BIOPLASTICS

ALTERNATIVE TO CONVENTIONAL PLASTICS IN TRIPURA

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ENVIS TRIPURA

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Dedicated to th People of Tripura and its Environment

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FOREWORD

Plastics have been intimate part of human life ever since it was discovered in 1907 and later when its mass production began at a very cheap price in 1950s. Between 1950-1990, scientists invented more and more kinds of plastics and plastic-mixed material that revolutionise making of many things that human kind use today- from innocuous tooth pick and toothbrush, to pen and pencils, polybags and water tank, storage items, telephones, vehicle bodies, and many more that we see all around us. All these have imprints of plastics once considered as the human invented marvel.

Easy to produce from earth fossil minerals (coal, gas, petroleum products), plastics surpassed all the expectations of humans in its properties of lightweight, heat resistance, flexibility and cheap cost. By early 2000, so much quantity of plastics was produced that it became a huge problem to store and dispose these because of their non- degradable nature, very long end-of-life duration, and very high carbon foot print due to high emission of greenhouse gases. Waste plastics could be seen all around us in the clogging of drains and water bodies, littering in public places, drainage to rivers and oceans, and huge accumulation on land and in water. By late 2000, there was a strong urge to find alternative to conventional plastics. Soon we saw emergence of bioplastics made from renewable bio-mass. By 2010, technologies became widely available for the mass production of bioplastic products, and these could replace many of the popular items that were earlier made from conventional plastics. The one apparent drawback of the bioplastics is its cost of production which appears to stopping it from becoming a popular replacement of plastics. There is a cost in the production of raw material and its processing to manufacture bioplastic products. This cost has to be made bearable by the common users of plastics. Inventions must continue to find a cheaper and affordable replacement of conventional plastics. Bioplastics provide a good hope in this direction. I firmly believe that people will slowly but surely adopt the eco-friendly alternatives to harmful plastics for the well-being of our environment.

The book Bioplastics – Alternative to Conventional Plastics in Tripura by Prof. B.K. Agarwala, Chairman, Tripura Pollution Control Board is a timely publication for creating awareness in the people of the state and those involved in the administration of sustainable developmental goals (SDP). I hope that the readers will find its contents useful and the book will provide them a better understanding in the subject.

Jishnu Dev Verma

Deputy Chief Minister Government of Tripura

PREFACE

In 1907, when plastics was first discovered, this material was considered as blessings of the science because of its various properties like heat resistance, lightweight, waterproof, soft or tough, flexible, and above all very cheap. All these properties made this discovery of synthetic polymers of Petro-based material very popular in quick time. Since then, inventions in plastics made rapid strides and by 1950 it became one of the most sought- after products of human use in all walks of life. Mass production of different kinds of plastics since 1950 benefitted people and the market to the extent that people loved using varieties of plastics in different shapes and colours for all the possible purposes that one can think of. Period between 1950-1990 can be called 'Plastic Age'. People embraced this wonder material with great pleasure and pride.

The properties for which plastics became so popular and a common sight in all parts of world are also the reasons for which it started to be considered as curse in 2000 onward for chocking the drains and all kinds of waterbodies, very slow degradation, high cost of recycling, accumulation of thousands of tons of non-degradable plastics in rivers and oceans, reported death of domestic and wild animals due to its accidental consumption, and unmanageable disposition.

By late 2000, huge voices started to raise against the use of plastics, single use plastics in particular, that has become order of the day. Governments around the world and agencies concerned with well-being of the environment raised warnings of the impeding environmental crisis due to plastics. In came the pro-active measures including findings of eco-friendly alternatives to plastics, banning of most used single use plastics, and returning to age-old traditional methods of packaging, storing and servicing of commodities and foods.

The invention of Bioplastics made of renewable biomass gained acceptance world-wide and soon several products made of bioplastics started to appear in the market. What was once the 'Plastic Age' in 1950s onward is about to be replaced by 'Bioplastic Age'. The properties and advantages of plastics comes at a cost in the making of most bioplastics which are degradable to simple material that can mix very well with the soil, has very short end-of-life duration, can be very light or tough depending on requirements, has low carbon foot print, and can be produced in mass scale from starch and fibers of several crops and wild plants, root crops in particular, which grow extensively in most parts of the world. The one thing that goes against the popular demand and use of bioplastics is its cost of production which

is 30% - 80% higher than the conventional or Petro-based plastics. Technologies are now available for mass scale production of bioplastics, and market is fast catching up with this replacement of plastics even for a cost.

