

PFNDAI Online Seminar

Plastics as Packaging Material : A Boon or Bane

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Origin of Plastics

- ✓ The word, 'plastic' is a household name, derived from the words 'plasticus' (Latin) or 'plastikos' (Greek) that simply means, 'being able to mould'.
- ✓ Human life appears to be inseparable from the world of plastics for the immense benefits of this versatile, man-made material.
- ✓ A judicious use of this material is, however, imperative as the non-biodegradability of plastics poses a serious threat to our environment.

History of Plastics

- ✓ **World War II: When Allies and the Axis powers were faced with severe shortages of natural raw materials.**
- ✓ **The plastics industry proved to be a rich source of acceptable substitutes.**
Examples: Nylon, Textile fibers; polyesters, fabricating war material; etc
- ✓ **In 1930: Thermoplastics were made from styrene, vinyl chlorine and ethylene.**
- ✓ **1960s: The main growth of the plastics industry**
- ✓ **1973: Reaching a peak (reached over 40 million tonnes per year)**
- ✓ **1990: Touched 86 million tonnes**

Today plastic production worldwide far exceeds the combined production of non-ferrous metals such as aluminium, zinc, lead and copper.

Advantages of Plastics

- ✓ Easily molded and given appropriate shapes.
- ✓ Less dense and lighter than steel, but at the same time they can be reinforced with other material to develop exceptionally stronger materials
- ✓ Various design specifications can be incorporated and plastics can be designed to withstand higher temperatures.
- ✓ They can be made transparent like glass or even developed into thin films that are used in food packaging.

Disadvantages of plastics

- Negative effects on the environment.
- They are non-degradable, and persist unchanged in the environment for many years.

Key Measures to reduce the use of plastics

Examples

- ✓ The Government of Tamil Nadu has declared many places to be plastic-free zones.
- ✓ A suitable alternative should be advertised and even sold at subsidized rates for replacing the plastic items.

Example, if polybags are being banned in shops, a substitute of cheaper paper bags must be available that could be manufactured from recycled paper.

Indian Plastic Industry

- ✓ Plastic waste is increasing due to increase in population, developmental activities, changes in lifestyle, and socio-economic conditions.
- ✓ Plastic waste is a significant portion of the total municipal solid waste in India. It is estimated that approximately 10,000 tons of plastic waste is generated every day.
- ✓ This waste constitutes two major categories of plastics: thermoplastics (80%) and thermoset (20%) plastics.
- ✓ The thermoplastics are recyclable plastics that include Polyethylene Terephthalate (PET), Low Density Poly Ethylene (LDPE), Poly Vinyl Chloride (PVC), High Density Poly Ethylene (HDPE), Polypropylene (PP) and Polystyrene (PS).
- ✓ Thermoset plastics comprise melamine formaldehyde, phenolic formaldehyde, urea formaldehyde, polyurethane, metalised and multilayer plastics.
- ✓ The plastic industry in India started with imported machines, raw materials, and processing technology in the late 1940's.
- ✓ The industry gained momentum in 1960, when a small naphtha cracker plant for production of ethylene was set-up.

