associated with.

In this final chapter there will be an overview of some of the company which works on the recycled plastics market. The focus for each one is on their production method and collections that can propose to the consumers.

Dezeen Website Blog, Enis Akiev's Plastics Stone Tile





Smile Plastics official website, Kaleido Panel on the productive field

SMILE PLASTICS

Smile Plastics may well be a familiar brand name, and indeed material, to anyone working in the fields of design and architecture. The distinctive mottled and often colour-clashing surfaces were conceived in the early 1990s and became synonymous with the recycling movement that had begun to gain traction as the century drew to an end.

Smile Plastics offered the first sheet material made fully from recycled plastics and became an iconic brand up until 2010, when its instigator Colin Williamson retired without anyone to carry on manufacturing the material. That is until designers Adam Fairweather and Rosalie McMillen picked up the baton and re-launched the brand at the London Design Festival in 2015.

The design duo have a unique synergy with the material having both used recycled materials in their own individual work: Adam creating the concept of a disposable coffee cup made from recycled coffee grounds in 2004, and Rosalie having also used recycled metals and coffee in her jewellery for a number of years.

Furthermore, the pair share a balanced approach to developing the brand: Adam brings the technical materials expertise, whilst Rosalie focuses more on the aesthetics of the materials and the relationship consumers have with them. They've already come on a long way in two years, adding their new South London gallery to their original and pre-existing production unit based near Swansea on the Gower (United Kingdom).

With a mission, the designers duo works to change people's perceptions around waste via innovation, art and technology; to unlock the hidden potential of recycling, and open peoples' eyes to the unexpected beauty of scrap. They hope to inspire more people about sustainability and recycling.

The mission at Smile Plastics is to encourage all to value the materials more and therefore waste less. They do this by reimagining end-of-life materials into beautiful new products that tell a story and that people can connect with.

The materials themselves usually have a strong narrative that is shared directly through the colours and

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PUTTING A SMILE ON YOUR WASTE

patterns in the panels themselves.

Smile Plastics materials are designed to last, but at the end of their life, they can be recycled over and over again both through local recyclers as well as through their buy-back schemes so that the plastics are constantly regenerated, facilitating a circular economy.

The basic formula used by Smile Plastics for their panels is pressure and heat in order to fuse the plastics waste into large architectural panels.

The range of materials involved are made from waste sources such as yoghurt pots, plastics bottles and food trays. But they also work with clients to create completely bespoke materials and have played around with sea plastics, refrigerator plastics, WEE* waste, plant pots and ground coffee. There is a lot of processing required before make panels: cleaning and cutting down the plastics into small pieces is one part of the process, but also hand treat of the waste streams to make their unique patterns and textures. Is it possible to combine different waste streams into a single material. Most of the time the combinations of waste streams are of the same plastics type but they have also found a way of combining different material types such as ground coffee with plastics.

They can make make their sheets on a very small scale of just a few centimeters across but most of the time the panels are 2 m per 1 m. The material would be capable of being manufactured at a larger scale but till now they can rarely go beyond this with the existing equipment. Panels are bespoke artisan materials and could be made according to clients material, color and pattern preferences further than the geometrical shape they need.

*WEE: Waste from Electrical and Electronic equipment

'Clients come to us because they love the unique surfaces that we create and it's an added bonus that all our materials are 100% recycled and recyclable. I think designers these days demand local sustainable materials for their projects.'

Rosalie McMillan and Adam Fairweather, CEOs of Smile Plastics



Haus Von Eden website, The designer duo Adam Fairweather and Rosalie McMillan

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Their approach to making panels depends on the specific project which come.

The core range comprehend 7 panel products called classics, made from a variety of post-consumer and post-industrial recycled plastics. The classics family consists of three different plastics types, which have very varied aesthetics from more subtle lighter tones in Alba panels (yoghurt pots) to a sensational multicoloured Kaleido panels (cosmetic pots).

They make these classics in batches of anything from 2 tons to 30 tons, and sourcing the right ingredients to create these batches is a fundamental part of the process.

Supplies of raw materials vary quite a bit, and therefore Smile Plastics craftman spend a great deal of time sourcing and then preparing raw materials to give a final aesthetic that has some consistency with previous batches. Afterwards, they also embrace the nature of the waste feedstocks themselves and artisan pressing processes, which lead to unpredictability in the results and variation both within and between sheets.

On the other hand there's the custom materials which can be quite different from classics approach, and the first stage will depend on customers' priorities. In general, it tends to be the raw materials themselves that provide the first and most direct inspiration for the end result.

Bespoke commissions are the most exciting project at Smile Plastics. It all starts with understanding the real priorities for customers and getting as much information at an early stage. Considerations around the application for the material has a key role because it leads to the plastics types and wastestreams that need to put forward for the project.