For common good of the environment, it is necessary that inventions should get further momentum to make the bioplastics as popular as conventional plastics so the vast majority of the people around the world can afford its use. States of north-east India, being the green repository of the country, requires special attention in the use of conventional plastics. Government must make social and environmental investments to guard the harmful effects of the non-degradable plastics. A national policy coupled with the initiatives by the local government should begin to appear sooner than later. The Tripura state and its people will adopt single use bioplastics without reluctance to be followed by other uses of bioplastics.

This booklet is a small effort by the author and the Tripura State Pollution Control Board through the ENVIS (Environment Information System) programme of the Ministry of Environment, Forests & Climate Change, Government of India for bringing essential information regarding the bioplastics in a popular format. I hope that it will serve its purpose well.

Prof. B.K. Agarwala

CONTENTS

1. Introduction

India is the third largest plastic consumer in the world, with a total consumption of about four million tons and a resulting waste production of about two million tons. Since 1950s the world has produced, used, and thrown away more than nine billion tons of plastics. Single Use Plastics (SUP) among all the plastics are the immediate cause of environmental concern. These plastics are mostly disposed after one use and usually are properly disposed safely. Polythene carry bags, PET water bottles, and food wrappers are major sources of SUP. As plastic-clogged drains, water bodies, road sides, markets, Coasts and ocean surfaces are common sight of SUP, there have been an increasing urge to found alternatives to these petroleum-based products. Bioplastics produced from renewable and biodegradable biomass have emerged as a viable alternative to conventional plastics, also called petroleum plastics, and are replacing these very fast.

Demand for bioplastics has been increasing since past decade due to growing awareness concerning hazardous effects of plastics and plastics wastes, environment conservation, and to meet new regulations for single use plastics across countries of the world. Products and solutions based on bioplastics/biopolymers present interesting opportunities globally. Bioplastics present new opportunities of use and applications in a variety of industries like packaging, bottle water, beverages, insulation materials, films and lamination, specialty materials, and many more including garbage bags, bio-medical waste bags, carry bags, and grocery bags.

The key factor driving the bioplastics market is the need for use of eco-friendly and less polluting materials. Other factors include increasing prices of fossil fuel and the need for companies to decrease their carbon footprint due to statutory restrictions and commitment to corporate social responsibilities. Bioplastics are produced from renewable biomass sources, such as vegetable fats and oils, corn starch, rice starch, straw, woodchips, sawdust, recycled food waste, etc. Plants rich in starch are used for the purpose.

In the United States, corn is the principal source of starch. Other countries, including India, use starch fibers present in sugarcane, sugar beets, cassava roots of tapioca, wheat, and potatoes. This makes bioplastics renewable and better than

conventional plastics for the environment. The demand for bioplastics has been gradually increasing due to its renewability and availability of raw material, numerous applications, and technical properties, and a range of recycling options available. Let us examine the available facts and emerging prospects of bioplastics as a replacement of conventional or petroleum plastics.

