REPORT FOR EARTHBAGS AUSTRALIA PTY LTD

BIODEGRADABILITY OF ‘ BEBAK BAG’, AN ALTERNATIVE TO NON DEGRADABLE ‘GREEN BAGS’

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Disclaimer

The report is based on the research conducted by RAUM International Pty Ltd for Earthbags Pty Ltd with the academic participation from Murdoch University. The report is based on the experiments that were conducted using the sample bags provided by ‘Earthbags Pty ltd’ and tested under the conditions described in the report. We accept no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

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Executive Summary

The issue of the inertness of plastic products in the environment has been a great concern over recent years as they are used widely all around the world. They cause environmental problems as they remain intact after the organic components that are contained in them are degraded. To compensate for the high number of plastic bags used in supermarkets and supply chains, 'Green bags' have been introduced and has received wide publicity as it reduces the number of plastic bags used. The 'green bags' are made of polypropylene which are non degradable. The green bags though reduce the number of plastic bags, being non degradable, has long term impact on the environment after disposal. Earthbags Australia Pty Ltd has introduced a new product called Bebak Bags made from paper pulp which after a series of processing are made into a product that has a use as carry bags similar to 'Green Bags'. This research assessed the degradability of Bebak bags under various disposal conditions such as (1) in a home composting system using tumbler compost bin (2) in a natural environment by leaving it in garden and (3) immersed in water to find out the changes in an aquatic system. The results proved that bebak bags are decomposed efficiently in a composting system with material starting to breakdown in 14 days and in 35 days it gets completely disintegrated and become part of the substrate with only the stitching thread left. The bags left in the garden to the effect of natural conditions only faded and not much changes to the ones immersed in water were noticed within 40 days. No change was noticed for the 'green bags' in all those conditions tested. The study therefore revealed that bebak bags are strong bags as carry bags while it can be ***biodegraded*** completely in a composting environment without any negative impact on the environment.

Introduction

The issue of the inertness of many domestic waste materials especially plastic products in the environment has been a great concern over recent years. These materials cause serious environmental problems in most countries and in landfills as they remain intact after the organic components that are contained in them are degraded. Plastics such as polyethylene are widely used in packaging and other agricultural applications. They accumulate in the environment at a rate of 25 million tons per year (Orhan and Buyukgungor, 2000). It is estimated that more than 100 million tonnes/year of plastic is produced and in the European countries, per capita consumption is over 60 kg (Reddy et al., 2003). Plastics have been used as a convenient material due to its strength, durability and lightweight however plastic bags in particular have received much scrutiny and media attention due to its common usage and their obvious impact on the environment. Plastic bags create a visual pollution problem, chock waterways and affect aquatic life. 'Plastic Vortex' a phenomenon identified recently is the large patch of the Pacific Ocean, where maritime currents causes plastic litter to congregate (GLOBE-Net, 2009) which reveals the serious impact littering is causing to natural ecosystems. Plastic products remain in land and marine ecosystems for considerably long periods and have environmental impact as the plastic 'vortex' in the Pacific Ocean (http://en.wikipedia.org/wiki/Great_Pacific_Garbage_Patch) (Moore, 2008). Australia alone consumes 6.93 billion plastic bags annually where approximately 53% deriving from supermarket outlets and the remaining from other retail outlets, however in 2007 the use of HDPE bags were reduced to 3.93 million with a percentage reduction of 33.9% (EPHC, 2008). Although plastic bags are found to be around 2% of the litter stream at most surveyed sites, their impact is nonetheless significant (EPHC, 2002).

Thus, the development and use of degradable plastics was proposed as a solution for plastic waste problem. Because of the ever-increasing use of different forms of plastics, biodegradability has become a useful characteristic for plastics. Conversely, the introduction of biodegradable plastics has generated a need for methods to evaluate the biodegradation of these polymers in landfills and solid waste treatment systems such as composting or anaerobic digestion treatment plants. Goldstein (1990) has commented that source reduction and recycling is still limited, and with landfill space at a premium, the so-called degradable garbage bags, agricultural mulch films, six-pack connector rings, and diapers containing degradable liners available commercially need to be studied in detail for their degradation rates and the conditions at which they degrade and whether they can be categorised as biodegradable.

