46

Plastic Packaging Waste Impact on Climate Change and its Mitigation

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Abstract

Use of plastic in multiphase aspects of human life projects critical environmental challenges such as Greenhouse gas (GHG) emissions and depletion of fossil resources, mainly due to the consumption of fossil energy. This paper reviews the impact of plastic packaging waste on climate change due to impact on earth's environment and their emissions of Greenhouse Gases (GHG) into the atmosphere. In this paper assessment of the effects of packaging plastics recycling on GHG mitigation and resource saving was described. The strategy for reduction of plastic waste and its recycling was suggested to curb the problem of climate change. Recycling of plastic waste and innovative packaging is the alternative to drastically reduce the emission of such gases and vapours that would otherwise have had damaging effects on the environment.The paper implicates minimum plastic use strategies and management of plastic packaging wastes to mitigate impact of climate change at local, state and national level.

Keywords: *Packaging plastic, Change, climate, mitigating, recycling, waste.*

Introduction

The Earth has gone through many natural cycles of warming and cooling during droughts, flooding and extreme weather patterns. Scientists have confirmed that the Earth's atmosphere and oceans are warming gradually as a result of human activity (Intergovernmental Panel on Climate Change-IPCC, 2007). This warming will exacerbate climate variability and ultimately, adversely impact food and water security around the planet. Central to global warming

and climate change is the "greenhouse effect". Carbon dioxide (CO_2), Nitrogen Oxides (NO_X), Sulphur dioxide (SO2), dioxins, fine particles and other greenhouse gases entering the Earth's atmosphere by activities of everyday energy use and the way of management of the environment still contribute to the build-up of Green House Gases (GHG), which are directly released into the atmosphere. Climate change impacts are only one of a number of environmenta limpacts that derive from solid waste management options.

Plastic is the major source of food packaging as its versatility in terms of cost, availability and comfort. We generate large quantities of waste in the form of plastics that remain in the environment for many years and cause damage. Packaging represents roughly one -third of municipal waste. Packaging used once and then promptly discarded, it seems like only an ephemeral presence in our lives as it rushes from factory to landfill. Consumers benefit from packages because they protect products as they travel, whether fast food or refrigerators, no matter how far they have to go. A well-designed package is attractive and appealing to consumers, and inspires confidence of product safety.

Potential sources of distribution of plastic chemicals to the environment include waste water, sludge from sewage treatment plants, leakage from landfills, incineration fumes, and local, regional and global transport of chemicals from plastic waste. Methane is also emitted from landfills and other waste dumps. If the waste is put into an incinerator or burnt in the open, carbon dioxide is emitted.

The potential material recovery from recycling amounted to 903 kg of plastic granules per tonne of plastic waste and thereby it is assumed that an equivalent amount of virgin plastic production could be eliminated. The estimated net GHG emissions and net fossil resource consumption amounted to 853 kg CO_2-eq and -1,374 kg crude oil-eq per tonne of recycled packaging plastic respectively. The resulting negative values indicate that packaging plastic recycling can make a significant contribution to GHG emissions mitigation and can significantly contribute to avoiding the depletion of fossil resources. (Menikpura *et.al.*, 2014)

It advocates that instead of production of materials from earth's virgin resources and disposal of wastes by burning or degradation, minimal production from virgin materials and total recycling of wastes drastically reduce the emission of such gases and vapours that would otherwise have had damaging effects on the environment. This was based on the European Commission Study on Environment's Report, (Smith *et al.*, 2001), which showed that reduced dependence on fresh production of goods and overall source segregation of Municipal Solid Waste (MSW), followed by recycling, gives the lowest net flux of greenhouse gases, compared with other options for industrial production processes and treatment of bulk MSW.

On an average, 134 tonnes/day of source separated packaging plastic waste is collected and transported by private companies using compactor trucks followed by baling. The baled plastic is then transported to several facilities, which are situated in different prefectures, for recycling. Recycling activities contribute to the global environmental challenges of GHG emissions and the depletion of fossil resources (Menikpura *et al.,* 2011). However, material recovery from plastic recycling can offset the GHG emissions and resource depletion that would otherwise occur through the production of virgin resin.