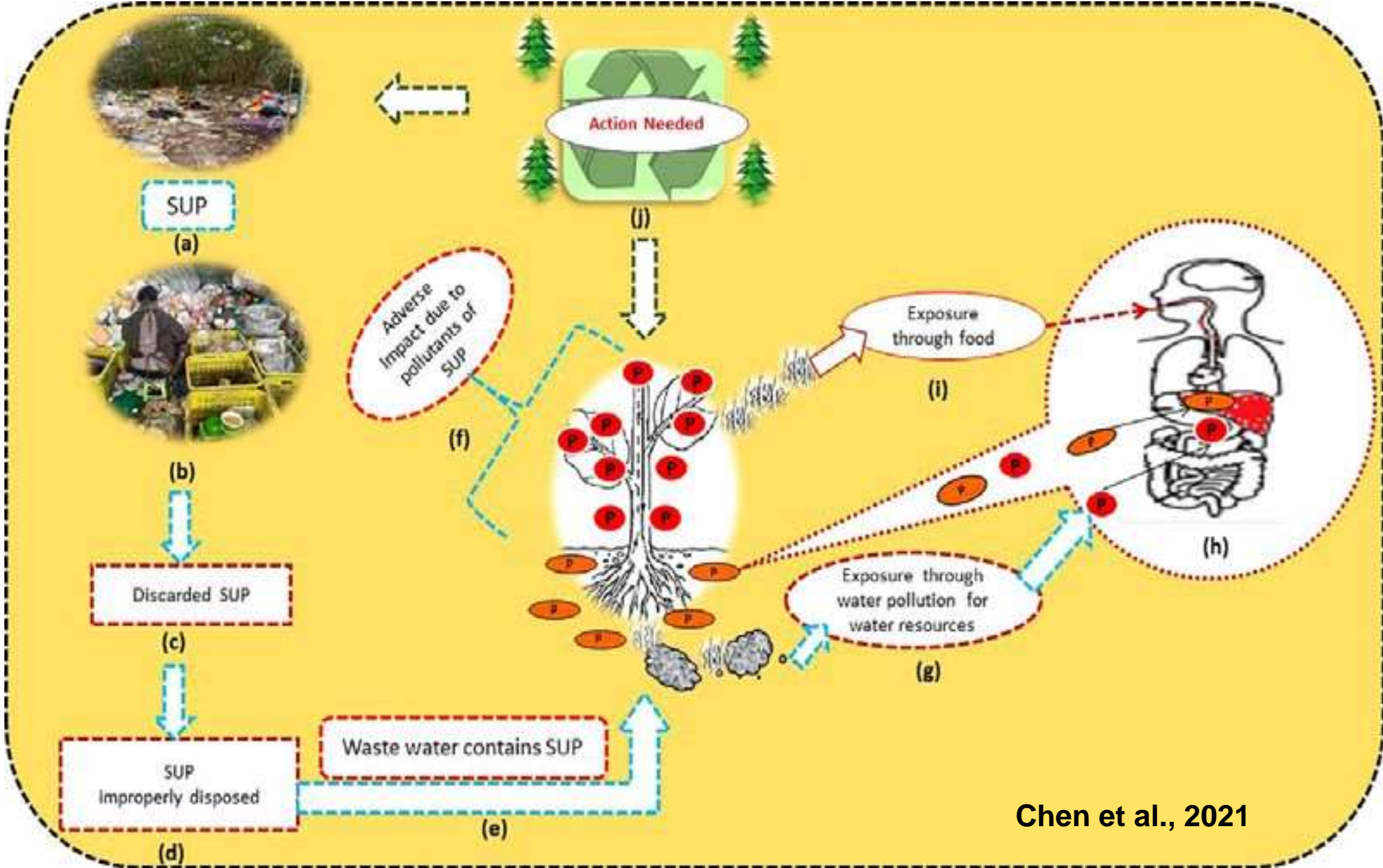
- ✓ **With the availability of ethylene, production facilities for HDPE and PVC were established.**
- ✓ **The pace of growth was slowed with successive crisis faced by the polymer industry in the 1970s.**
- ✓ **The global oil crisis in 1973 resulted in a major increase in feedstock prices for the petrochemical industry in India.**
- ✓ **In the late 1980's, as a part of the seventh five-year national plan (1986-1990), the Government sanctioned a number of petrochemical complexes with the proposed investment of Rs 30,000 crores (US \$ 6.4 billion).**
- ✓ **The main aim behind the promotions was that India was seeking to be self-sufficient in commodity plastics.**
- ✓ **The growth of the Indian plastic industry has been phenomenal. The growth rate (17%) is higher than for the plastic industry elsewhere in the world.**
- ✓ **However, the per capita consumption of plastics (4 kg) in India is very low as compared to the world average of 18 kg consumption.**

Versatility of Plastics

- ✓ Different types of plastics have different uses in a variety of forms.
- ✓ **Polyethylene:** Bags, pipe and tubing, bottle stoppers, lids, plastic wrap.
- ✓ **Polypropylene:** Household items, plastic wrap, bottles, appliances.
- ✓ **Polystyrene:** Plastic wrap, kitchen utensils, thermal insulation,
- ✓ **Polyvinyl Chloride:** Household items, water pipes, floor, window and door coverings.
- ✓ **Polytetrafluoroethylene or Teflon:** corrosion-resistant mechanical parts, frying pan coatings.
- ✓ **Polymethyl Methacrylate or Plexiglas:** Used as glass substitute, portholes, optical fibers.
- ✓ **Polyamides:** Food wrap, fuel pipes, fishing gears.
- ✓ **Urea-Formaldehyde:** Organic glass, dishes.
- ✓ **Polyesters:** plastic wrap, bottles, switches, appliances

