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Biodegradability Measurement of Unidirectional Cotton/Polyester Composites

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ABSTRACT
Nowadays, the composite material becomespopular in engineering,medical and sports fields due to better mechanical properties such as tensile strength,hardness and impact strength. Since last two decades, it rises up as a new green material in the field of engineering for various applications.Natural fibercomposite material offers more benefits compared to synthetic fiber reinforced composite due to their environmental friendly behavior. This paper focuses on measurement of biodegradability of thecomposite. For this purpose, manufacturing of cotton/polyester composite was carried out by hand lay-up technique.The unidirectional fiber arrangement was considered during the fabrication to get high strength in one direction ofcomposite. In this paper, the efforts are carried out for the measurement of biodegradability as per OECD 304 standard (OECD: Organisation for Economic Co-operation and Development) by using soil. The soil was selected instead of water and sand for the proper growth of microbial activity. The paper signifies outcome as: the cotton/polyester composites has partial degradations of 4.76% to 12.50% to weight of composites.

KEYWORDS
Bio Composite, Cotton/Polyester composites, Fabrication, Biodegradability Measurement.

INTRODUCTION
A composite material consists of two phases, first primary phase in which forms the matrix within which the secondary phase is imbedded and second secondary phase in which the imbedded phase or called the reinforcing agent which serves to strengthen the composite (fibers, particles, etc.). The important feature of composite materials is that they can be designed and to meet different requirements. Since natural fibers are cheap and biodegradable, the biodegradable composites from biofibers and biodegradable polymers will render a contribution nowadays due to theserious environmental problem.Biodegradable polymers have offered scientists a possible solution to waste-disposal problems associatedwith traditional petroleum-derived plastics [1].The bio composite materials are classified as shown in figure 1.

The biodegradability of organic substances is the degree of the changes in physical and chemical characteristics and molecular structure of substances under degradation by microorganisms [4]**.**The term ‘‘biodegradation” indicates the predominance of biological activity in this phenomenon. However, in nature, biotic and abiotic factors act synergistically to decompose organic matter [5]. There are several environmental problems rise up with the conventional material and they are not biodegradable but these all problem are overcome by the natural fiber composite materials. Biodegradability tests are generally used for predict the biodegradation behavior of test material in thenatural and technical environment. The diagram of the

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mechanism of biodegradation as shown in figure 2.The environmental conditions do not only affect the degradation, they also affect the microbial population and activity of the various microorganisms. There are various factors such as temperature, humidity, presence or absence of oxygen, depth up to material is buried etc. These all the factors must be considered when the biodegradability of the composite is tested [6].