They declared, during an interview, that they have some customers who's priority is to focus on the narrative of the materials themselves. They may have ideas for the specific waste steams that they would like to explore, or even want to supply those waste streams themselves. They are often quite flexible in the end result, honouring the original waste plastics as much as possible.

On the other hand they have customers who would meet specific technical materials requirements or are achieving a particular RAL colour match.

'We have worked on ombre materials transitioning quickly from one colour to another and materials that include more unusual waste streams such as cigarette butts, ground coffee, make-up, ribbons, and Christmas decorations'

Adam Fairweather, co-CEO of Smile Plastics

Unless they are used to make up one or a series of small test tiles before scaling up to make a one-off larger 2 m sheet. The whole process from start to finish can take as little as four weeks right the way through to several months if it's a larger-scale project with trickier materials sourcing or preparation requirements.

The making process itself requires good attention to detail and craftsmanship to deliver the end result.

Historically they sold their materials as flat sheets 2 m per 1 m in differing thicknesses of 5, 12, and

mm. Over the last year, Smile Plastics has introduced smaller sheet sizes for those doing sampling or smaller projects from 250 mm² to 1000 mm², and they are now ready to launch a larger sheet size of 3 m per 1.2 m.

In addition to the panels, Smile Plastics also offer a cutting and basic fabrication service for customers to send out pre-cut shapes with different profiles. In this way shipping costs can be reduced and the company also collects and recycles all the skeleton wastage and milled shavings, reintroducing them back into their future products.

While materials come as flat slabs, they are also incredibly versatile: craftmen can thermoform them into three-dimensional structures and can cut, glue, screw, and mill them, opening up a huge scope of possibilities. The panels are also solid and consistent throughout the sheet, which means that is it possible to create beautiful detailing around the edges with minimal finishing required.

The versatility of materials combined with aesthetic and quality means that they get used for wide-ranging decorative applications in the commercial environment from displays, fixtures, counters, and furniture within retail, office, and hospitality environments, through to art installations.

Their plastics are waterproof and rot-resistant, so they are perfect in wet environments as a replacement for tiling and bathroom panelling or for bathroom vanities and cabinetry.

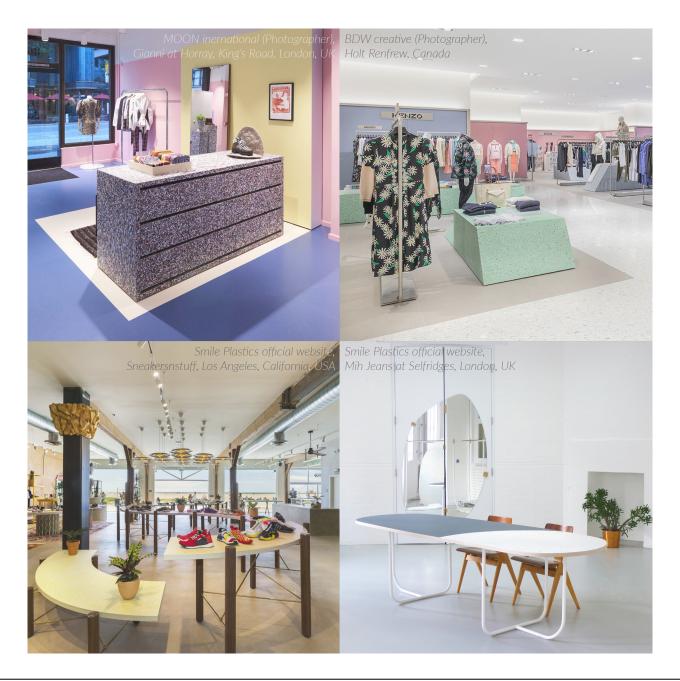
There are even some who have made jewellery and guitars from Smile Plastics panels, so the possibilities can stretch a lot.