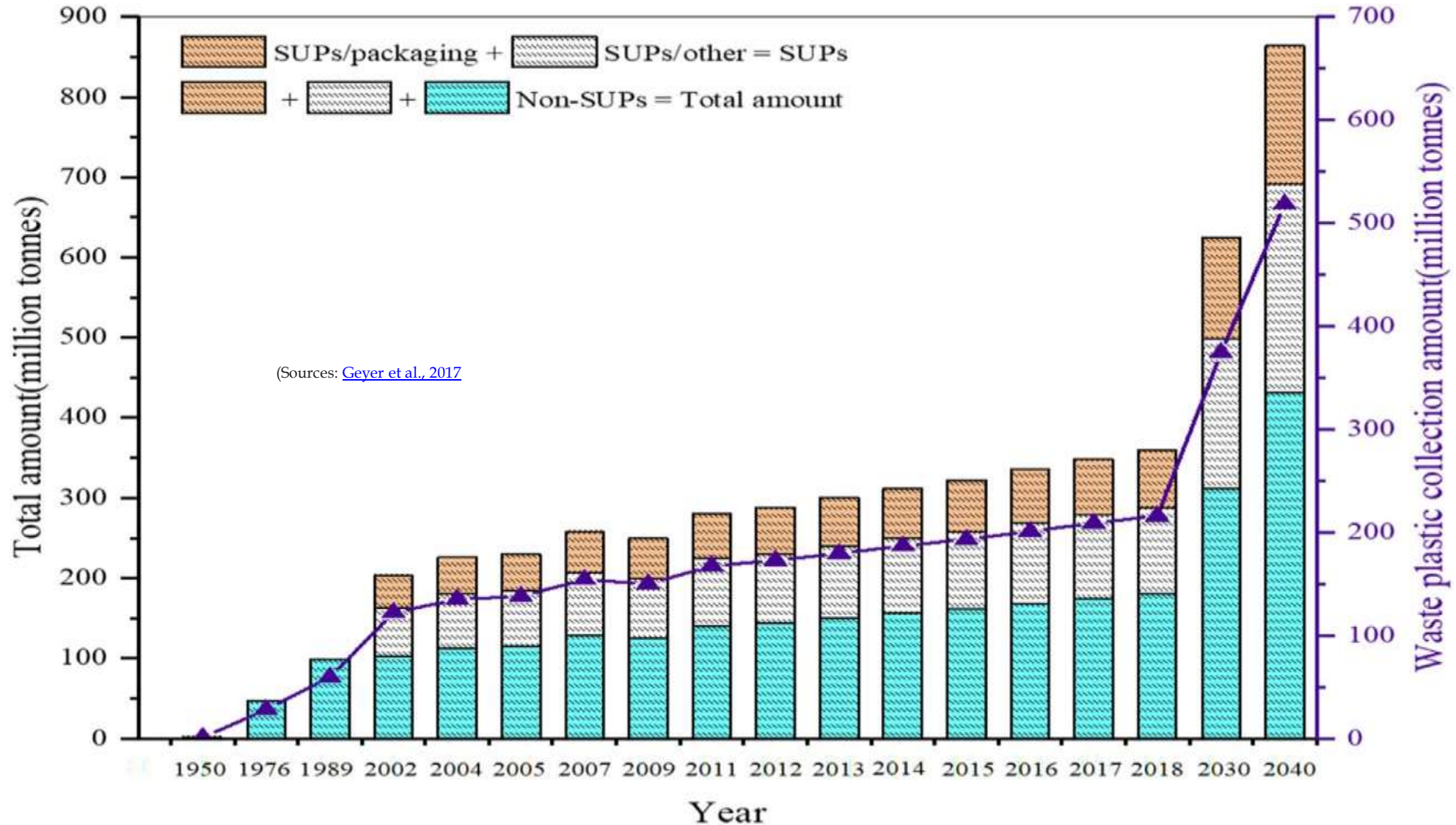
Single Use Plastics (SUP)

- 1) SUPs doubled as the amount in 2000, with packaging is the highest portion (40%).
- 2) Landfilling accounts for >40% and is presently the dominant disposal method.
- 3) SUP wastes leaking into the environment have visible adverse impacts on ecology.
- 4) Multi-solution strategies are the most effective way to stop SUP pollution.



Chen et al., 2021

Global plastic and SUP production growth trends.