The objective of this paper is therefore to encourage and advocate minimum plastic use, zero-waste recycling, and innovative packaging in production of goods and services which leads less energy and less carbon emissions. Sustainable packaging and packaging waste reduction means to promote cleaner environment.

Environmental impacts of plastic packaging waste

Packaging is used in business to contain and promote finished products for consumer sales and also to transport them to the point of sale safely. The function of packaging includes protecting products in shipping, offering consumers information, providing a branding billboard and giving us a way to carry things home. The most commonly used packaging materials are paper, fiberboard, plastic, glass, steel and aluminum.

Pollution problems of plastics

Industrial practices in plastic manufacture can lead to polluting effluents and the use of toxic intermediates, the exposure to which can be hazardous. There is growing concern about the excess use of plastics, particularly in packaging. This has been done, in part, to avoid the theft of small objects. The use of plastics can be reduced through a better choice of container sizes and through the distribution of liquid products in more concentrated form. A concern is the proper disposal of waste plastics. Litter results from careless disposal, and decomposition rates in landfills can be extremely long. Marine pollution arising from disposal of plastics from ships or flow from storm sewers must be avoided.

Production and wastes contribute to climate change

Much of the plastic waste that is disposed of in landfills decompose, resulting in the release of both methane and carbon dioxide. In 2008, 20 million tonnes of CO_2 equivalent (eq.CO_2) were released from the disposal of solid waste on land (Gregory, 2010). Energy consumption contributes directly to climate change by adding carbon-based molecules to the atmosphere in excess

of naturally occurring amounts. Carbon molecules, primarily carbon dioxide from burning petroleum products, trap radiant heat and keep it from escaping from the Earth's atmosphere. The resulting warming of the air has continued to change in global climate. Materials consumption contributes indirectly to climate change because it requires energy to mine, extract, harvest, process and transport raw materials; more energy to manufacture, transport and dispose of waste products.

A life cycle analysis study has indicated that the use of plastics leads to significantly less energy consumption and emissions of greenhouse gases than the use of alternative materials (Pilz *et al.*, 2010). In 2009, around 230 million tonnes of plastic were produced and around 25 per cent of these plastics were used in the EU (Mudgal *et al.*, 2011).

The disposal of solid waste produces GHG emissions in a number of ways.

- The anaerobic decomposition of waste in landfills produces methane (CH_4), a GHG *21 times more potent* than carbon dioxide. Landfills are the top human-caused source of methane.
- The incineration of waste that could be recycled produces carbon dioxide (CO_2) as a by-product.

Consumers are increasingly willing to buy concentrated products in light weight refill packs for dilution at home.

Plastic bags and their nuisances

Plastic bags are popular with consumers and retailers as they are a functional, light-weight, strong, cheap, and hygienic way to transport food and other products. Most of these go to landfill and garbage heaps after they are used, and some are recycled. Once littered plastic bags, it find their way on to our streets, parks and into our waterways.

Plastic bags create visual pollution problems and can have harmful effects on aquatic and terrestrial animals. Plastic bags are particularly noticeable components of the litter stream due to their size and can take a long time to fully break down. Many carrier bags end up as unsightly litter in trees, streets, parks and gardens which, besides being ugly, can kill birds, small mammals and other creatures. Bags that make it to the ocean may be eaten by sea turtles and marine mammals, who mistake them for jellyfish, with disastrous consequences. The biggest problem with plastic bags is that they do not readily break down in the environment. It has been found that, the average plastic carrier bag is used for five minutes, but takes 500 years to decompose.

Issues relating to plastics – There are about 50 different groups of plastics, with hundreds of different varieties. All types of plastic are recyclable. To make sorting and thus recycling easier, the American Society of Plastics

Industry developed a standard marking code to help consumers identify and sort the main types of plastic. Before recycling, plastics are sorted according to their resin identification code.

Plastic food containers recyclability

Plastic food containers cannot be recycled to make new food containers for sanitation reasons.

But plastics used in the food industry can be recycled for other uses if they can be separated easily. For example, recycled PET plastic is used for carpet backing, fiberfill for sleeping bags or ski jackets, fiberglass tubs and shower stalls, paint brush and appliance handles, floor tiles, and more.

Recycled HDPE plastic is used for such things as trashcans, flowerpots, traffic cones, and plastic "lumber" for park benches, railroad ties, boat docks, and fences. Polystyrene can be recycled, but systems for doing this are not well established.