Their projects

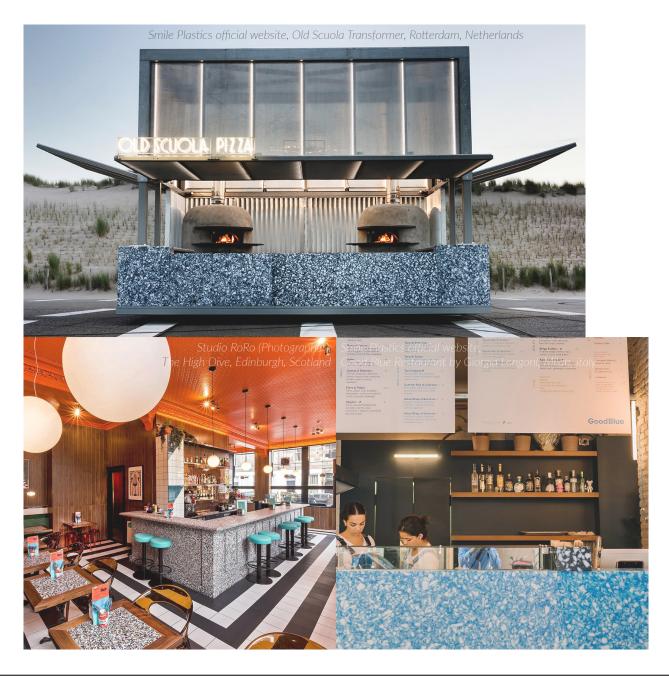
RETAIL

Smile Plastics materials are a springboard for the creativity and imagination of designers and architects across the world.

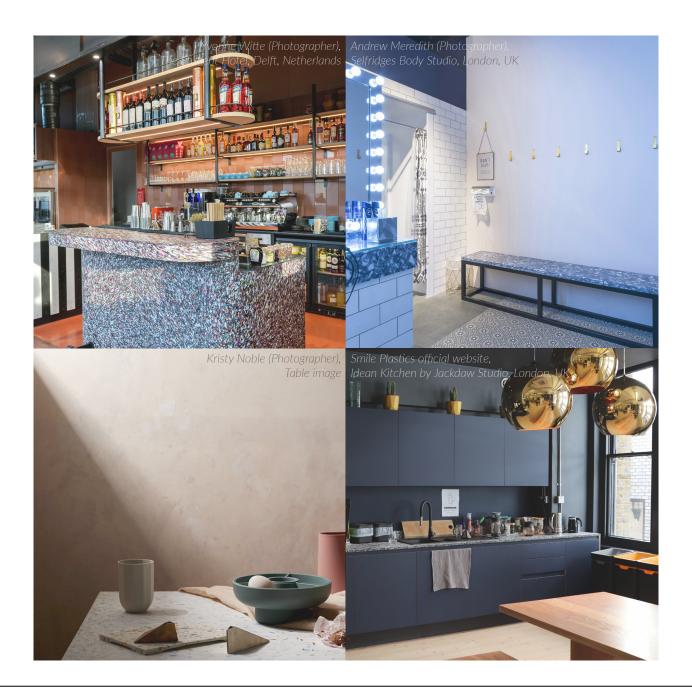


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counters, bars to furniture and chopping boards, visual display, retail windows through to furniture and jewellery.



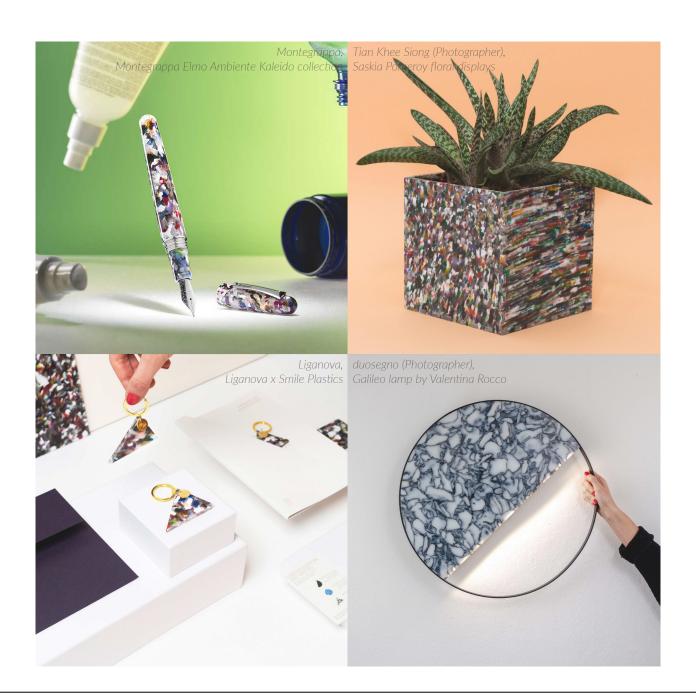
INTERIORS



PRODUCTS

From functional Food Platters, storage and display concepts to sculptural lighting and covetable home

accessories, Smile Plastics curated small product Lookbook provides effortless inspiration for all interiors.



BETTER FUTURE FACTORY

Hidde Middelweerd (Photojournalist, 2019) The Better Future Factory team in Blue City, Rotterdam



Better Future Factory is a new-fangled design studio, a young company based in Rotterdam and founded by 5 former fellow students of Technical University of Delft, a group of designers, scientists, and weirdos with a shared motivation: reuse and sustainable innovation.

Their main focus is to find sustainable solutions for 3D printing and plastics waste but, for them, this doesn't mean simply designing products.