(Sources: [Geyer et al., 2017](#); [Advisors et al., 2019](#))

Plastic for food packaging

Packaging performs five main functions

- 1- product containment**
- 2- preservation and quality**
- 3- presentation and convenience**
- 4- protection during Distribution and Processing**
- 5- provide storage history**

Ideal Packaging

- Zero toxicity
- High product visibility
- Strong marketing appeal
- Ability of moisture and gas control
- Stable performance over a large temperature range
- Low cost and availability
- Suitable mechanical strength (i.e., strength in compression, wear, and puncture characteristics)
- Easy machine handling and suitable friction coefficient
- Closure characteristics, such as opening, sealing and resealing, pouring
- Ability to include proper labeling
- Resistance of migration or leaching from package
- Protection from loss of flavor and odor
- Controlled transmission of required or unwanted gases



Packaging categories



1- Primary packaging

It surrounds the product and features labelling.

2- Secondary packaging

Ease of manual movement of products.



3- Transit packaging

Wrapping used to bundle the boxes or crates for transport and distribution.



Transit packaged products are placed in shipping containers for long-distance transportation and distribution



Plastic–Food Interaction

- Polymer materials are not absolute barriers. Interactions occur between foods, packages, and polymer materials...

In case of plastics, the major source of concern is the component migration.

Migration from plastics is mainly due to:

- 1- residual components and reactants from the manufacturing process
- 2- compounds formed during conversion into packaging materials and packages,
- 3- additives incorporated for functionality
- 4- adhesives used during conversion.

Leaching of toxic components when the food is of acidic pH.

- Other factors includes crystallinity of polymers, glass–rubber transition, environmental conditions, and composition of packaged food.

Environmental Issues

- ✓ Recently, a new dimension of safety has arisen, the ecological dimension.
- ✓ This means that packaging has not only to satisfy physical, chemical, and biological criteria using their life cycle as packaging, but once the original function has been fulfilled the packaging should decay without polluting the environment.

Biodegradable material for packaging

Biodegradation is the process by which carbon-containing chemical compounds are decomposed in the presence of enzymes secreted by living organisms.

Acceptable bioplastics are listed below

- 1- Cellulose
- 2- Starch
- 3- Poly-beta-hydroxyalkanoates (PHB)
- 4- Polylactide Acid (PLA) plastics

Application of nanocomposites

- Research on application of nanocomposite (scale of 1e100 nm) materials (nanomaterials) in packaging is exponentially increasing.
- Nanocomposite materials are composed of nanoscale structure that enhances the macroscopic properties of food products.

The common nanocomposites used in the food packaging industry are:

- (1) Polymer clay nanoclay** → increased stiffness, strength, nucleating agent in foams, smaller cell size, higher cell density, and flame retardant.
- (2) Silica nanocomposites of nanosilver** → has excellent antibacterial properties