Rigid plastic containers must be identified by code numbers to assist in sorting for recycling:

#1 = PET (polyethylene terephthalate),

#2 = HDPE (high density polyethylene),

#3 = PVC (polyvinyl chloride),

#4 = LDPE (low density polyethylene),

#5 = P/P (polypropylene),

#6 = P/S (polystyrene),

#7 = other, including multi-layer.

The type of plastics (as per the resin identification code) and their most common uses are given below:

(a) **Plastic process scrap recycling** - Currently most plastic recycling in of the developed countries are of 'process scrap' from industry, i.e. polymers left over from the production of plastics. This is relatively simple and economical to recycle, as there is a regular and reliable source and the material is relatively uncontaminated. This is usually described as reprocessing rather than recycling.

(b) **Post-use plastic recycling** – Post-use plastic can be described as plastic material arising from products that have undergone a first full service life prior to being recovered. Households are the biggest source of plastic waste, but recycling household plastics presents a number of challenges. One of these relates to collection.

(c) **Mechanical recycling** - Mechanical recycling of plastics refers to processes which involve the melting, shredding or granulation of waste plastics. Plastics must be sorted manually prior to mechanical recycling. Recently, technology is being introduced to sort plastics automatically, using various techniques such as X-ray fluorescence, infrared and near infrared spectroscopy, electrostatics and flotation. Following sorting, the plastic is either melted down directly and molded into a new shape, or melted down after being shredded into flakes and then processed into granules called re-granulate.

(d) **Chemical or feedstock recycling** – Feedstock recycling describes a range of plastic recovery techniques to make plastics, which break down polymers into their constituent monomers, which in turn can be used again in refineries, or petrochemical and chemical production. A range of feedstock recycling technologies is currently being explored. These include: (i) Pyrolysis, (ii) Hydrogenation, (iii) Gasification and (iv) Thermal cracking.

Feedstock recycling has a greater flexibility over composition and is more tolerant to impurities than mechanical recycling, although it is capital intensive and requires very large quantities of used plastic for reprocessing to be economically viable.

Indicators for the quantification of the impacts

Appropriate indicators were identified in order to assess the environmental implications of packaging plastic recycling activities. It was found that all kinds of recycling activities are associated with a significant amount of fossil energy consumption in the form of diesel fuel, grid electricity and thermal energy. This contributes to *Conference Proceeding, 3R International Scientific conference on Material Cycle and Waste Management, 10-12 March 2014, Kyoto, Japan* greenhouse gas (GHG) emissions as well as fossil resource depletion. In contrast, the materials recovered as a result of recycling enable to gain environmental benefits from the avoided virgin production of such materials and related GHG emissions. In order to quantify the overall environmental implications of recycling activities, net GHG emissions potential and net fossil fuel consumption potential were therefore identified as the most relevant environmental indicators. In order to estimate the climate impact, all the GHGs were considered, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The GHG mitigation potential is expressed in the unit of CO_2 equivalent. Fossil fuel consumption potential is expressed in crude oil equivalents (42 MJ/kg, in ground).

Strategies to mitigate climate change for plastic packaging waste

Although no packaging is the best choice of all, it is not always practical. The need for any packaging should be evaluated in the research, design and marketing stages of a product. The goal should always be to reduce unnecessary packaging. The bulk delivery of solids and liquids to food industries and bulk retail sales from bins (including hardware products, produce, housewares, toys and other items) eliminate unnecessary packaging. Where the need for packaging exists, packaging should follow the 3R's hierarchy. Waste minimisation, recycling and re-use represent an important and increasing potential for indirect reduction of GHG emissions through the conservation of raw materials, improved energy, resource efficiency and fossil fuel avoidance (Bogner *et al.*, 2007).

The concept of Reduce Reuse Recycle is applicable to any sphere of life – whether it is in home front or in industries such as energy and power.

1. Reduction of packaging waste

Packaging should be reduced prior to the manufacturing stage, by designing and marketing products for the first "R". This means reducing the number of layers, materials and toxins at source. If people refuse plastic as a packaging material, the industry will decrease production for that purpose, and the associated problems such as energy use, pollution, and adverse health effects will diminish.