Their work is mainly about recycling and they recycle in an innovative way, by melting and transforming plastics waste into granule. This can then be recycled into new products by 3D printing.

Better Future Factory develops the entire process

from the identification of a problem, through the selection and design of solutions, to the support for people to set up their own business on those solutions. Together with companies and designers they create iconic and scalable projects that sometimes develop into independent start-ups or profitable business cases. All their projects have an educational touch. Old slices of bread are converted into energy, orphaned 'flippo's' (Dutch for 'milk caps') become sunglasses. Everything is always quite visible and understandable. The designers are the lawyers of the circular economy, they believe that fascinating stories and innovative technology can create a cleaner and better future.

'Our goal is to make things that actually change the world for the better. We try not to talk that much about it, but we do much. That's the most important thing. If we think of something, we make it, and then we change it to make a new better version. That's how we evolve the company.'

Casper van der Meer, CEO & Co-founder

Better Future Factory work together with big partners to produce it, they don't really do it themselves, but they hold the concept and sell it all over the world.

3D printing is a really complex technology, especially for those who don't have that much education. Team of researchers try to adapt recycling technology to make it fit for the local educational levels and also for entreprises because, in some part of the world, it's not about recycling, it's about the money and the people who need to make a living.

They use the principle of making a machine that can use recycled input material, or waste, and turn it into a valuable product.

"Tell me and I will forget; Teach me and I may remember; Involve me and I will learn."

With this quote in mind, Better Future Factory has been working on a better future for years by giving plastics waste a second life as design products that take consumers along in a circular story.

Better Future Factory got off to a flying start at Lowlands in 2012. They developed an installation that takes festival-goers step by step through the recycling of their plastic festival cup. From shredding the cup to 3D printing the end result: a plastic ring. The installation, which was given the name Perpetual Plastics Project, was a direct hit.

'People normally throw their festival cups on the floor, but they queued in front of that ring. If you show in a fun and interactive way how you can turn plastics waste into a new product, you do encourage behavioral change. Then people will interpret waste differently. The next time they see a PET bottle floating in the canal, they don't see waste but the basis for so much more.'

Laura Klauss, CTO & Co-founder



No credits, The Better Future Factory ring for the Lowlands in 2012

Their projects

GROENPLEK

A sustainable decking system for public space, restaurant, bars, shops and more. Municipalities in the Netherlands are looking for solutions to organize their city or village differently in the short term.

By using parking spaces, extra space can easily be created for, among others, catering entrepreneurs and retailers. Better Future Factory has developed a sustainable solution for this, a modular decking system that is easy to install, indestructible and requires virtually no maintenance. In addition, it is completely made of recycled plastics and also fully recyclable.



ASN BANK

Let it grow! From ASN digipas to plant trellises.

What to do with thousands of discarded digipasses? That was basically the initial challenge for Better Future ingineers stated by the ASN Bank. The little banking devices are nowadays obsolete with everything going via mobile phones, but the plastics cover is of good quality. In collaboration with Sprinklr and ASN bank they've developed a unique plant trellis system made from the old devices.



LET WASTE BE THE HERO

Custom furniture made from old toys.

For a major Danish toy manufacturer Better Future Factory has designed and produced unique set of furniture pieces from their waste. The furniture is placed in their sustainability and inspiration room on their company campus in Denmark, showing the beauty of recycling to everyone. The set of furniture consists of a meeting table, stools, flower pots and lighting. Using recycled materials doesn't mean you'll get dull colors, let waste be the hero!



ELHO FLOWERPOTS

How do you show the world that you are already a frontrunner in using post consumer recycled plastics for your products? Recycled plastics are of such a good quality nowadays that customers do not see the difference between virgin and recycled. This challenge by Elho, Europe's biggest producer of planters, led to a production technique innovation that creates unique marbled planters made from plastics waste fished from the Amsterdam canals.



FIZROY WASTED RUM

For Wasted Rum, Better Future Factory has developed a rum bottle cap made from oceans plastics with a marble effect that could be produced through injection molding. The striking marble effect is a result of different colored oceans plastics used in a non-blending injection molding technique.



PERPETUAL PLASTICS PROJECT

Interactive recycling installation for events.

The Perpetual Plastics Project is an interactive recycling installation for young and old where plastics waste is recycled on the spot into new products by 3D-printers. The installation can be booked for events, festivals or other occasions. It gets visitors involved and educated about the value of recycling of plastics waste. The fun and learning by doing experience is what makes the Perpetual Plastics Project stand out on every event.