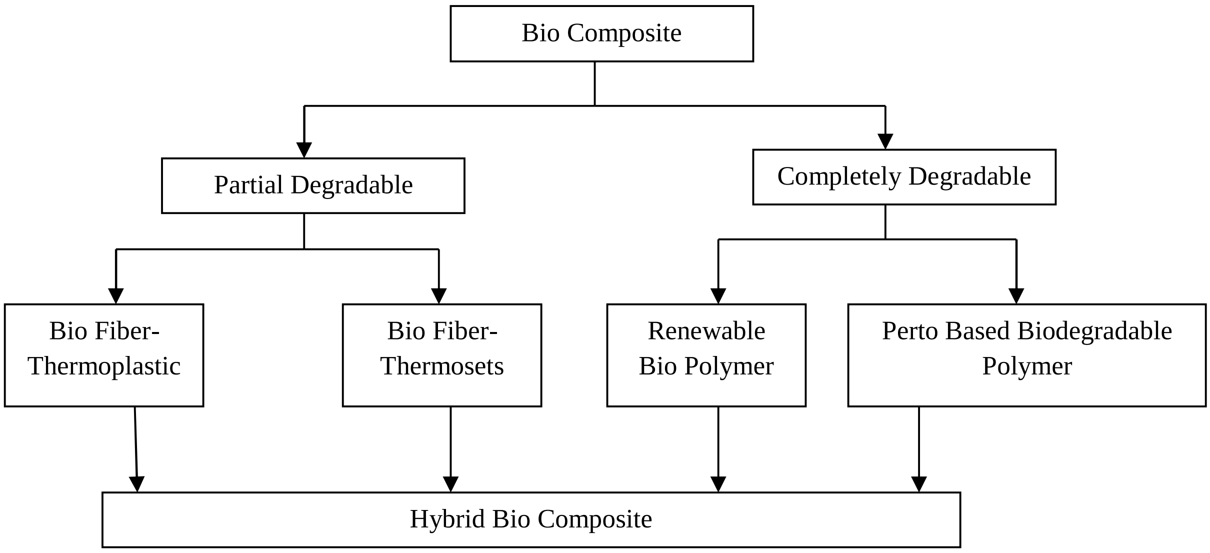

Fig 1: Classification of Bio Composite[2-3].

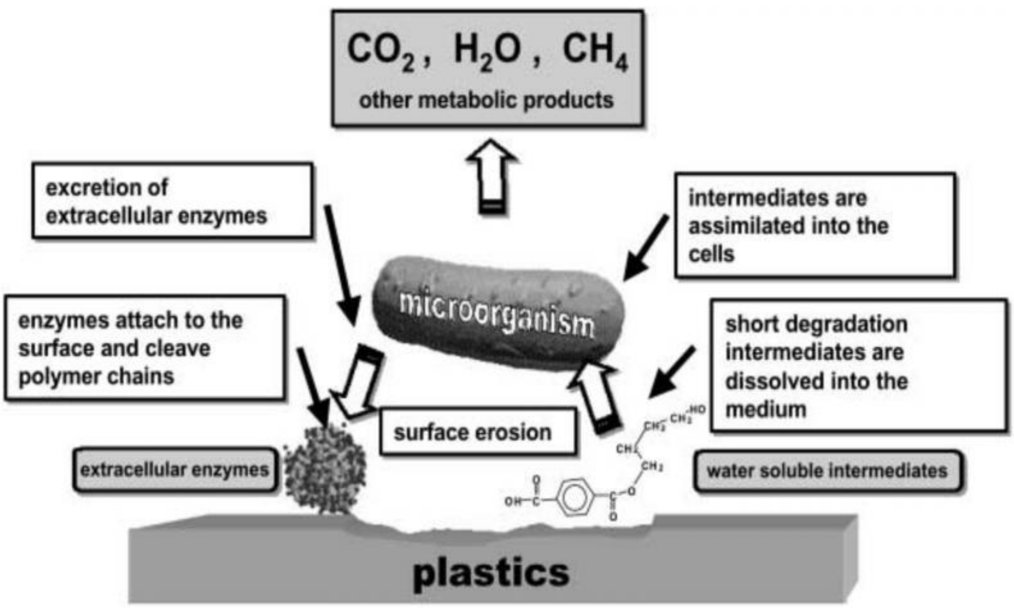

Fig 2: General Mechanism of Plastics Biodegradation [6]

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LITERATURE SURVEY

The various natural fiberssuch as banana,cotton,flax,hemp,jute,sisalare available in themarket as shown in figure 3. The bio composites are the most desirable material in light weight application.The various complex structuresi.e., tubes, sandwich plates,car, door have been made from the biocomposites[7].For the degradability of LDPE (low-density polyethylene) starch blends was confirmed by weight loss measurements and changes in mechanical properties [8].In most of cases the degradation processes are constantly taking place on a large scale in the natural environment, especially in the aquatic sphere[9].An increase in moisture content of these composite materials induced plasticization of the samples[10].The water content of the soil to 50% of holding capacity and moisture level is considered ideal for aerobic biodegradation processes in the soil. The pH of the soil was adjusted by the addition of $CaCO_3$ (liming) to 7.5[11].For measuring the biodegradation of any material selection of proper medium is most important factor.Generally, it is observed that the biodegradation in aqueous media has mostly neglected[12].