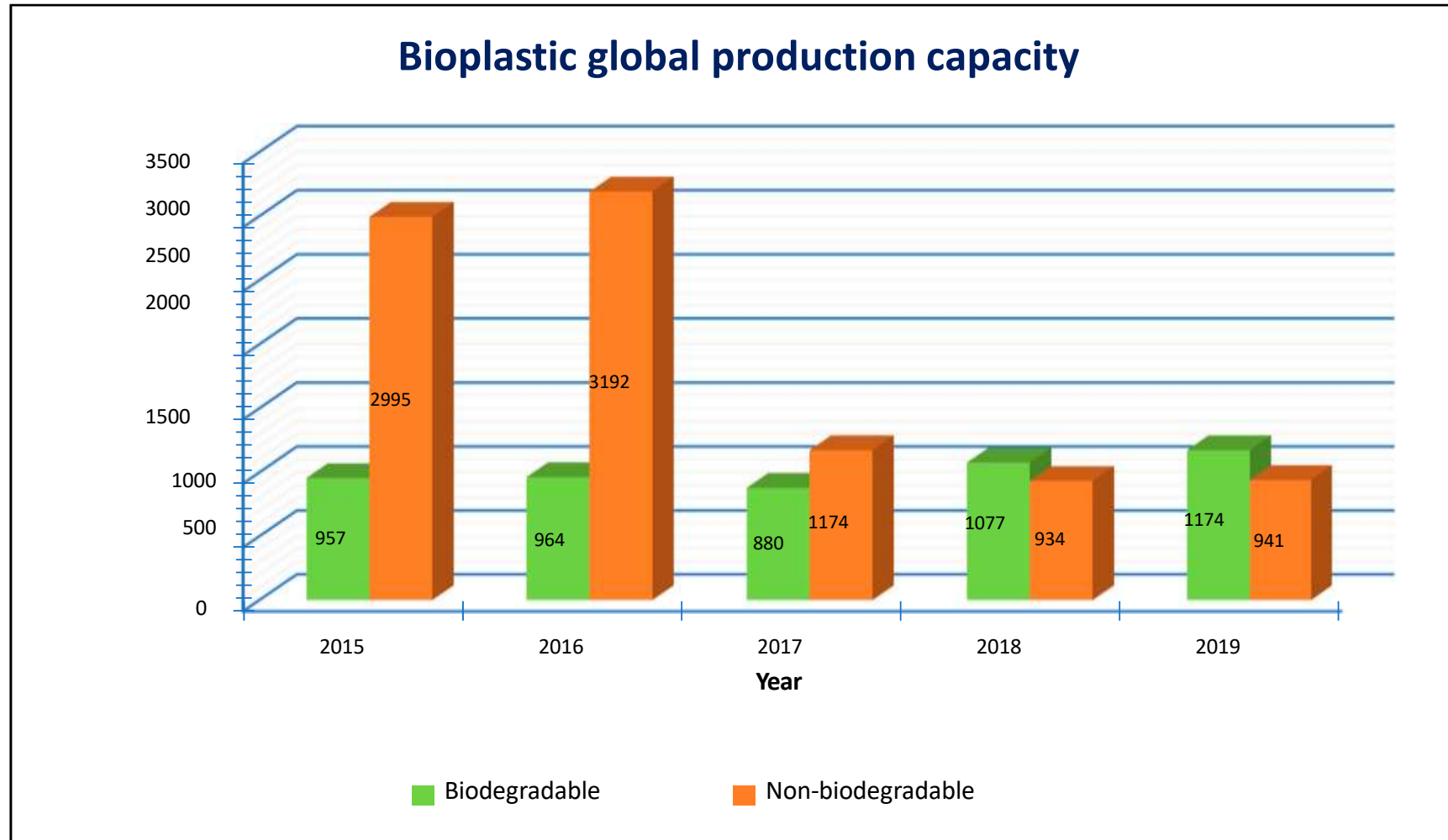
Modified-atmosphere packaging

- The modification of the atmosphere generally implies a reduction of O₂ content or an increase of the CO₂ concentration, but in some cases changing the level of carbon monoxide (CO), ethylene, ethanol, or other compounds in the atmosphere can also contribute to shelf-life extension.
- After closing the package, the respiration of the product will cause a decrease in the oxygen content and an increase in the carbon dioxide content.
- The course of the atmosphere modification is determined by three interacting processes: respiration of the commodity, gas diffusion through the commodity, and gas permeation through the film. Each of these processes is in turn strongly influenced by several commodity- and environment-generated factors.
- Strict temperature control in the distribution chain would be a prerequisite for optimal use of MAP in practice.