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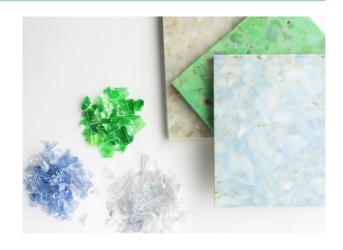
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NEW MARBLE

Wall tiles made from old PET bottles.

New Marble is a sustainable tile brand making new tiles from old PET bottles. 1 m² of New Marble is made from 302 plastics bottles and the tiles are fully recyclable, it is the best tile for a new circular designed world. The tiles are included in some iconic projects like the first circular bathroom of The Netherlands and in the floating Recycled Park, in Rotterdam, made from bottles collected from the river Maas. Both tile designs and the recycling technology are developed by Better Future Factory.



PELLICAN ROUGE

Espresso tools from recycled packaging.

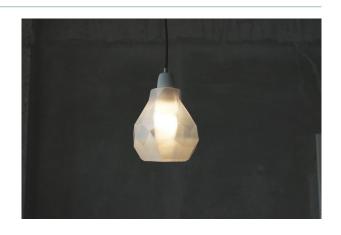
This coffee product is made from old coffee packaging. It's called the good knock and catches the used coffee out of the portafilter.



UNC BOTELLA LIGHT

From bottle to lamp.

The Botella light is developed in-house and made from their unique recycled filament. The lampshade is 3D printed and made from about 2 bottles. The printing process creates a lampshade with textured surfaces that plays with the light, dispersing it in unexpected ways.



STAHL

From waste stream to stool.

For Stahl, the world leader in the specialty chemistry of coatings, Better Future Factory has developed a recycling technology to create new products from their off-spec PU-coatings and waste water.

By mixing waste fibers, like jeans recycling dust and leather shavings, with the water based poly-urethane, tough but flexible fabrics were made. The polyurethane acts a binder, while the fibers create beautiful textures. With this recycling technology we have designed and produced a series of iconic products from the closed loop recycled plastics.



AVR

Furniture made from the company's own waste. What better way to educate your visitors and own employees than tangible products made from your own waste? In this way waste treatment company AVR could show what is possible with the waste streams they collect, sort and recycle.



REFIL

High quality 3d printing filament from waste.

Refil which is short for REcycled FILament is the continuation of the success of the Perpetual Plastics Project but then on an industrial scale. Being the world's first fully recycled high quality 3d printing filament, globally available via resellers and the Refil webshop. It offers makers around the world a sustainable alternative for 3d printing.



















PRECIOUS PLASTICS



'Precious Plastics is a combination of people, machines, platforms and knowledge to create an alternative global recycling system.'

Precious Plastics is one of the early initiatives.

It started from Dave Hakkens' intrest to trackle plastics pollution and take shape through the graduation project by Dutchman in 2013.

He designed four machines for recycling plastics on a small scale. Throughout the years, Dave improved his designs, and more people joined him to make the machines more efficient. To date, the Precious Plastic Universe continues gaining a large following of people supporting their alternative recycling process.

Till now it has quickly evolved into one of the most original and engaging ways of handling plastics waste. Dave Hakkens releases Precious Plastics Version 1 during his graduation show at DAE on 2013.

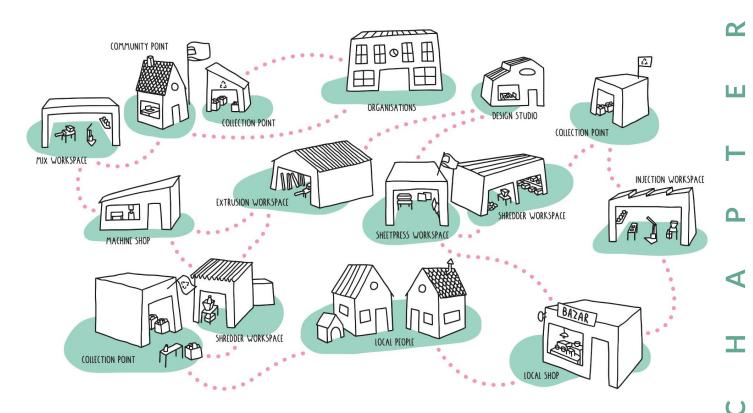
In 2014 three people independently replicated the V1 recycling machines. This was enough to see the potentials. Then founder and a team of five goes back to the drawing board and start developing Version 2, released to the world on 2016.

At the moment there are people who have the resources for a machine, but don't know how to make one. At the same time, there are people who want to build a machine, but don't know anyone who would want one. Sometimes it's a matter of bringing these two people together, which locally can create a building scenario. This is a key point to consider in the development of the third version, to smoothen the building process by offering a map where people can see where the builders and the plastics are located.

Dave, Mattia and a team of 12 start working on Version 3. The focus is to offer more techniques to work with the existing machines. The Precious Plastics is now mature and global and it is 2017.