Lots of work was carried out for the biodegradability measurement for biodegradable polymers like polycaprolactone, bioceta,scone cell etc. So, there is a need to carry the systematic work in the field of bio composites and provide the bio degradability measurement data for bio composites.So, in present study the efforts are carried out for the measurement of the biodegradability of the bio composite. Here, the cotton/polyester bio composite is selected for the study.

Fig 3(a)

Fig 3(b)

Fig 3(c)

Fig 3(d)

Fig 3(e)

Fig 3(f)

Fig 3:Natural fibers (a) banana fiber yarn,(b) cottonfiber yarn (c) flax fiber yarn,(d) hemp fiber yarn, (e) jutefiber yarn, (f) sisalfiber yarn[13-18].

MATERIAL AND METHOD

The natural fibers are easily obtained from the plant and they containlarge portion of thecellulose which sustains the load during theperformance. So, the cotton fiber yarn was procured from the local market of Petlad, Gujarat, India as shown in figure 4. For binding of fibers, the resin is required for the preparation of composite. So, the unsaturated polyesterresin was procured from loacal market of Ahmedabad, Gujarat, India. The cotton fiber yarn and unsaturated polyester resin was selected due to its easyavailability, good mechanical properties, and low cost.Then, cotton/polyester unidirectional composites was fabricated by hand lay-up

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technique. The fiber layers were prepared in unidirectional to achieve good strength in single direction. During the fabrication, the fiber layers were inserted into the die and mixed with the resin. Then, the punch was inserted in to the die with the help of anvil up to achieve a thickness of composite as 4 mm. The roller was used to spread the resin uniformly among the fibers.MEKP (Methyl Ethyl Ketone Peroxide) as catalyst and cobalt weremixed with polyester resin before the fabrication to initiate the polymerization process of polyester resin incomposite material.The curing was done for resin for 24 hours. The weight fraction of fiber was achieved as 25% of composites through the fabrication of composites. The figure 5 shows the die and punche setup and figure 6 shows the anvil which is used for the fabrication of composites.Figure 7 shows the fabricated cotton/polyester composites plate. The obtained plate size due to fabrication is 300 mm * 300 mm *4 mm.

