

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES PACKAGING MATERIALS: THEIR ENVIRONMENTAL IMPACTS AND CONTROLLING

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ABSTRACT

Packages were probably taken directly from nature, such as leaves and shells. Although no longer a significant packaging medium, clay still continues to have a major artistic value. Today, a wide range of materials are used for packaging applications, including metal, glass, wood, paper or pulp-based materials, plastics, ceramics, or a combination of more than one material as composites.

I. INTRODUCTION

The first package was developed as a container and its principal function was to hold the food and water. Packages were probably taken directly from nature, such as leaves and shells. Later, containers were fashioned from natural materials like wooden logs, woven plant fibers, pouches made from animal skins. The next containers developed by early societies were clay pots, which date back to 6000 B.C. The first known pottery is from Syria, Mesopotamia, and Egypt. Besides being functional, clay bowls and vessels were an artistic medium that today provide important clues regarding the culture and values of ancient people. Although no longer a significant packaging medium, clay still continues to have a major artistic value. Today, a wide range of materials are used for packaging applications, including metal, glass, wood, paper or pulp-based materials, plastics, ceramics, or a combination of more than one material as composites. They are applied in three broad categories of packaging:

***Primary packaging:** It creates sales unit and is normally in contact with the goods

***Secondary packaging:** Packaging such as cardboard boxes, wooden crates, or plastic containers which are used to carry quantities of primary packaged goods.

***Tertiary packaging:** This is a transport packaging that is used to assist freight transport of large quantities of goods, such as wooden pallets and plastic shrink-wrap.

India generates approximately 133 760 tones of solid waste per day, of which approximately 91 152 tones is collected and approximately 25 884 tones is treated .Solid Waste generation *per capita* in India ranges from approximately 0.17 kg per person per day in small towns to approximately 0.62 kg per person per day in cities(Data released in 2017 on the occasion of international seminar on ‘Sustainable solid waste management for cities: opportunities in South Asian Association for Regional Cooperation (SAARC) countries’ organized by the Council of Scientific and Industrial Research-National Environmental Engineering Research Institute and the Royal Society).The 80 % of solid waste is generated from Packaging material .Once the contents of the packaged product are used, the packaged product is then a waste material and shifted to dustbin .

The Environmentalists are told that packaging is wasteful and harmful to the environment as it is frequently unnecessary and unnatural. The packaging materials should be used in an optimum way keeping in view the environmental effects. An Environmentally responsible pack is one that gets the product from production to consumption with minimum use of materials and energy, generating the least amount of waste.

Lifestyle requirements of the late 20th and early 21st century include the contemporary questions of what we eat, when we eat and where we eat. Now, since around sixty percent of all consumer packaging is food packaging. It is of no little interest to those involved in supplying the packaging and food needs of consumers. Modern supermarkets bring a highly competitive retail environment, with different versions or brands of the same product all displayed together. The Packaging is help to make the selection on color, graphics or shape based.

Energy and materials are the main resources in packaging manufacturing. Gas and electricity are used as energy and in some cases (i.e. plastic production) heat is used as energy to form material. The use of material is not only up to primary sources e.g. steel coil, plastics granules or paperboard but also to a wide range of secondary materials such as inks, coatings and solvents. Another material that is used extensively and has considerable environment impact is water. Pollution affects air, land and water. This can be illustrated by atmospheric emissions, effluents into drainage systems and natural waterways and land contamination, e.g. from hazardous solid waste. It ranges from the original mining of raw material to the disposal of post-consumer packaging within the industrial and commercial or municipal waste streams.

II. ENVIRONMENTAL IMPACTS OF PACKAGING MATERIALS

The following basic packaging materials are used now a days and a study of their environmental impacts as well as their sustainability is discussed as below:

A) Aluminum and its environmental impacts: Aluminum was first used for cans in the 1950s and today is widely used for drinking, especially for carbonated soft drinks. It is also used in beer can, aerosol cans and other required packages. It has high re-use capacity. After oxygen and silicon, aluminum is the third most abundant element in the earth's crust and the most abundant metal. Aluminum is an active metal, which implies that it likes to react or combine with other elements. It rarely occurs by itself in nature. It is found in numerous ores combined with lots of different minerals. Bauxite ore is the most common source of aluminum. Aluminum is a valuable material. Aluminum is lightweight, strong, easy to form, corrosion resistive, and infinitely recyclable. It has good reflective and conductivity qualities. It is impermeable and non-combustible.