During late 2018 Dave, Mattia, Kat and a team of 40 start working on Version 4. Developing new machines, techniques and strategies to tackle plastics waste.

On january 2020 the Precious Plastics Universe is released to the world and aims to become the global alternative recycling system.



The Dave's idea was to build a machine that will allow people to process their own plastics waste and create something new out of it.

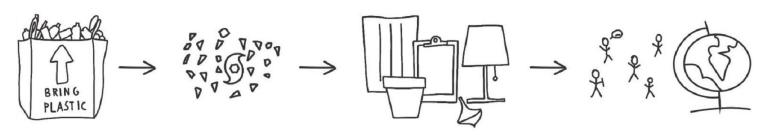
For now, four different processing principles (extrusion, injection, compression, shredding). It's all low-cost and DIY', as the website provides all the necessary guidelines and instructions in detail to start building.

Precious Plastics exists to reduce plastics waste.

Sometimes researchers team do it through boosting recycling. Sometimes through new biodegradable materials. Some other time by adopting zero waste lifestyles. Whatever works.

But the key point of everyone of them is to see people as the key element to fix the plastics mess.

Precious Plastics approaches count on people to bring about the necessary change. Small steps, multiplied by millions.



*DIY: Do It Yourself

DESIGN PRODUCT

To get started in the world of Precious Plastics people can build any combination of the points. A shredder is crucial as it is the backbone of all processes. Everithing people need for start is fully described on the website.

COLLECTING POINT

People collect their own waste at home, instead of bring them at the collection cans, they bring garbage to the nearest Collection point, findable on the website map. The goal of a Collection Point is to gather as much as possible clean, label-free plastics that can be recycled in the Precious Plastics Universe.

Here workers collect private plastics waste but also gather plastics from neighbours, organisations and businesses. They sort objects by plastics type, clean and dry plastics and then batches are ready for the next step.



SHREDDER WORKSPACE

In the Shredder Workspace people can find the Precious Plastics Shredder Pro: a double axis shredder machine that cuts plastics waste into small flakes ready for further recycling. The Shredder can shred up to 50 kg of plastics waste every hour.

Shredded plastics can have different sizes (small, medium, large) and can be sorted by colours to add value. The shredded plastics is sold to other Precious Plastics workspaces in the local network.



EXTRUSION WORKSPACE

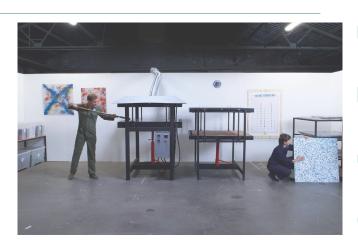
In the Shredder Workspace people can find the Precious Plastics Extrusion Pro: a single screw machine able to extrude recycled plastics into a mould.

This machine is able to recycle up to 20 kg of plastics every hour and its outcome can be beams and bricks. Once people nail the process they can run productions for customers playing with moulds, colours, patterns and sizes to attract different audiences.



SHEETPRESS WORKSPACE

In the Sheetpress Workspace people can find the Precious Plastics Sheetpress which presses shredded plastics into recycled sheets using a hydraulic press. This machine can make multiple sheets (1 m per 1 m) per day recycling around 20 kg of plastics per sheet. The Sheetpress outcomes are beautiful recycled sheets. Workers can play around with colours, patterns and thicknesses and sell them, so others can design stunning products with them.



INJECTION WORKSPACE

In the Injection Workspace people can find the Precious Plastics Injection machine which is their simplest machine to recycle plastics and is human powered making it easy to build. But this workspace also needs a basic Shredder.

The Injection Workspace outcome are small, high precision products. Designers can run small productions, master mould-making and run workshops for customers.



MIX WORKSPACE

The Mix Workspace can have multiple outcomes but generally are a great starting point for people that want to learn how plastics recycling works, the properties of plastics and Precious Plastics processes.

Once people gather the pecessary experience they

Once people gather the necessary experience they can also generate some income with artistic products, workshops, events and demonstrations to inspire and educate others.



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PLASTICIET



'Recycled plastics inspired by nature, aspiring to co-create a post waste world. This is what we love to do, and we're good at it too.'

Marten van Middelkoop and Joost Dingemans
CEO & Co-founder of Plasticiet

Plasticiet is a collection of high-end fully recycled surfaces for design.

It was founded in 2018 by Marten van Middelkoop and Joost Dingemans, two Rotterdam based designers with a passion for sustainable material development. Their aim is to keep challenging the status quo by continuously developing new techniques and create high quality, functional and beautiful materials.

At Plasticiet designers are inspired by the primal beauty of natural stone, used as the foundation for the

visual language of Plasticiet materials.