Fig 4: Natural Cotton FiberYarn

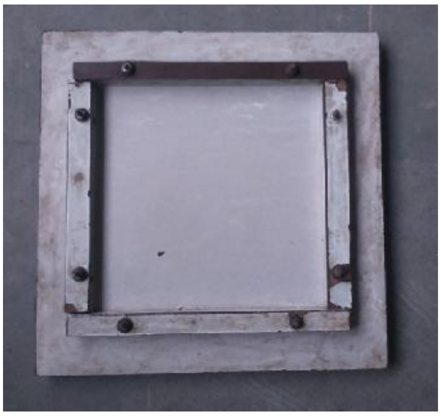

Fig 5 (a): Die

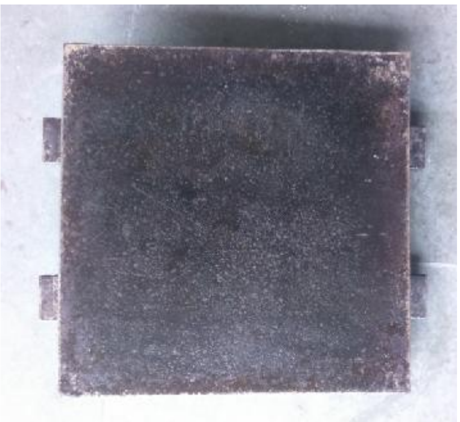

Fig 5 (b): Punch

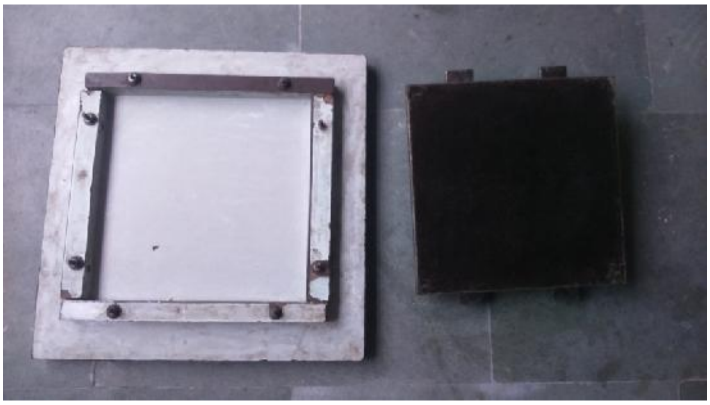

Fig 5: Die and punch set up for the fabrication of composite plate

Fig 6: Anvil

Fig 7: Fabricated Cotton/Polyester Composite Plate

BIODEGRADABILITY TEST

The degradation of cotton/polyester composites was measured as per the OECD 304 standard. The cutting of specimens was carried out by a hack saw blade. The dimension of cut specimen was 15 mm*2 mm. After cutting of samples, the samples were washed by the distilled water and putfor few minutes at room temperature for drying. Figure 8 shows photograph of the cut testing samples. Washing of the samples were carried out in glass as shown in Figure 9.

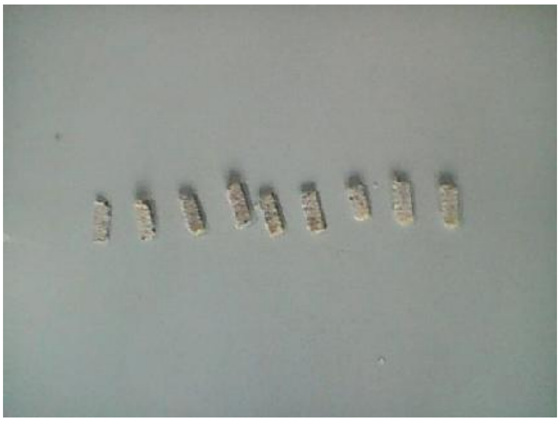

Fig 8: Cut samples of cotton polyester

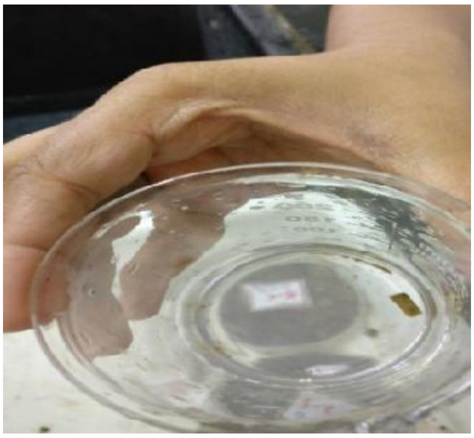

Fig 9: Washing of sample

After completion of the drying of all samples, the initial weight was measured with help of electronic weighing machine with a least count of 0.01 mm.Then,the samples were buried in the soil up to one-inch depth in the glass plate.The photograph of testing samples is shown in figure 10 before the buried in to soil.Ifthe depth of buried sample is more thanone-inch, degradation maybe reduced due to less availability of oxygen for microorganism activity. So, here the one-inch depth is selected for the proper degradation of composites. The glass plates are kept at room temperature during the period of testing. the activity of the microorganisms cannot take place if the temperature is lowand microorganisms are die if temperature is high. So, the room temperature is selected for the testing.

Fig 10: Samples buried in soil

RESULT AND DISCUSSION

The degradation process was carried out up to five weeks as per the OECD 304 standard. The weight of the samples was measured at the end of every week. The table 1 shows the reduction in weight of samples. figure 11 to 17 shows the graphical representation of weight of the samplewith respect to time. The degradation rate is found using following equation 1.

$$\%Degradationrate = \frac{(initialweight)-(finalweight)}{(initialweight)}*100 \qquad \text{Eq. (1)}$$

Table 1. Weight of Cotton/Polyester Composites.