In general order of hierarchy, reduction occurs by:

1. Using less packaging and by meeting all or most of the 3R's hierarchy, including reuse and recycle.
2. Minimising the number of materials used.
3. Minimising the weight and volume of materials used.
4. Employing bulk delivery systems.
5. Product concentration resulting in smaller packages.
6. Using fewer toxic chemicals in the product and its packaging.
7. Utilising modes of shipping requiring less packaging and use of repairable pallets by manufacturers.
8. Using multi-layered, multi-material packaging. However, this usually makes the product non-recyclable (i.e. composites, laminates).

Minimising Packaging and Disposables: Reasons for zero-waste recycling are saving in energy, preservation of the natural environment and its resources, reduction in air and water pollution, elimination of need for landfill sites and employment generation. TEPA´s approach to waste prevention put a strong emphasis on Extended Producer Responsibility(EPR)—making producers responsible for changes in design and production to reduce the waste generated by their products and packaging, by:

(a) Restricting the weight of boxes.

(b) Banning disposable tableware at schools and government agencies.

(c) Reducing plastic bags and plastic packaging.

(d) Encouraging a reduction in disposable chop-sticks.

(e) Reducing disposable cups.

2. Reuse of packaging waste

Packaging should be designed to be reusable, refillable, returnable and durable to the greatest extent possible. Source reduction, Retailers and consumers can select products that use little or no packaging. Select packaging materials that are recycled into new packaging – such as glass and paper. Since refillable plastic containers can be reused for many times, container reuse can lead to a substantial reduction in the demand for disposable plastic and reduced use of materials and energy, with the consequent reduced environmental impacts. Container designers will take into account the fate of the container beyond the point of sale and consider the service the container provides.

In general order of hierarchy, reuse is achieved by:

1. Reusing/refilling commercially and redistributing refilled products.
2. Refilling by the consumer through dispensing systems at retail outlets.
3. Reusing containers which have been standardised to assist in reuse applications.
4. Refilling via a second package (i.e. smaller, concentrated containers or larger family-size packages).
5. Reusing in the home - INFREQUENTLY purchased, durable and distinctive containers (i.e. teddy bear peanut butter jars that can later be used as cookie or candy jars).
6. Reusing in the home - FREQUENTLY purchased containers (i.e. margarine tubs).

3. Recycle of packaging waste

Packaging should be designed to be recyclable and/or made with recycled content.

A package or packaging material is considered to be "recyclable" if there is a widely available and economically viable collection, processing and marketing system for the product/material.

In general order of hierarchy, packaging may be recycled in the following ways:

1. Recycling over and over back into its original packaging type (also known as primary or "c losed loop" recycling.

2. Recycling back into another recyclable, useful package/marketable product.
3. Recycling back into another non-recyclable product (also known as "open loop" or tertiary recycling). Examples include:
4. Durable and marketable goods such as synthetic carpet.
5. "Cascaded" (delayed disposal), short-lived or single use marketable items such as seeding flowerpots
6. Recycling into "show piece" product that is not marketable in quantity such as park benches made from disposable diapers.

4. Extended producer responsibility

Extended Producer Responsibility (EPR) is a waste management framework that seeks to shift the responsibility for managing the end-of-life of a product from the government and taxpayer to those in charge of designing and producing the product. The theory is that if a producer is burdened with the cost of disposing a product at the end of its life, it has an incentive to design the product for recyclability or reusability as well as to reflect on the environmental cost of the disposal.

Get plastic manufacturers directly involved with plastic disposal and closing the material loop, which can stimulate them to consider the product's life cycle from cradle to grave. Make reprocessing easier by limiting the number of container types and shapes, using only one type of resin in each container, making collapsible containers, eliminating pigments, using water-dispersible adhesives for labels, and phasing out associated metals such as aluminum seals. Container and resin makers can help develop the reprocessing infrastructure by taking back plastic from consumers.

5. Legislatively require recycled content

Requiring that all containers be composed of a percentage of post-consumer material reduces the amount of virgin material consumed.

6. Standardise labeling and inform the public

Standardised labels for "recycled," "recyclable," and "made of plastic type X" must be developed for easy identification.