Aluminum also has many environmental impacts. It has pollution risks associated with purification processes. There are environmental impacts associated with each stage of aluminum production, from extraction to processing. The major environmental impact of refining and smelting is greenhouse gas emissions. Sulfur dioxide and sodium fluoride are emitted from smelters and electrical plants. The filtering process leaves behind a toxic sludge, commonly called red mud or red sludge. Red mud is highly caustic and may contain radioactive materials and heavy metals. The high pH of red mud is strong enough to kill plants, animals, and burn airways if breathed in. Eventually, the red mud dries out, is buried under a layer of soil, and becomes a toxic landfill. Aluminum production requires such massive amounts of electricity that it has been called solid electricity. It takes 15 kWh of electricity to produce just 1 kilogram (2.2 pounds) of aluminum. Smelting aluminum emits greenhouse gases and toxins including carbon dioxide, fluoride, sulphur dioxide, dust, polycyclic aromatic hydrocarbon, and toxic effluents.

B) Glass and its environment impacts: Glass is probably the oldest in its use as a packaging medium, dating back to its use for hollow vessels, in about 1500 BC. Glass remains an important packaging material and studies have shown that in the mind of today's consumer it is associated with features such as cleanliness, inertness and high clarity. Its high quality image makes its popular in market sectors such as beers, wines and spirits, perfumes and some pharmaceuticals. Glass is good in recovery and recycling.

A pollution risk is also associated with production by furnaces. The major environmental impact of glass production is caused by atmospheric emissions from melting activities. The combustion of natural gas/fuel oil and the decomposition of raw materials during the melting lead to the emission of CO₂. This is the only greenhouse gas emitted during the production of glass. Upon the glass manufacture process, air-polluting compounds like nitrogen oxides, sulfur dioxide and particulates are released. The last are even more of a health issue since the particles of metals, chemicals, acids and dust that the particulates are comprised of, are so tiny (10 micrometers or even smaller) that they are able to easily enter the nose and throat and reach the lungs, where they produce quite some damage. The

main emissions are sulfur oxides (SO_x), nitrogen oxides (NO_x), and particulates, which can contain heavy metals such as arsenic and lead.

C) Paper & Board & and its environment impacts: Paper and Board are the most widely used materials in today's packaging. Applications vary from labels to corrugated boxes and their ever increasing use in paper crockery. Paper bags come as a big alternate of plastic bags in many cases. Papermaking is thought to date back to China in the second century AD and originally made from used woven strips of wet papyrus, laid down by hand and then dried. Papermaking machinery developments in the nineteenth century brought the ability to build up layers of cellulose fibre into a continuous web, thus allowing a wide range of materials of different thickness and performance to be made.

There is a pollution risk at the time of manufacturing i.e. bleaching and other chemical treatments. The production and use of paper have a number of adverse effects on the environment which are known collectively as paper pollution. Pulp mills contribute to air, water and land pollution. Discarded paper is a major component of many landfill sites, accounting for about 35 percent by weight of municipal solid waste (before recycling). Even paper recycling can be a source of pollution due to the sludge produced during de-inking. Worldwide consumption of paper has risen by 400% in the past 40 years, with 35% of harvested trees being used for paper manufacture. Plantation forest, from where the majority of wood for pulping is obtained, is generally a monoculture and this raises concerns over the ecological effects of the practice.

Air pollution is caused due to the excessive use of paper and board. Nitrogen dioxide (NO₂) sulfur dioxide (SO₂) and carbon dioxide (CO₂) are all emitted during paper manufacturing. Nitrogen dioxide and sulfur dioxide are major contributors of acid rain, whereas CO₂ is Water pollution. On the other hand, wastewater discharged for a pulp and paper mill contains solids, nutrients and dissolves organic matter such as lignin. It also contains alcohols, chelating agents and inorganic materials like chlorates and transition metal compounds. Nutrients such as nitrogen and phosphorus can cause eutrophication of fresh water bodies such as lakes and rivers. Organic matter dissolved in fresh water, measured by Biological Oxygen Demand (BOD), changes ecological characteristics. Waste water may also be polluted with organ chlorine compounds. Some of these are naturally occurring in the wood, but chlorine bleaching of the pulp produces far larger amounts.