Sample no.	Initial Weight (gm)	Weight after Week 1 (gm)	Weight after Week 2 (gm)	Weight after Week 3 (gm)	Weight after Week 4 (gm)	Weight after Week 5 (gm)	Degradation Rate (%)
1	0.19	0.19	0.18	0.17	0.17	0.17	10.53
2	0.19	0.19	0.18	0.18	0.18	0.18	5.26
3	0.18	0.18	0.17	0.17	0.17	0.17	5.56
4	0.24	0.23	0.21	0.21	0.21	0.21	12.50
5	0.19	0.18	0.18	0.17	0.17	0.17	10.53
6	0.16	0.15	0.14	0.14	0.14	0.14	12.50
7	0.21	0.21	0.21	0.20	0.20	0.20	4.76

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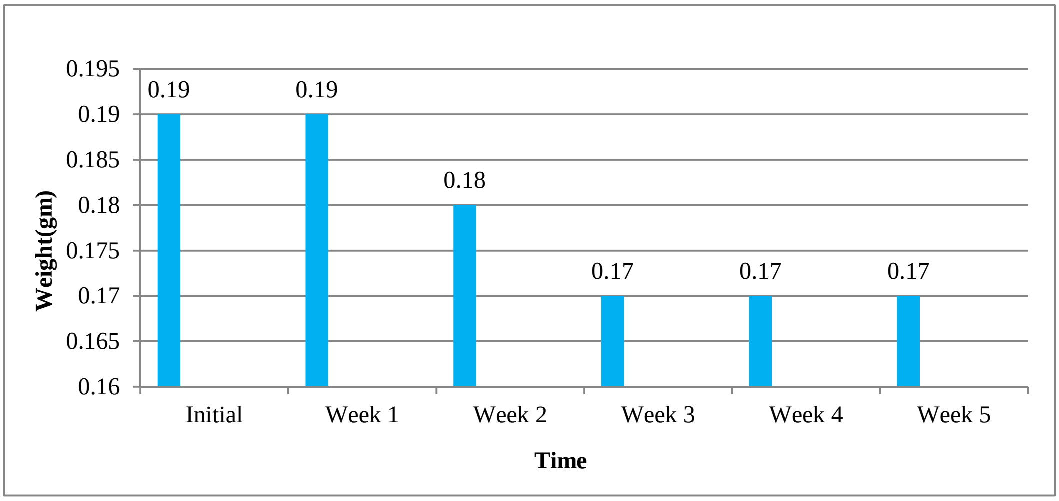