2. Raw Material of Bioplastics

Bioplastics are made from renewable biomass. Basic raw material are starch or lignin polymers, vegetable fats, wood fibers etc. derived from sugarcane, maize, potato, cassava roots of tapioca, soya, sugar beet, and any other abundant and cheap bio-source. In contrast, **petroleum plastics** are made from natural materials such as cellulose, coal, natural gas, salt and crude oil through a polymerisation or polycondensation process. Between the two kinds of plastics, bioplastics take much less time (usually less than 100 days to one year in suitable condition) to break-down in to simple elements and compounds (carbon dioxide, water, carbon, etc.) and mix with the environment (soil, water, air) than the conventional plastics which takes 100 to 1000 years depending on the source and process by which these are made. Bioplastics usually melts in water at much lower temperature, are much less harmless, and dissolves faster in natural or synthetic organic solvents than the conventional plastics. Also, most biodegradable bioplastics produce little or no toxic material during degradation unlike conventional plastics that releases several toxic materials during degradation process, and, thus, are harmful to the environment (soil, water, air and other organisms). However, depending on the use, all bioplastics may not be made of renewable organic mass only and may also contain natural fibers or resins or mineral material that render these bioplastics to achieve more mechanical strength, become weight bearing and durable. Such bioplastics degrade slowly and are less eco-friendly. Thus, bioplastics many not be 100% vegetable matter. Sometimes they can be as little as 20%. The rest could be conventional materials. As stated above, it all depends on the type of bioplastics being made for certain use and applications. In any case, on average, any bioplastics is less harmful, has shorter end-of-life duration, and a better source of recycling than conventional plastics.

3. Bioplastic Classification

Based on ingredients used in the making of bioplastics, and end-of-life duration, bioplastics available in the market are classified in to four categories-

3.1. Biodegradable bioplastics: Under right conditions, these will decompose into carbon and water due to the biological action of microorganisms like bacteria, fungi, algae in a few weeks. Decomposition begins by breaking of chemical bonds of polymers by the enzymes secreted by microorganisms. The best biodegradable

products can achieve complete biodegradation under suitable condition within 90-100 days. But many biodegradable products of industrial grade may still contain tougher biofibers similar to ingredients of conventional plastic, making them more difficult to break down and leave behind some persistent and toxic residues. Such bioplastics require optimum condition of heat/ temperature and presence of soil and moisture/ water for decomposition to occur within a short time. This can happen in a facilitated environment of waste yards of municipalities or corporations or such other solid waste disposal facilities.

Photo source: https://www.indiamart.com/proddetail/project-report-on- biodegradable-plastic-products-22013492388.html

3.2. Non-biodegradable bioplastics: These are not easily broken down by microorganisms. Although made from fibre-rich natural materials like sugarcane, they are chemically identical to some petroleum-based plastics. At times, Petro-based material are used along with bioplastics to make the product strong, durable, and corrosion free. Like conventional plastics, they will only degrade slowly and may take many years and leave behind non-toxic as well as some toxic residues. These plastics have long life and are used as poly sheets, poly fibers, etc.

3.3. Partially biodegradable or durable bioplastics: Microorganisms can break down these plastic into smaller pieces under the right conditions of humidity and temperature. Unfortunately, the process generally takes longer than 3-6 months. 'Break down' and 'decomposition' or 'compostable' are not the same. In 'break down', material is broken to smaller and simple material, but not necessarily in to their elements or simple inorganic substance through the process of bio- as well as chemical actions. But 'decomposition' or 'compostable' means complex material is converted in to ultimate simple substance through the process of bio-action involving fungi, bacteria and other organisms under suitable condition. So, these bioplastics are not compostable.

3.4. Compostable plastics: These bioplastics decompose completely into natural materials like water, carbon dioxide, and biomass within about 90 days by the actions of microbes in presence of environmental oxygen. Most of these plastics need industrial facilities to fully decompose. Compostable materials will eventually turn into compost or humus or nutrients that can be used by plants. They do not leave behind any residues. Homestead compost pit is not congenial for these plastics to compost in a short time.

(Photo source: https://biotuff.com.au/about-us/bioplastics/)

4. Chemical Ingredients of Bioplastics

According to chemical ingredients, bio-based plastics belong to two main categories:

4.1 Polylactic Acids (PLA): It is made by fermentation of ingredients like corn starch, or sugarcane or arum (also called taro). This is currently the cheapest source of bioplastic in the market. PLA bioplastics are commonly used in food packaging, tea bags, clothing, cosmetics, making cups, lids, cutlery, straws and home furnishings. PLA is often more brittle than regular plastics and does not stand up well to heat. PLA is biodegradable and has characteristics similar to polypropylene (PP), polyethylene (PE), or polystyrene (PS).