D) Plastics and its Environmental impacts: Although more than 30 types of plastics have been used as packaging materials (Lau and Wong, 2000), polyolefin's and polyesters are the most common. Polyolefin is a collective term used for polyethylene and polypropylene, the two most widely used plastics in food packaging and other less popular olefin polymers. Plastics packaging industry has flourished since 1940. Of all the packaging materials, Plastic packaging has seen the most significant growth since then, due to the development of low –cost processes and materials with a wide range of different properties, and probably most significantly the ability to tailor those properties to suit a range of different needs. Plastic Packaging is the most versatile and diverse family of packaging materials. Non Biodegradable nature is a challenge for packaging industry. So plastics have replaced the more traditional materials such as glass and metal in some applications, such as Polyethylene Terephthalate (PET) containers for bottled water and soft drinks in place of glass. High- Density polyethylene (HDPE) takes the place of glass containers. Flexible plastics pouches are used for pet food; soup and sauces take place of metal cans.

1) Polyethylene Terephthalate and its environmental impacts: PETE is a durable, transparent plastic commonly used to make beverage and food products, bottles and jars as well as microwaveable food trays and ovenproof plastic wrap. When recycled, it becomes part of new plastic containers.

The plastic bottle takes 500 years to decompose and most of the plastic cannot be recycled. Those bottles that are recycled are not used to make new bottles. This means more raw material is required to be used to create new plastic bottles. The chemical compounds released by these plastics can change hormones and have other possible human health effects. Animals, including more than 180 species of which have been documented to consume plastic waste, are also affected by the chemicals and can be permanently injured or can die as a result of the poison. Plastic bottles contain Bisphenol A (BPA), the chemical used to make the plastic hard and clear. BPA is an endocrine disruptor

which has been proven to be hazardous to human health. It has been strongly linked to a host of health problems including certain types of cancer, neurological difficulties, early puberty in girls, reduced fertility in women, premature labour, and defects in newborn babies – to name a few examples. BPA enters the human body through exposure to plastics such as bottled drinks and cleaning products. It has been found in significant amounts in risk groups such as pregnant women's placentas and growing foetuses. A study conducted found that 96% of women in the U.S have BPA in their bodies. Phthalates are also endocrine-disrupting chemicals that have been linked to a wide range of developmental and reproductive effects, including reduced sperm count, testicular abnormality and tumors, and gender development issues.

2) High Density Polyethylene and its Environmental impacts: This type of plastic is the most common in packaging goods that needs protection from light and a stiff container. It can be either translucent, such as milk jugs, or opaque, such as the packaging for household detergents or bleaches. HDPE is also used in plastic bags for carrying food and retail items, reusable shipping containers and wire and cable sheathing .Plastic bags can absorb pollutants like PCBs (polychlorinated biphenyl) and PAHs (Polycyclic aromatic hydrocarbons), which are known to be hormone disrupting chemicals. Plastic bags and their associated plastic pieces are often mistaken for food by animals, birds, and marine life like fish and sea turtles. The consumed plastic then congests the digestive tracts of these animals, and can lead to health issues such as infections and even death by suffocation. Animals can also easily become entangled in this plastic. To produce nine plastic bags, it takes the equivalent energy to drive a car one kilometer.

3) Polyvinyl Chloride and its Enviournmental impacts: PVC is usually associated with blister or clamshell packaging. It is typically used, in its flexible state, for heavy duty packaging bags and films, blood bags and medical tubing. It is reported that no other plastic presents such a direct environment and human health threat as PVC does throughout its lifecycle from manufacture to disposal after use. Substances called phthalates are added to PVC to make it flexible. Studies of animals show that some of these chemicals may cause cancer, Kidney and reproductive system damage. Dioxin is one of the most deadliest of man-made poisons and it is cumulative toxin, which means it stays in the body for a long time, concentrating in food chains at the highest levels in carnivores.

4) Low-Density Polyethylene and its Environmental impacts: Low density polythene (LDPE) is the most widely used packaging material primarily because of its excellent mechanical properties, barrier properties against water, light weight, low cost and high energy effectiveness. However, due to its all over nature, and resistance to biodegradability, the disposal strategies are crucial and need attention. Thus, over the years, the rapid biodegradation of plastic has been a subject of interest in the waste management problem. This flimsy thin plastic is used most often to protect dry cleaning and as bags for bread. It also coats food cartons and disposable plates and cups. Recycled LDPE is used in the production of heavy-duty garbage bags.

III. CONTROLLING

Today, controlling the environmental is a very crucial issue. The Environmentalists are told that packaging is wasteful and harmful to the environment as it is frequently unnecessary and unnatural. The disposal of domestic waste also causes a problem in the environment. Indeed, who is the polluter? This is much debated: is it the waste disposer, the consumer, the retailer, the distributor, the product manufacturer, packers or filler, the farmer, the raw material supplier? All are somehow implicated. The packaging materials should be used in an optimum way keeping in view the environmental effects. Once the contents of the packaged product are used, the packaged product is then a waste material and shifted to dustbin.