7. Innovative and sustainable packaging

Innovative packaging design can mean that the amount of materials used is reduced and that all packaging can be reused or at least recycled. In other words, it is nothing but creating more 'sustainable packaging'. Using

the minimum and most efficient packaging will increase your competitiveness and save your money, as well as attracting environmentally-aware consumers.

Designers should expand and evolve creative processes to include strategies like

(a) optimising material and energy resources;
(b) sourcing materials that are produced responsibly with environmental best practices, fair labour and trade;
(c) choosing materials that are non-toxic, bio-based and made from renewable resources; and
(d) designing for resources recovery or reintegration back into nature after end use.

Sustainability criteria for packaging

1. Is beneficial, safe and healthy for individuals and communities throughout its lifecycle;
2. Meets market criteria for performance and cost;
3. Is sourced, manufactured, transported and recycled using renewable energy;
4. Maximises the use of renewable or recycled source materials;
5. Is manufactured using clean production technologies and best practices?
6. Is made from materials healthy in all probable end-of-life scenarios;
7. Is physically designed to optimise materials and energy;
8. Is effectively recovered and utilised in biological and/or industrial cradle-to-cradle cycles.

Degradable plastic packages

Degradable plastic packages decompose over time from exposure to light, hydrolysis, biological organisms such as fungi or bacteria, or some combination of environmental factors. Currently, degradable plastics are used in such non-food items as garbage bags and disposable diapers. A food package must be a sufficient barrier to prevent contamination from the surrounding environment during the intended shelf life of the product. Also, the degradation or decomposition process must not release toxic products that could migrate into the food, making it unsafe. Standards for measuring acceptability of degradable plastics for use in the food industry currently are in development, and must be approved by the Food and Drug Administration.

8. Online shopping

Online shopping has meant a rise in goods being delivered direct to customers' homes. This means that more packaging is needed to supply the goods. You can encourage customers to return your packaging to you for reuse by supplying them with a "freepost" return label.

Conclusion

Plastic packaging waste generated a great problem in environment lead climate change due to GHG production. Plastic packaging waste management should reduce emissions of carbon-dioxide (CO_2), nitrogen-oxides (NO_x) and sulfur-dioxide (SO_2). In view of the issues described in this paper, it is recommended that minimum use of plastic, waste byproduct utilisation, recycling of plastic waste and innovative plastic packaging to curb the problem of climate change. The governments should encourage the following practices at local, state and national levels to implement waste reduction practices like minimum use, reuse, recycle, use recycled content products and take back the waste of plastic packaging.

References

Anselm, E.O. E. and S. N. Oluigbo, (2012). Mitigating the Impact of Climate Change through Waste Recycling, Research Journal of Environmental and Earth Sciences 4(8): 776-781.

Bogner, J., A.M. Abdelrafie, C. Diaz, A. Faaij, Q. Gao, S. Hashimoto, K. Mareckova, R. Pipatti and T. Zhang, (2007). Waste Management. In: Metz, B., O.R. Davidson, P.R. Bosch, R. Dave and L.A. Meyer (Eds.), Climate Change: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge and New York, Retrieved from: http://www. ipcc.ch/pdf/ assessment-report/ar-4/wg3/ar4/-wg3-chapter10.pdf, (Accessed on: August 19, 2011).