(Photo: https://www.ecoexist.com/mailchimp/bioplastics.html)

PLA is generally considered safe for its intended uses as a polymer for fabricating articles that will hold package food. PLA emits a sweet smell resembling the burnt sugar when heated. The United States Consumer Products Safety Commission (USCPSC) specifies that food products are deemed safe when they contain less than 1,000 ppm (parts per million, which is equivalents to less than 1 mg/litre of liquid or less than 1cucm of solids) of the plasticizers that are present in proportionately much higher quantity in petroleum plastics.

4.2 Polyhydoxyalkaneoates (PHA): This form of bioplastic is manufactured and stored

by bacteria when fermenting vegetable sugar or fats. PHA can withstand higher temperatures than PLA. These are increasingly used in food packaging, agricultural products, and medical devices. Because PHA is produced by bacteria, therefore it is a much eco-friendlier polymer that can handle high temperatures and decomposes in soil and waterways as well. But its process of production is slower and require bio-fermenter facility. **PHAs** are biodegradable, readily compostable and thermoplastics. The properties of **PHA** polymers are customizable to the application, depending on the specific combinations of different monomers incorporated into the polymer chain.

5. Uses and Application of Bioplastics

World-wide, bioplastics have gained popularity of use in single-use disposable items such as carry bags, grocery bags, garbage bags, plates, utensils, cups, and film wrap plastic bottling and as paper linings by fast- food companies,and in clothing fibers, compost bags, in the biomedical field, etc. In India, biodegradable plastics are used in the manufacturing of carry bags, agricultural mulching, surgical implants, industrial packaging, wrapping, milk sachets, foodservice, personal care, pharmaceuticals, medical devices, recreational items, etc.

The global bioplastic market is experiencing significant opportunities in the consumer goods and packaging sectors. Global market growth during 2016- 2020 is estimated to be 30%. This market is driven by the emergence of renewable biomass and bio-based raw materials such as starch and vegetable crop derivatives. The use of bioplastics in numerous applications has facilitated plastics manufacturers to reduce the overdependence on petroleum-based plastics. In India, several states/provinces have strictly enforced ban on single use plastics. The Himachal Pradesh state in the western Himalaya and the Sikkim state in the eastern Himalaya are good examples. Willingness to desist from using conventional plastics items in daily life or in public places by people at large, and the public offices in particular, is the common factor between the two successes. The same cannot be said of the state of Uttarakhand and Darjeeling district of West Bengal which are the neighbouring hilly places in western and eastern Himalayas, respectively. The socio-economic profile of the people of our country demands that we are sure and steady in removing the menace of single use Petro-plastics through constant persuasion and administrative actions.

According to an estimate, global production of bioplastics was 2.1 million metric tons in 2020, an eight percent increase over the year 2019. These comprised 884,000

metric tons made from non-biodegradable bioplastics, while the biodegradable bioplastics was 122,000 metric tons. Growth is expected to continue in the coming years, and is likely to increase to approximately 2.87 million tons by 2025.

6. Bioplastic Manufacturing

Corn, potato, sugar beet or rice starch are some of the sources of the starch which can also be combined with biodegradable polyesters to enhance its properties. Pure starch can absorb moisture and is used in medical products. Thermoplastic (heat tolerable) starches are more water resistant and are applied industrially. Cassava root starch (popularly used as 'Sago' in Bangla or 'Sabu' in Hindi) of tapioca, a plant of African origin, is grown widely in India and is a major source of raw material used to produce biodegradable plastic that can be used for food packaging or carry bags. The ozone (O_3) gas is applied to starch that changes its molecular properties from the root vegetable to produce a transparent bioplastic which is 30 per cent tougher than those made of the untreated starch of potato, rice or maize.


Cassava or Sago or Sabu dana roots

Source: https://www.indiamart.com/proddetail/ biodegradable-corn-starch-bag

Nearly half of the bioplastics currently being made in the world come from starch. This bioplastic is found to be as strong as petroleum plastics.