Fig 11: Degradation of sample 1

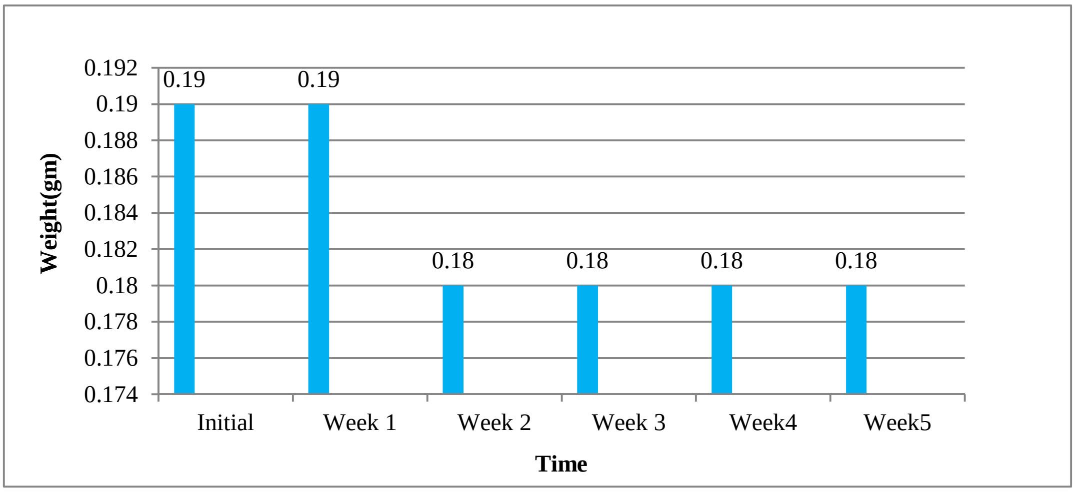

Fig 12: Degradation of sample 2

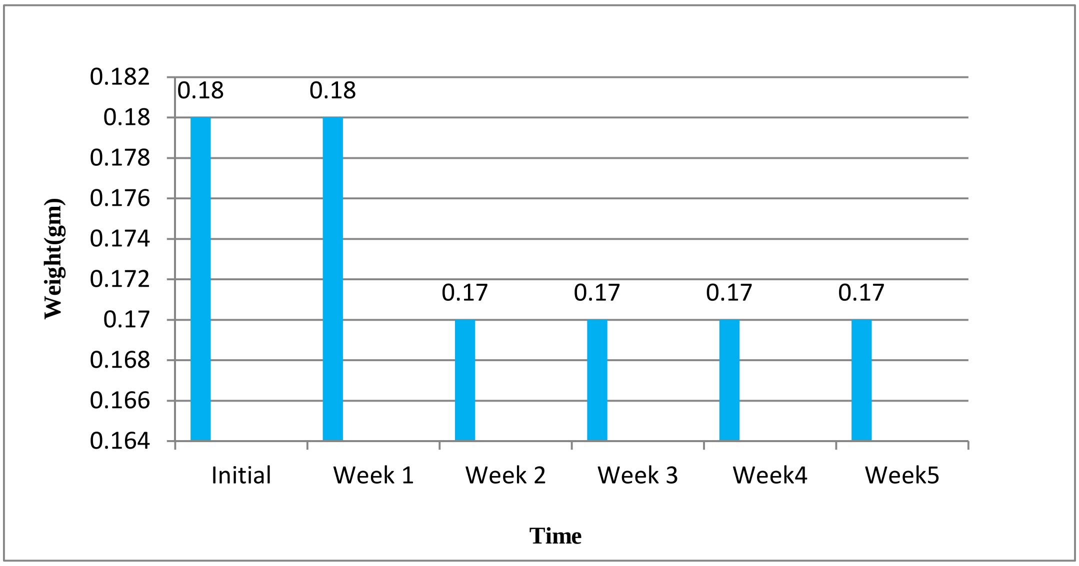

Fig 13: Degradation of sample 3