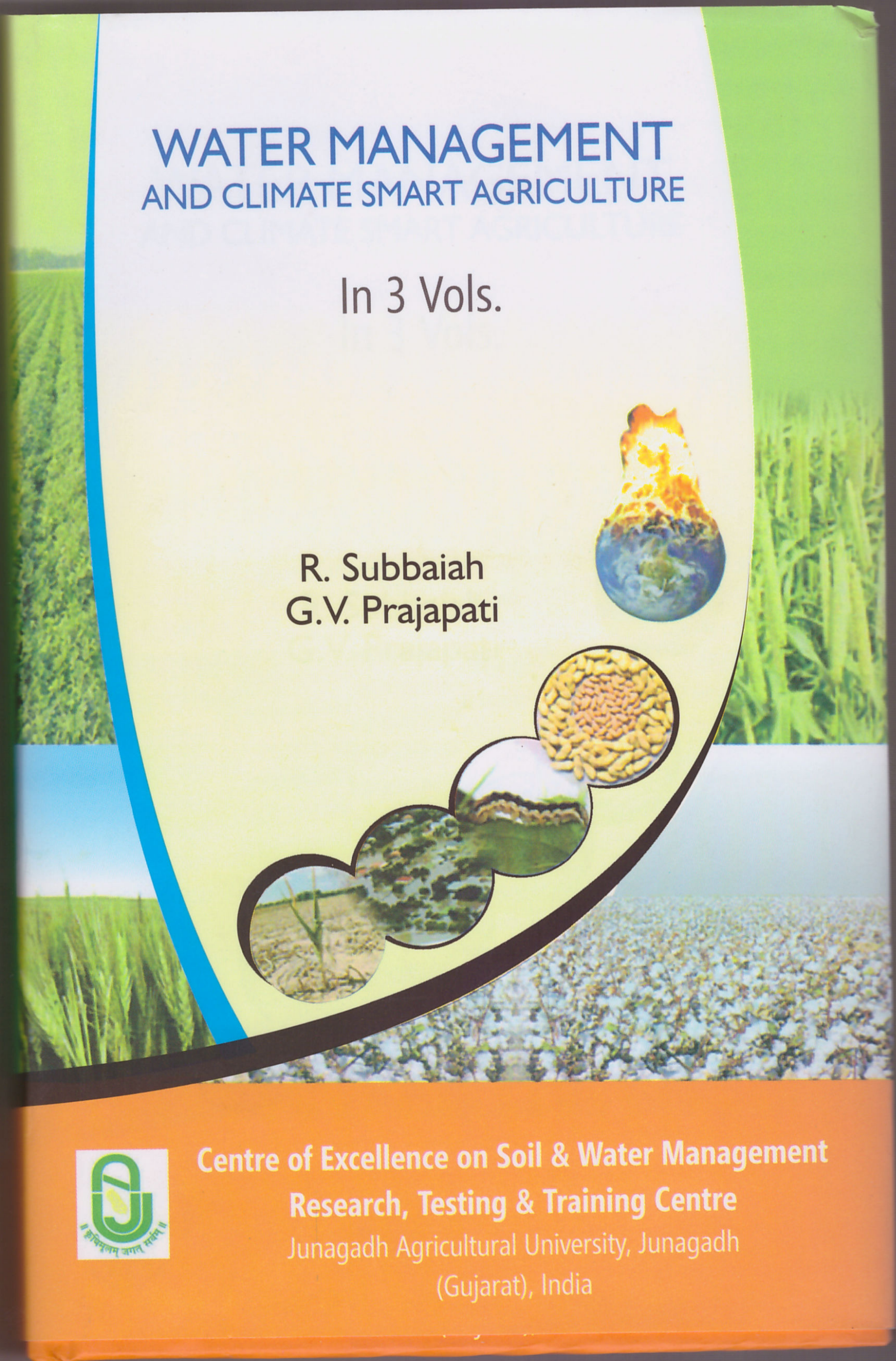
Gregory, J., (2010). Climate Change and Waste-The Missing Link. Retrieved from: http://www.ceilap.org/pdf/ EPR. Climate change Brief. Pdf, (Accessed on: August 20, 2011).

Mudgal, S., Lyons, L., and J. Bain (2011) Plastic Waste in the Environment – Revised Final Report for European Commission DG Environment. Bio Intelligence Service. Downloadable from http://www.ec.europa.eu/environment/waste/studies/pdf/plastics.pdf

Menikpura, S.N.M., Yoshiaki T. and S.A. Janya (2014). The Implications of Packaging Plastic Recycling on Climate Change Mitigation and Fossil Resource Savings – A Case Study in Japan Conference Proceeding, 3R International Scientific conference on Material Cycle and Waste Management, 10-12 March 2014, Kyoto, Japan.

Narayan, P. (2001). Analyzing Plastic Waste Management in India: Case study of Polybags and PET bottles published by IIIEE, Lund University, Sweden, pp. 24-25 accessed at http://www.iiiee.lu.se/information/library/publications/reports/2001/Priya-Narayan.pdf

Pilz, H., Brandt, B. and R. Fehringer (2010). The impact of plastics on life cycle energy consumption and greenhouse gas emissions in Europe. Summary report by Denkstatt for Plastics Europe.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