PLA (polylactic acid) is the most common transparent bioplastic in use today. It is made from the sugars present in corn starch, cassava or sugarcane. PLA is biodegradable, carbon-neutral and edible. One of the common methods involve corn kernels which are immersed in a solution of Sulphur dioxide and hot water, where its components break down into starch, protein, and fibre. The kernels are then grounded and the corn oil is separated from the starch. The starch is comprised of long chains of carbon molecules, similar to

the carbon chains in plastic from fossil fuels. Starch granules produced by this process are similar to that produced in Petro-based virgin plastics. PLA can look and behave like polyethylene, polystyrene or polypropylene. Several industries have come up in India and abroad that manufactures semi-automatic and automatic machines for manufacturing different bioplastic items from bio-resources. Appropriate guidelines and standards are in place for the quality of products manufactured by these machines in terms of end-of-life duration, greenhouse gas emissions, and carbon residues. Indian standard in the shape of guidelines issued by the Central Pollution Control Board is largely in tune with the European and American standards.

7. Cost Effectiveness

Bioplastics are relatively expensive. PLA and PHA can be 20 to 70 percent more expensive than comparable conventional plastics because of the complex process involved to convert corn or sugarcane into the building blocks for PLA or PHA. Nevertheless, many nations and prosperous economies of the world have started phasing out several categories of petroleum plastics by bioplastics, single use and medical use plastics in particular, to reduce environmental pollution and their carbon footprint. In India, single use carry bags less than 50 microns thick (1 micron = one thousand parts of 1 millimeter) and made of petroleum plastic is banned. But the production, storage, transportation, and sell of these bags are happening in most places of the country, and the ban is not effectively enforced mainly because the market forces are not ready to adopt the expensive alternatives to cheaper single use petroleum plastic bags. Eco-friendly paper bags, bioplastic bags, cloth bags, jute bags, bio-polymer fibre bags are manufactured and available for use in the market, but a sizeable number of people are either not ready or not willing to use the alternatives because of cost, and also because they expect the market to bear the cost. A good number of people of the present generation show disregard to the prevailing rules and laws, and are indifferent to the concerns of

harmful effect on the environment. By and large, the prevailing situation demands that legislative means alone is not sufficient to deal with the situation in a country of our size and with so much heterogeneity. Instead, a mix solution of integrating the costs of eco-friendly bags and other single use plastics should be enforced at the source of sale, along with a rigorous implementation of ban orders on the production, storage, transport, and sale of petroleum plastics. Government of the day has to show the mettle as has happened in several small and large economies and nations of the world. Singapore, South Korea, and Japan are the leading examples in the eastern part of the hemisphere.

8. Prospect as Alternative to Conventional Plastics

Undoubtedly bioplastics are better for the environment, even if they end up in the landfill or energy recycling. That is because they are made from renewable materials. Displacing fossil fuels with renewable resources is a positive step. Under the right conditions, bioplastics produce less greenhouse gas emissions than petroleum-based plastics.

However, there is other side to it also. Various studies have shown that some bio- based plastics can have a greater negative impact on the earth's environment than conventional products. This is because producing the plants needed for bioplastics involves chemical fertilizers and pesticides, along with chemical processing. When the negative effects of agricultural production combine with the chemical processes needed to convert plant matter are considered, some bioplastics are less environmentally friendly than regular plastic.

8.1 How good are bioplastics?

Bioplastics are good to the extent that they are used with responsibility. None of the marketable bioplastics decompose or break-down or can be composted fully within a short time, and in ordinary condition. Given the fact that several bioplastic products contain some quantity of mineral-grade ingredients, they require a minimum of 90 days to more than 10 years to degrade, and the fact that they are used or can be used in millions of tons per day, therefore, it is anybody's guess that none of these plastics are a solution to end plastic waste. Add to these is our throw-away habits which do not sense the micro- and macro-level problems of drains clogging, waste accumulation in water bodies, drainage to rivers and oceans, and their littering all around in public places.

Despite the negatives of any kind of plastics we might be using, the good part of bioplastics is that they are emerging as lightweight, reusable alternatives to single-use

plastic, food containers, and shopping bags in particular. These bioplastic products are fast replacing single-use items. As a result, thousands of tons of petroleum plastic trash are prevented from entering landfills, inland water bodies and oceans. These cut down on greenhouse gas emissions.