Controlled-atmosphere packaging

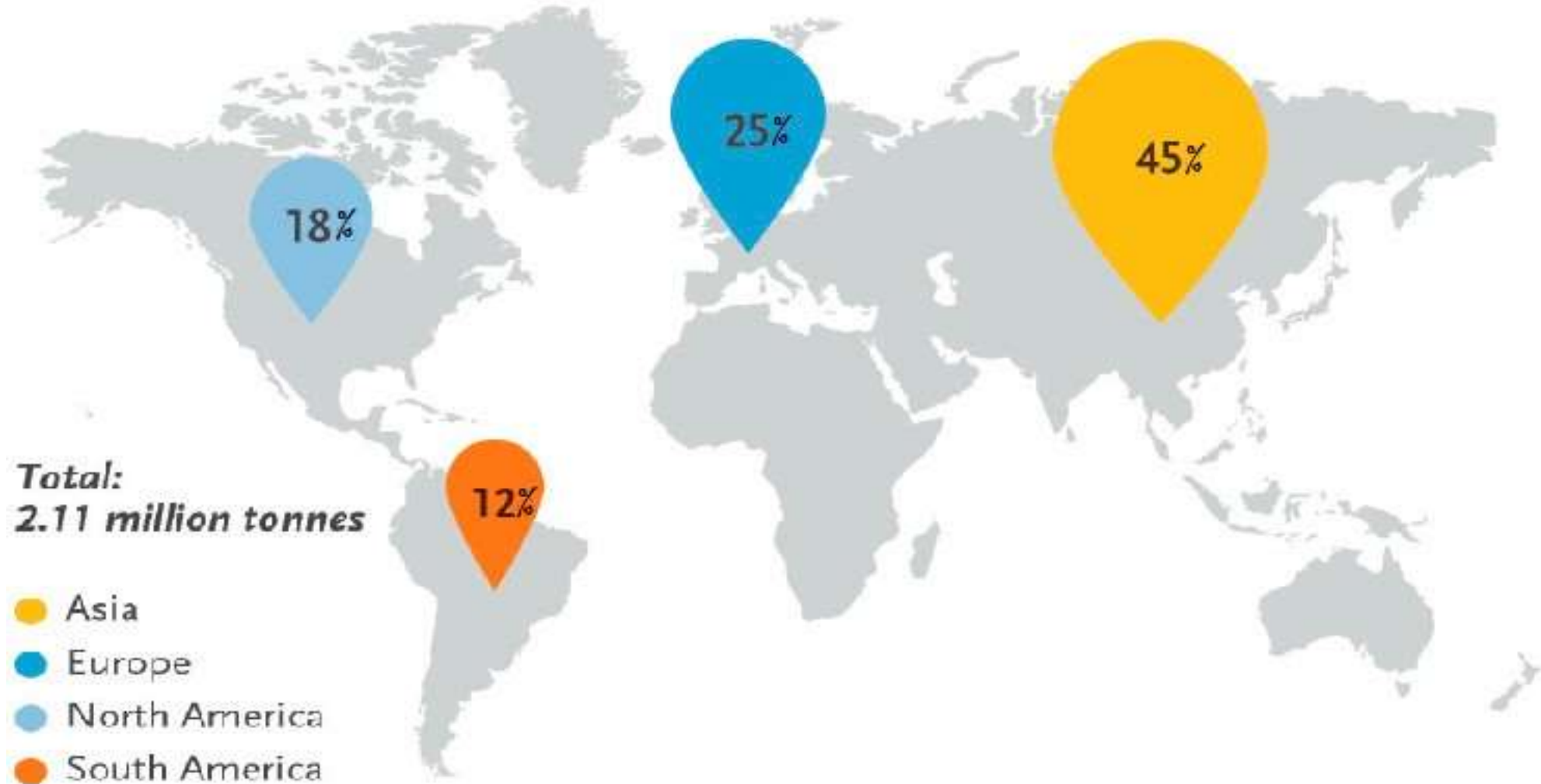
- In CAP, the altered gas composition inside the package is monitored and maintained at a preset level by means of scrubbers and the inlet of gases.
- This method closely resembles the practices used in large controlled-atmosphere (CA) storage facilities where produce is stored essentially unpacked in bulk, except that CAP is used for storage or transport of smaller quantities of produce.
- The ULO storage uses O_2 levels close to the minimum level required for maintenance of plant tissues.
- Using ULO storage at 1°C – 2°C with preset levels of 0.5%–1% O_2 and 2%–3% CO_2 , for instance, Elstar apples can be stored for almost a whole year without unacceptable quality loss.