Alike stone, plastics has an incredible longevity.

So instead of wasting it they recycle it by manufacturing beautiful and functional solid surface materials which people can use to realise their project, all the while reducing plastics waste.

Plasticiet was set out to change the way people view plastics. Rather than a waste material, plastics should be viewed as the new gold and treated as a highly valued resource, never cast aside.

Created with reuse and repurpose in mind, all of the materials use raw ingredients that are easy to recycle and have sizeable, consistent waste streams. Each surface uses a singular material like fully recycled polystyrene or polycarbonate, so every panel can be easily turned into new again and again, never wasted. With the ability to process large volumes of plastics otherwise unwanted or contaminated, destined for

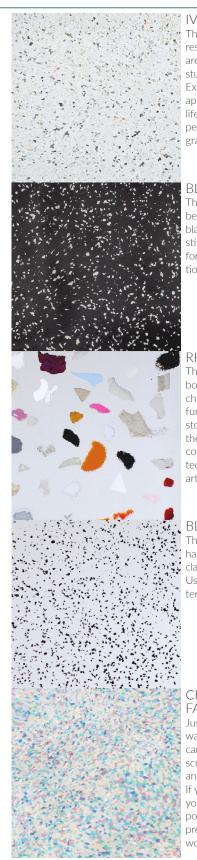
landfill or incineration, Plasticiet captures and transforms it into a material for furniture, fixtures, architecture and design.

Taking plastics from local post-industrial or post-consumer waste sources and sorting them by type, rather than colour makes the production more efficient. What would be waste plastics is shredded or flaked into recycled pellets or chips that melters fuse together. The way the pellets are dispersed and the melting temperature create unique, but simple organic patterns inspired by the beauty of natural stone. Each type of plastics has its own fluidity and some sources are contaminated so this allows for experimentation within the testing and development stages. Each material then inherits the unique characteristics of the recycled plastics used to make the panel.

As they're all plastics, Plasticiet materials are hardwearing, soft to touch and hygienic. The matte finish comes with deep rich colours that have a look similar to marbled stone, recycled glass, terrazzo or art and can even be customised, like with a modern Memphis or a mother of pearl look that will really last.

The dense, hardwearing, homogenous surfaces can be used with or without a substrate in places like ceiling panels, wall cladding, tiles, doors, signage, chopping boards, knife handles, jewellery, retail and museum displays, furniture, joinery pieces, table tops and work surfaces.

Produced in full press loads of 0.8 m per 0.8 m square sheets, full scale large sheets are in development. With UV stable and fire resistant options, Plasticiet designer plastics can be plastics welded, thermoformed, cut and routed or laser etched.



VORY

These old refrigerators resembling faux-ivory are harder than the real stuff and stiff like a board. Excellent for constructive applications. Though Ivory's lifespan is long and strong, people shouldn't take it for granite.

BLACK ROCK

The name says it all. This beautiful material is deep black, hard like a rock and stiff like a board. Excellent for constructive applications.

RHINESTONE 2.0

The new age material is born, combining Italian chic with modern day fresh funk. The coloured rhinestones find their origin in the urban mines of Belgium, collected by Suez and sorted with their state of the art infrared scanner.

BLIZZARD 2.0

This white stormy sheet has been Plasticiet's all time classic, but now perfected. Used it wisely and this material will set the right tone.

CHOCOLATE FACTORY

Just as magical as Charlie walking around in lavish candy gardens. Magically scratch resistant, colourful and soft like a baby's skin. If you look long enough you might just hear a song popping up. Against all prejudices; very easy to work with.

SURFACE MATTER STUDIO



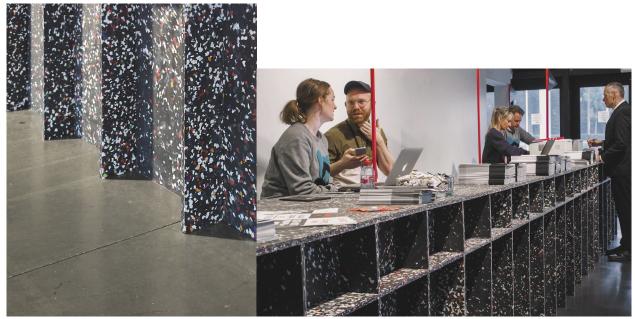
Daniel Sellam (Photographer), Daniel Sellam (Photographer), Surface Matte Studio Surface Matte Studio