8.2 How safe is environment from bioplastics?

Overall, it cannot be said that environment will be safer if bioplastics are produced, used and disposed safely. Environment of oceans, rivers, mountains, and air is universal and knows no boundary. Consequences of environmental harm in any part of the world can be manifested in multiple ways and its effects can be far-reaching. These are well established. Therefore, such issues invite global participation and commitment to achieve certain targets to keep the world environmentally safe. The issue of bioplastics as alternative to conventional plastics has to be viewed in this perspective.

With these basic facts, it can be said that PLA plastic without addition of mineral ingredients degrades into lactic acid, which is anaerobically decomposed (in the absence of environmental oxygen) in to carbon dioxide and water. Because of these properties, PLA plastic is safe to use as medical devices such as anchors, screws, plates, pins, rods, and as a mesh. Depending on the exact type used, it breaks down inside the body within 6 months to 2 years. This gradual degradation is desirable for a support structure, because it gradually transfers the load to the body (e.g., the bone) as that area heals.

PLA is also safe for use as a decomposable packaging material, either as a film wrap, or cast, injection-moulded, or as spun fibre. Cups and bags have been made from this material. In the form of a film, it shrinks upon heating, allowing it to be used in shrink tunnels. It is safe and useful for producing loose-fill packaging, compost bags, food packaging, and disposable tableware. In the form of fibers and non-woven fabrics, PLA also has many potential uses, e.g., disposable garments, feminine hygiene products, and diapers.

PHA and PLA plastics, both, are easily compostable within short time with certain industrial composting facilities. These natural-based plastics decompose completely through intervention of bacteria and fungi. But the difficult part is segregation of bioplastics from petroleum or conventional plastics which are used side by side. Most municipalities do not yet have these facilities in place. Improper

disposal can create another environmental problem. Biodegradable and compostable plastics with 3D printing on them is not safe because such printing release some volatile chemicals and tiny particulates. Printing involves synthetic chemical lining and layering including some hard chemicals that are not decomposable in eco-friendly end-products. It requires a safeguard on this count.

9. Disposal of Bioplastics

9.1 Landfilling – In poor economies, landfilling is the easy option as also for petroleum plastics. Then it can take 10 to 1,000 years to break down. The law requires landfills to be airtight, blocking out water, light and air. Under these conditions, biodegradable and compostable bioplastics will not produce natural material that are produced in the presence of oxygen, but will produce methane, a gas which is 30 times more potent than carbon dioxide in terms of greenhouse effect. If we consider thousands of tons of bioplastics to reach landfills, then we shall be creating a reservoir of methane gas 1000 years from now that will be very harmful to all kinds of life that we see around us today. Petroleum plastics, in addition, will produce several toxic residues. So, it does not make difference which plastic is used in landfilling. It is not a safe option. But the fact remains that a significant quantity of all kinds of used plastics reach landfill sites.

9.2 Recycling – It is technically possible, but not viable till sufficient quantity of bioplastics are separated from non-bioplastics and are processed under suitable conditions. It is not cost-effective in comparison to recycling of conventional plastics because of fragile and brittle nature of bioplastics. In the long run, however, sustainable development goals will gradually force the communities to accept these realities and develop intrinsic or mandatory system by law to accept the hard facts of environmental issues.

9.3 Composting – Home composting of fully biodegradable single use bioplastics is possible like the composting of organic food wastes. It takes little longer to degrade or compost than the usual renewable biowastes but the principle and process are essentially the same. Industrial composting, whether by dedicated industries or municipalities, on industrial scale is easily possible by creating necessary facilities that will involve heating of the waste bioplastics to certain temperature and use of micro-flora to accelerate break- down of bioplastics in to natural simple ingredients. These ingredients, then, can be recycled to produce new bioplastics.

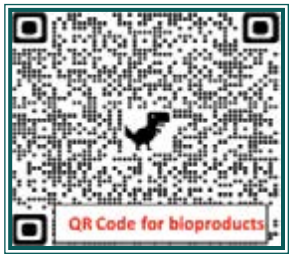
9.4 Electric power - There will be a time, not too far from now, when cheaper technology

will be available to produce electric power from bioplastics of all kinds. The technology presently available is not sustainable and it cannot be afforded by the rich economies also. But efforts are afoot around the world to develop cheaper technology to deal with the ever-increasing menace of plastic use and its sustainable disposal.