To compensate for the high number of plastic bags used in supermarkets and supply chains, 'Green bags' have been introduced and has received wide publicity as it reduces the number of plastic bags used. These bags have a reported usable lifespan of 2 years. However the fate of the material after its disposal needs to be considered. The 'green bags' are made of Poly propylene having low oxygen permeability and resistant to moisture (Lemos et al., 2004) and is known as a non-biodegradable polymer. Petroleum based plastics are non degradable and faces serious disposal problems (Lemos et al., 2004). Generally large molecule such as in polypropylene cannot easily enter into the cells of micro organisms and therefore hard to be metabolized by microorganisms consequently used in making tough products such as electrical components and car parts. The possible method for its treatment is thermal cracking although it is a tough process (Uddin et al., 1997). Recently pyrolysis was investigated as a process for thermo chemical recycling of these polymers which could give promising results (Achilias et al., 2007), however the technology has not yet been standardised to be economical for integration into the waste management strategies.

Earthbags Australia Pty Ltd has introduced a new product called Bebak Bags made from paper pulp which after a series of processing are made into a product that has a use as carry bags similar to the 'Green Bags' with a life expectancy of 2 years under normal use. Earthbags Australia Pty Ltd contacted us to study the degradability of the product as against the 'Green bags' and this research assessed the degradability of Bebak bags under various disposal conditions particularly to assess if they can be categorised as 'biodegradable'.

Methodology

Experiments were carried out to understand the degradability of Bebak bags under different disposal methods adopted by the common public. The following conditions were tested:

1. In a home composting system using tumbler compost bin
2. In a natural environment by leaving it in garden
3. Immersed in water to find out the changes in an aquatic system

Degradability in a composting system (Biodegradability): A compost mix was prepared using lawn clippings and sheep manure in a 3:1 ratio. Four tumbler compost bins were set up using the compost mix. The moisture content of the mix was adjusted to around 60 percent. Bebak bags sourced from the supplier were compared for its degradability with 'Green Bags' bought from the supermarket. Two bags each of Bebak and Green bags were put in each compost bin. The bins were rotated ten times daily for aerating and mixing the compost. Temperature and moisture was also checked daily. The bags were taken out every week and assessed its condition and rate of degradation. The experiment was continued until the bags degraded completely and became part of the compost mix.

Degradability in natural environment:

Four bags were left in the open garden along with four green bags to understand the effect of UV, rain and other natural physical factors on the degradability of the bags. The bags were assessed for their condition and rate of degradation every week.

Degradability in an aquatic environment:

Since there are various cases where plastic bags end up in an aquatic system from irresponsible disposal/littering causing serious environmental damage to aquatic system and

aquatic life, test was done to understand the fate of Bebak bags if ended up in an aquatic system. Four bags were immersed in water, their condition and degradability assessed every week.

Results and Discussion

Temperature changes in the compost bins:

The temperature changes in the compost bins during the experiment period are given in Figure 1. It can be seen that the systems went through a thermophilic condition, the maximum temperature being 44^{o}C. However the system stayed at above 35^{o}C for 9 days during the trial which shows that the composting process of the mix occurred at an optimum condition. In small composting systems it is normal that thermophilic conditions reaching only up to this temperature range due to the low bulking effect and loss of temperature (Nair et al., 2006) although a higher temperature of up to 70^{o}C could be achieved in large scale composting operations.

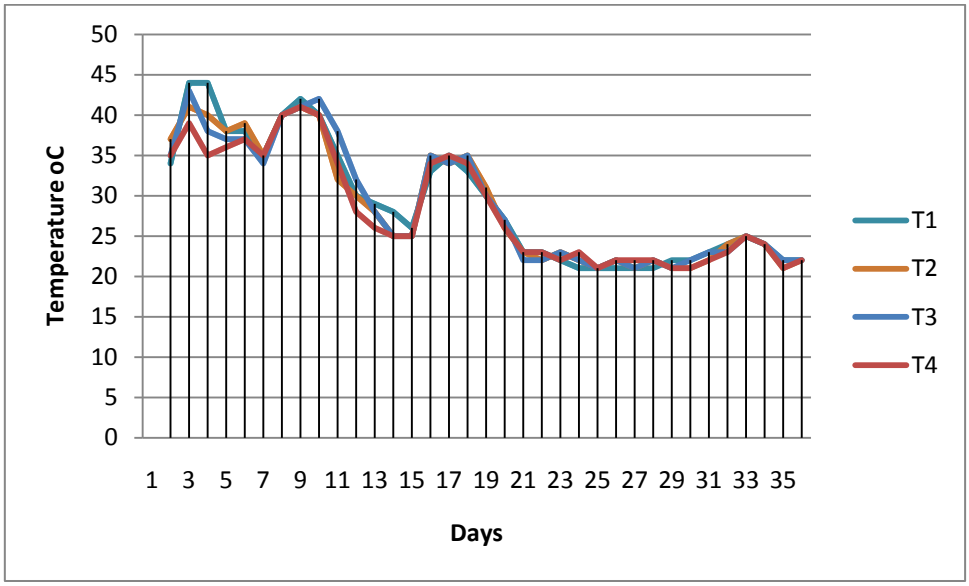

Figure 1. Changes in temperature in the compost tumblers during the trial

Day 7 observations:

It was observed that by 7 days, all bebak bags in the compost bins started to become weaker and could be ripped apart by applying pressure (figure 2), whereas the bags left outside in the garden were still intact as were the bags immersed in water. The bags left outside started to

fade in colour, whereas those in water maintained the colour. The green bags were as good as new.

Figure 2. Bebak bags could be ripped apart compared to ‘green bags’ which remained intact after 7 days of composting

Day 14 observations:

On day 14, the bebak bags had shrunk and it was easy to rip apart with two layers together showing signs of fast degradation (figure 3). This period was also subjected to high temperature in the bins and the volume of the compost mix reduced 20 percent. The fast degradation could be due to the combined effect of temperature, microbial activity and getting in contact with degrading organic matter. The bags left outside had faded but still strong while those immersed in water remained same as original.

Figure 3. The bebak bags in the compost has started degrading fast (right) compared to that left in the garden (middle) and the ‘green bags’ (left) after 14 days

Day 21 observations:

The bebak bags in the compost bins started falling apart when taken out for inspection where as those left outside in the garden and immersed in water had not shown any signs of degradation. The ‘green bags remained as new in the different conditions tested (Figure 4).

Figure 4. Degradability of bebak bags against "green bags' (left). Bebak bags left in the garden and immersed in water (right)

Day 25 and day 28 observations:

As from the day 21 observations, the degradation rate of the bebak bags were occurring fast and therefore it was decided to inspect later on day 25. On day 25, the bags could only be taken out in pieces from the compost mix (Figure 5). It was also noted that the compost mix has only started to go through the maturation stage, where as the bags had already started to be part of the substrate. The bags left in the garden and immersed in water however were still intact (Figure 6).

Figure 5. Comparison of Bebak bags against 'green bags after 28 days of composting

Figure 6. The bag left in the garden (left) and immersed in water(right) after 28 days

Day 35 observations:

The bebak bags have degraded completely and became part of the substrate with only the stitching thread left which also has started to break apart (Figure 5). However the ones left in the garden and in water remained as in previous week. The ‘green bags were as good as new and showed no signs of degradation.

Figure 5. Bags left in the garden (left), in the compost bin (middle) and 'green bag in compost bin after 35 days

The degradation process of degradable plastics vary under different conditions according to their properties, because the microorganisms responsible for the degradation differ in each system (Glass and Swift, 1989) which could be the reason for the different percentage of degradation under various conditions for the different degradable plastics studied by Nair et al (unpublished). Starnecker, A., Menner, M. (1996) conducted an assessment of biodegradation in an aquatic environment by conducting a carbon mass balance by inoculating an inert material with aqueous extracts from compost when a biodegradation rates similar to a compost environment was obtained. This shows that organic content in the environment or substrate can improve the degradation rate of biodegradable material as observed in this study. It has been shown that Polyhydroxyalkanoates (PHA) based products, the component of bioplastics were known to decompose in 2 to 8 weeks (Doi, 1990) while degradation time for products with polylactates (PLA) and polyglycolides (PGA) vary from a few months to years. The Bebak bags assessed for its biodegradability in this study should be able to complement for the 'plastics' product especially because of its life time of 2 years and

when disposed can biodegrade completely in 35 days without any negative impact. This product therefore clearly supports the waste management strategies without compromising on the convenience of the current lifestyle.

Conclusion

The study proved that Bebak bags are biodegradable and best degraded in a composting system or left in a compost mix. The microbial activity in the organic mix along with the warm temperature would have facilitated its degradation. It was noted that the natural sunlight and temperature variation of 22 -39^{o}C during the experiment period were not very effective as a composting system, which reveals that microbial action could be the augmenting factor for its degradation. The polypropelene 'Green Bags' showed no signs of change which confirms that it could stay a long time in the environment when disposed. The Bebak bags took longer to degrade when left in the open environment which indicates that the bag is strong enough to meet the purpose as a carry bag and will not weaken easily as the other starch based biodegradable bags. Bebak bags can be disposed off safely in the environment after use which gets biodegraded in about 35 days in a compost mix without any environmental damage and can also contribute to the organic content of the soil upon degradation.

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