CENTRAL MARKET HONG KONG



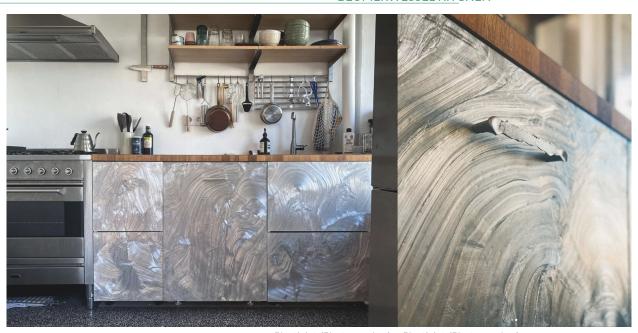
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INTERIEUR BIENNALE KORTRIJK



Plasticiet (Photographer), Plasticiet (Photographer), Interieur Biennale Kortrijk Interieur Biennale Kortrijk

BEUMERWESSEL KITCHEN



Plasticiet (Photographer), Plasticiet (Photographer),

Beumerwessel kitchen Beumerwessel kitchen







Plastic is a material that is misused and misunderstood. The potential is enormous, but its after life can be disastrous.

The speed of technological development is accelerating exponentially and, for this reason, by the year 2030, it will seem as if a whole century's worth of progress has taken place in the first three decades of the twenty-first century. In many ways, life in 2030 will be unrecognizable compared with life today. During this time, plastics will play a significantly increased role in people lives.

Plastics are already becoming 'smart' and will likely serve numerous important roles in future living, including human tissue or even organ transplants, key materials used in ultra-low-emission lightweight cars and aircraft, superior insulation for homes that run on photovoltaic technology based on plastics collectors, reusable electronic graphic media for books or magazines, smart packaging that monitors food content continuously for signs of spoilage and high-efficiency solid-state lighting based on plastics organic diode technology.

As petroleum reserves become more limited, new varieties of plastics are likely to increasingly be made from renewable bio-mass or recycling already made plastics products.

These will contribute to the already extensive array of mechanical and aesthetic performance properties that plastics are well known for.

Any future scenario where plastics do not play an increasingly important role in human life therefore seems unrealistic.

As exposed on the previous chapters, is comprehensible that plastics material plays foundamental roles in people daily lives.

Alredy exposed are also the effects that its degradation and its careless discard must cause to environment, biota and human body.

But, as already exposed, the main aim of this thesis is to collect significant informations about most of the plastics material characteristics, good or bad these are. Toward give an overview of how this material is useful for human daily lives but also dangerous in really microscopic ways.

Through the exposition of some companies which work just with recycled plastics, is shown how is possible to give plastics waste a second or third or infinite life aside lanfill and incinerator.

There were uncountable ways for recycle plastics material even if bought as single use, it will never be a single use object, but nowadays generation is the first that is facing trurly with this problem.

People are setting up the ground for the next generations, educating children and giving to recycled plastics objects a market possibility. At the same time studying innovative technologies for clean up polluted environment and fixing past generations mistakes.

But the information about this topic is still lacking and the messages that flow from the conventional advertising system are mainly perfuntory.

I decide to wrote this thesis also because I am really interested on this topic and I wished to get really deep on plastics material characteristics.

Hopefully that this brief paper will be useful for somebody with the same interest.





















Precious Plastics websites, HDPE wall tiles



I would like to write my aknowledgments just in italian becouse my heart speaks in italian.

Vorrei ringraziare first of all me stessa, per aver perso tutto il tempo necessario per scrivere questa tesi, non sarebbe stato tempo perso in miglior modo.

L che non ha mai mollato la mia destra.

Davide che a modo incomprensibilmente suo ha deciso di stare al mio fianco nonostante le mille disapparizioni, litigate e cene insieme, grazie per rendere ogni istante frizzante come le mentos nella coca.

Alfredo che è stato ogni sorriso dopo ogni lacrima, la mia coccola assicurata e la mia dose di serotonina giornaliera.

La Ciabli e Davix che hanno speso ogni secondo per ricordarmi quanto questo traguardo sia importante e mi sono stati a fianco come solo i miei genitori sanno fare.

La Chiabo e la Giugi che mi ascoltano, mi insegnano e mi permettono di capire ogni giorno quanto siano diventate grandi, forti e indipendenti dalla loro sorella maggiore che talvolta cerca ancora di proteggerle.

Le mie Giovi e Terri che tra pranzi e piante mi hanno aiutata a crescere e mi hanno insegnato come ci si prende cura delle cose, come si cucina e come riutilizzare fino all'ultimo grammo, dall'alto delle loro conoscenze da nonne.

Alla zia Barbi e lo zio Richi che hanno avuto e avranno sempre un abbraccio pronto che viene dal cuore.

A tutte le persone del mio piccolo cerchio, chi dentro e chi fuori, non avrei potuto desiderare persone migliori con cui scegliere di crescere.

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OUR PLASTICS AGE

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