10. Statutory Provisions

Registration with the State Pollution Control Board (SPCB)/Pollution Control Centres (PCC) in Union Territories followed by fulfilling the criteria of procuring raw materials from certified manufacturers/ vendors and approval from the Central Pollution Control Board (CPCB) are pre-requisites to manufacture and sell industrial products in India. CPCB has issued Standard Operating Procedure (SOP) for Issuing Certificate to Manufacturers/Sellers of Compostable Plastic Carry Bags (Rule 4(h) of Plastic Waste Management (PWM) Rules, 2016) (https://cpcb.nic.in/uploads/plasticwaste/SOP- Issue Cert CompostablePlasticManufacturers.pdf) according to which 'Compostable plastic' as defined in Rule 3(e) of Plastic Waste Management (PWM) Rules, 2016, means— plastic that undergoes degradation by biological processes during composting to yield CO2, water, inorganic compounds and biomass at a rate consistent with other known compostable materials, excluding conventional Petro-based plastics, and does not leave visible, distinguishable or toxic residue. As per the Rule 4(h) (Conditions) of PWM Rules, 2016, the manufacturers or sellers of compostable plastic carry bags have to obtain certificate from the Central Pollution Control Board before marketing or selling compostable carry bags. More details of application formats and requirements of submission of applications are provided in weblink stated above.

More than 116 producers and sellers are registered with the CPCB in the country. Most of these are located in south and west parts, and a few in north and east parts of India, but none in the north-east parts of the country. List of manufacturers and sellers are available for public knowledge in the CPCB weblink: https://cpcb.nic.in/uploads/plasticwaste/ Certified_Manufacturers_&_sellers.pdf. These are updated from time to time. Statutory provisions provide for important roles to SPCB and PCC in granting registration to manufacturers/sellers in their respective territories in terms of verifying the veracity of certified source of procurement of raw materials, approved process of manufacturing, compliance of guidelines of end-of-life disposal of compostable wastes, compulsory printing of QR Code (abbreviated from Quick Response code; it is a type of barcode or two-dimensional barcode made of matrix of dots; a barcode is a machine-readable optical



label that contains information about the item to which it is attached) on all compostable carry bags with details of manufacturers and registration numbers etc. and submission of quarterly and half-yearly verification and compliance reports by the SPCB/PCC to the CPCB as per the approved guidelines.

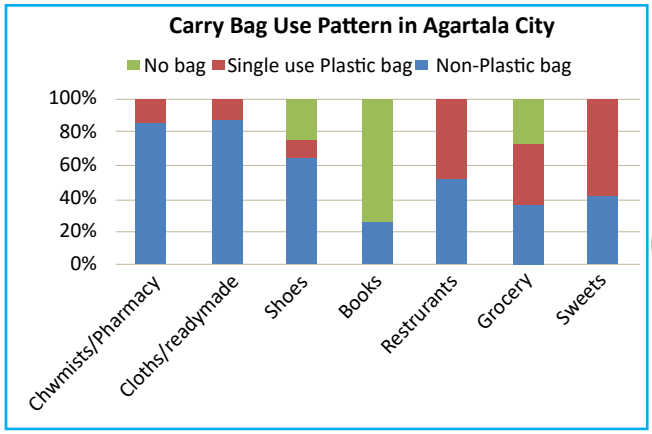
With the statutory rules in place, many producers and a chain of sellers are now active players in the market. For example, several reputed commodity sellers, offline or online, all over the country pack and sell loose grocery, medical, food and sweets, and other perishable and non-perishable items in compostable bags. Other reputed brands also use compostable bag in packaging to sell a large number of non- commodity items. These sellers have large- customer base and can afford to offer expensive compostable bags in lines with prevailing rules of the land. However, scores of vendors and sellers are yet to adopt the facility already available in the market. Shopping or grocery bioplastic bags, are often not used in the retail and un-organised markets due to lack of statutory provisions, strict implementation of the provisions even if in place, and also because of its higher price in comparison to less expensive conventional plastic bags that can be easily afforded by the sellers.