Biodegradable and non-biodegradable bioplastics production capacities

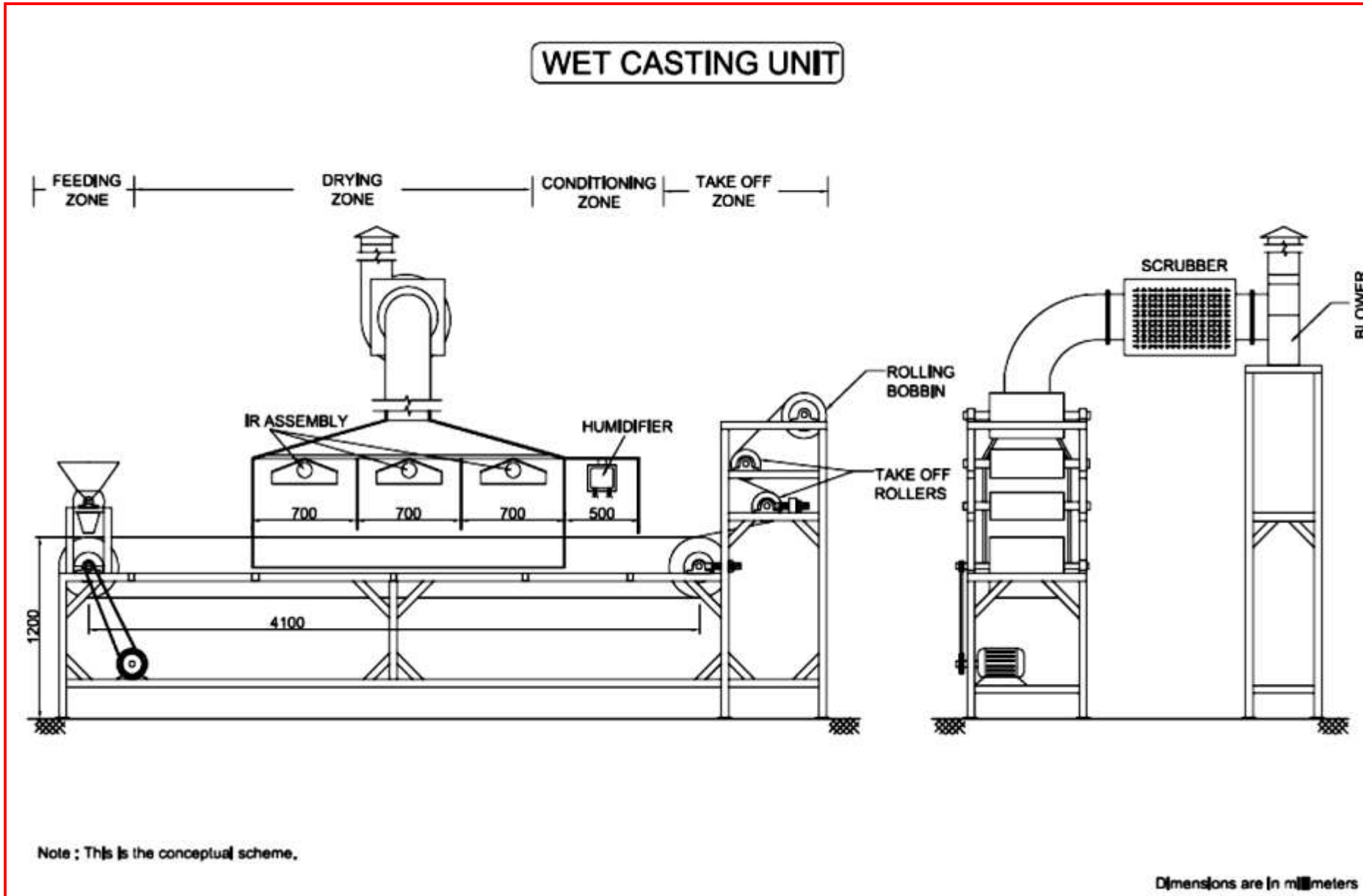


<https://www.european-bioplastics.org/news/publications/#MarketData>

Global production capacities of bioplastics in 2019



Design of wet casting unit



Continuous wet casting unit



Standardization work for continuous casting of chitosan films by machine is in progress.....

Continuous wet casting unit



Continuous wet casting unit



Features of wet casting unit

- **Consists of 4 zones: feeding zone, drying zone, conditioning zone and take off zone**
- **Solution feeder have a controlled metering and constant thickness spreading mechanism**
- **IR heating chamber of 3 zones with temperature control (50-200°C)**
- **Conditioning chamber sprays fine mist of water /alcohol vapour**
- **Film take off and rolling bobbins with adjustable speed**
- **Provision of data acquisition to computer along with data processing software**

Summary

- Optimization of process conditions to prepare polymer blend films was carried out.
- Polymer blend films chitosan/PCL were prepared of different ratio to develop a polymer composite system having low WVP and better properties.
- DSC, FTIR and SEM investigated the extent of PCL addition effected in the blend with chitosan.
- CH80 (80/20 chitosan/PCL blend ratio) indicated better mechanical and barrier properties. Hence, the miscibility to achieve better properties will depend on the relative blend ratio of chitosan and PCL.
- A machine for continuous casting of bio-films is designed and developed.

Plastics as Packaging Material : A Boon or Bane

- Reached a point of “No Return”.
- Big No to Single use plastics even for Food Packaging Applications.
- Biodegradable Plastics is the Future irrespective of the cost. Efforts to reduce its cost of production.
- Promote alternate Food Packaging material to the extent possible (Glass etc)

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**Thank you for
kind attention**