But another view about a packaging material is that Packaging is a necessity, not an option. This is like other utilities, such as water and electricity. Packaging is taken for granted and becomes a problem when it fails to achieve its basic functions. The customers consider the package to be safe against damage while carrying it from one place to another and become dissatisfied with a poor quality package. Packaging is a way of delivering a product to a customer in a prime and safe condition which is fit-for-use. The important functions that it has served before reaching the customer are of little public interest and beyond this poorly appreciated context, once the contents of

the packaged product have been removed for use or consumed, the package is considered as a waste material. Global warming, ozone depletion and general pollution are much more daunting and, if properly addressed, change the prospect of alienating a significant proportion of the public as well as industry.

Environment Controlling: The following factors have been adopted by the manufacturer to achieve the best environment controlling systems:

- A) **Integrate with Operational Activities:** As Quality is an integral responsibility in all manufacturing processes. In the same way, a culture of environmental concern needs to be developed and encouraged. Controlling Environmental impact should also be considered as an essential part of operational activities.
- B) **Environmental Management System (EMS):** This can be a very efficient tool in organizational structure to control the environment effects. An environment policy can be framed to ensure the protection of the environment and it should have the details of the strategy for implementation and of the action that is being or will be taken. Policy statement should be made available to all the employees, customers and suppliers as well as interested members of the public.
- C) **Environment Accreditation:** A procedure of external scrutiny has to be measured against the requirement of environmental standards. It is widely believed that exposure to external accreditation reinforces the validity of process and enables organizations to demonstrate publicly their commitment to environmental good practice. Environment standards are already becoming part of commercial agreements in some industries. It is significant that the ISO 9000 quality series is being developed to achieve greater compatibility with the ISO 14000 series. The decision to seek accreditation is the framework that will help the packaging manufacturer meet his/her environmental responsibilities.
- D) **Environment Audits:** It is a structured method by which organizations can ensure the identification of all the impacts, agreement of the required actions and monitor the review progress. Auditing is a powerful tool for recording status and assisting forward planning.
 - i) Define Aims and Objective.
 - ii) Plan how to achieve these objectives.
 - iii) Lay Down the Audit Procedure.
 - iv) Method, Report and Follow up.

All environmental impacts are so readily linked to economical benefits. In some cases, good practice involves the prevention of potential disasters such as pollution spills. Organizations with a history of good environmental accreditation can expect to benefit from lower insurance premiums than those competitors who do not follow this approach.

- E) **Audit Report and Follow-Up:** Action and follow-up must result from the audit process and the report is the vehicle by which awareness of the status of environmental performance is recorded and what needs to be done is communicated to management.
- F) **Fulfillment of the Regulations:** One of the important functions of the report is to disclose the operational agreement with existing regulations, and to indicate where action must be taken, or will need to be taken, as new laws are drafted and enacted.

IV. CONCLUSION

All packaging materials cause pollution into air and water directly or indirectly. Good control of materials and judicious manufacturing of packaging are needed to save the environment. Many government agencies (like National Green Tribunal) are coming forward for the cause of saving environment with their policies like Solid Waste Management and many more. The Municipal Corporations have begun an initiative of separating different items of garbage to recycle and decompose them but it is not enough. Personal involvement of the people is required to overcome the waste usage of packaging. "The best way to reduce the environmental impact of production and distribution of goods is to design packaging to carry out its main function of protecting." (Industry Council for Packaging and the Environment, 1997) Environment safety should be the moral responsibility of every Indian citizen in building a pollution free nation. Packaging materials should not be overused and an environment policy can be framed to ensure the protection of the environment and have the details of the strategy for implementation and of the action that is being or will be taken. Policy statement will be made available to all employees, customers

and suppliers as well as interested members of the public. It is also the need of the present time to replace the more hazardous packaging materials with some new environment friendly packaging materials. So, an initiative is required for the research and survey to be undertaken for finding out a better alternative. Quality is an integral part of everyone's responsibility in all manufacturing processes. In the same way, a culture of environmental concern needs to be developed and encouraged. Controlling environmental impact should also be considered as an integral part of operational activities. The procedure of external scrutiny has to be measured against the requirement of environmental standards. It is widely believed that exposure to external accreditation reinforces the validity of process and enables organizations to demonstrate publicly their commitment to environmental good practice or in short words environment audit will make it helpful.

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