Awareness regarding the harmful effects of plastic pollution has reached to people far and wide but consumer behaviour is not in consonance with the need of the time. Social inequality is one of the major factors in a developing economy that needs to be addressed. Time will tell when situation would be convenient and comfortable for one and all to replace the environmentally harmful single use petroleum plastics by renewable bioplastics. Until then, let us be judged by our individual or collective actions and wisdom towards concern for the environment.

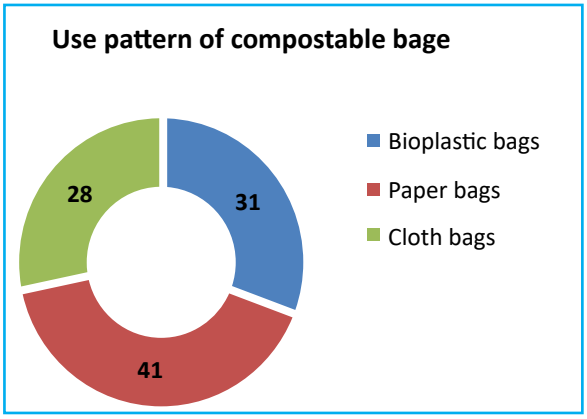
11. Prospect of Bioplastic Production in Tripura

Despite complete ban on the use of plastic carry bags in Tripura since 2015, these continue to be used in all forms and sizes, although in much less quantity than before the imposition of ban order. A recent study in the markets of Agartala city by the author showed that there is significant replacement (49.5%) of conventional plastic bags by compostable bags. Large stores and sellers observe the ban order and use non-plastic bags made of paper (41%), bioplastic (31%) and natural fibers like cotton or jute (28%). But most of the

small and street vendors either use conventional plastic bags (28.25%) which mostly come to the state in bulk from the outside or do not offer any bag (22.25%). The figures on this page shows a clear pattern of reduction in the use of plastic bags and use of alternative bags by the vendors and consumers. It is a welcome sign and require greater thrust from the friends of the environment and the concerned governmental agencies to sustain this trend till complete re placement of plastic bags occurs in the state.



Tripura and its neighbouring states (Mizoram, Meghalaya, Assam) are not great producers of corn, potato, cassava, tapioca, sugar beet or sugarcanes, etc. Therefore, it is un-realistic to propose that sufficient organic raw-materials for bioplastics are available in and around the Tripura state. But it is a fact that sufficient quantity of starch granules of these organic matters can be purchased from the areas where these are manufactured for sell. There is a cost for its purchase at the source and transportation. However, the fact remains that the present and the future times will have greater demands for bioplastics to reduce the burden of conventional plastics in the environment. Therefore, the people should prepare for the eventual cost embracing an effective and environmental-friendly way of dealing with the conventional plastics. Changing situation will enable the Tripura and neighbouring states to take a futuristic look at the production of more of such crops within their states that will match the requirements of viable production of bioplastic products for a sustainable environment of the state. Till such a situation becomes a reality, the state might support institutional arrangement of credits and subsidies that will encourage established entrepreneurs from other parts of the country to install production facility of biodegradable and compostable



plastics in the state. Our democracy professes for a welfare state, and our financial institutions must support the cause of a safe environment. Last four decades have already seen reflective behaviour of the environment in terms of increasing number of hot to very hot days, lesser number of rainy days, shorter winter, and increasing pollution loads in water, air and soil. All these tell upon the health of the abiotic components (e.g., air, water and soil pollutions) of the environment and also affect the living organisms that live in it. Terrestrial and aquatic environment in all parts of the world is limited by their threshold values (pollution bearing capacity), and is vulnerable to many un-friendly human activities happening around us. Let us act fast to save the life-saving oxygen and nutritional property of the soil and water for the present and the future. Adopting green plastic or bioplastics is one of such acts.

Closing excerpts:

— About two-thirds of this (Petro-based plastics) total — 6.3 billion tons — has been discarded as waste, while 2.6 billion tons are still in use, according to a study published in 2017 in *Science Advances*.

— Each year, the world produces about 350 million tons of petroleum plastics which is more than the total weight of human population‖, according to the *UN Environment*.

ENVIS TRIPURA

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