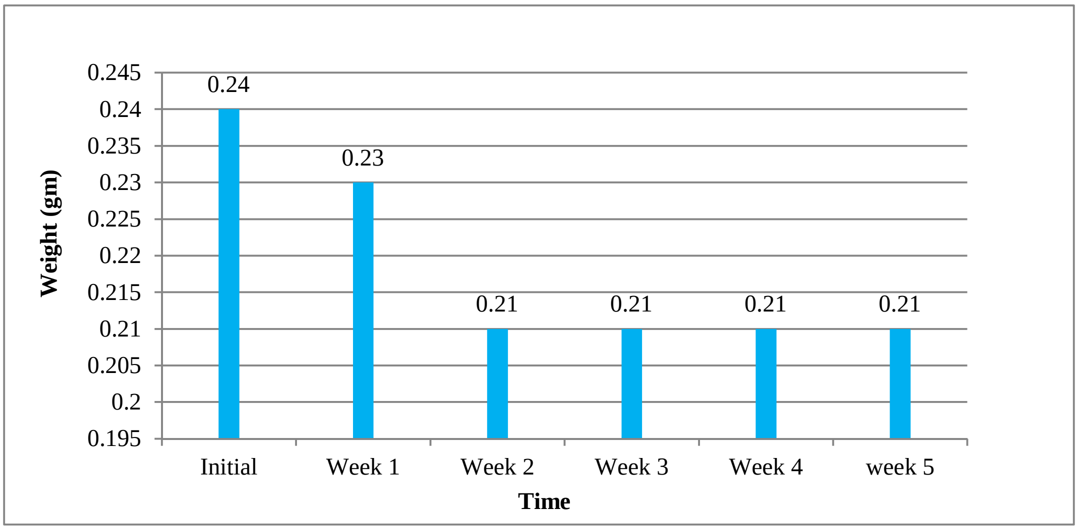

Fig 14: Degradation of sample 4

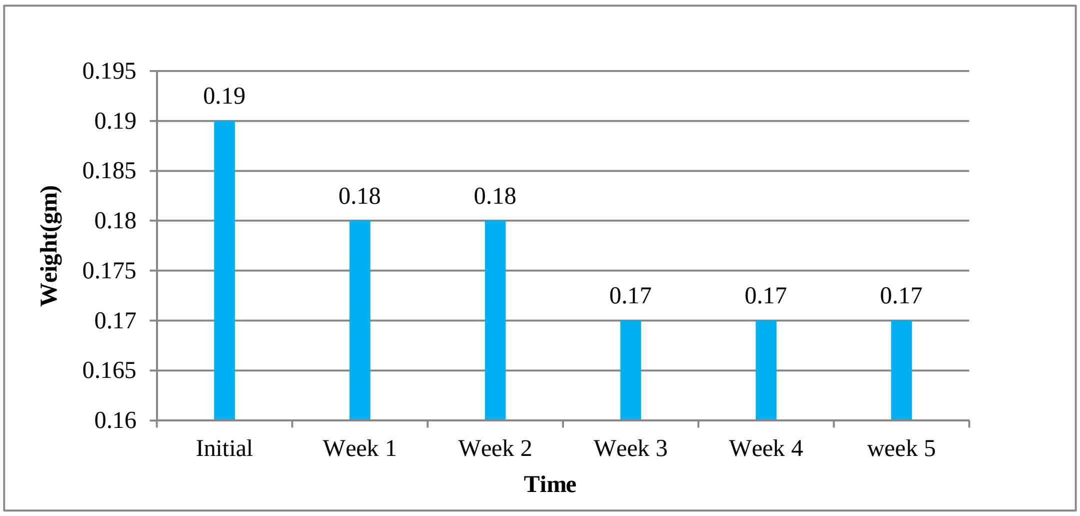

Fig 15: Degradation of sample 5

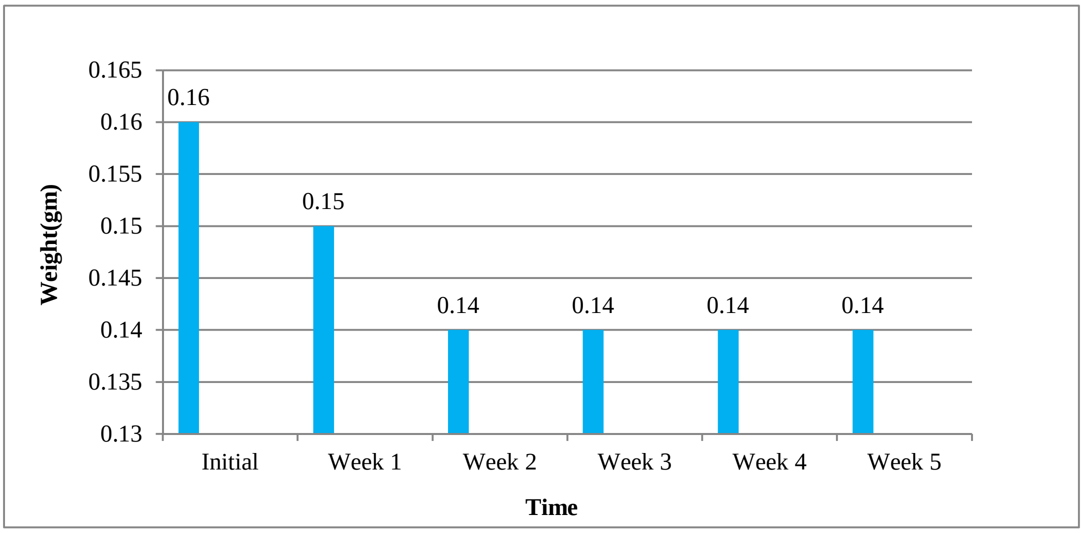

Fig 16: Degradation of sample 6

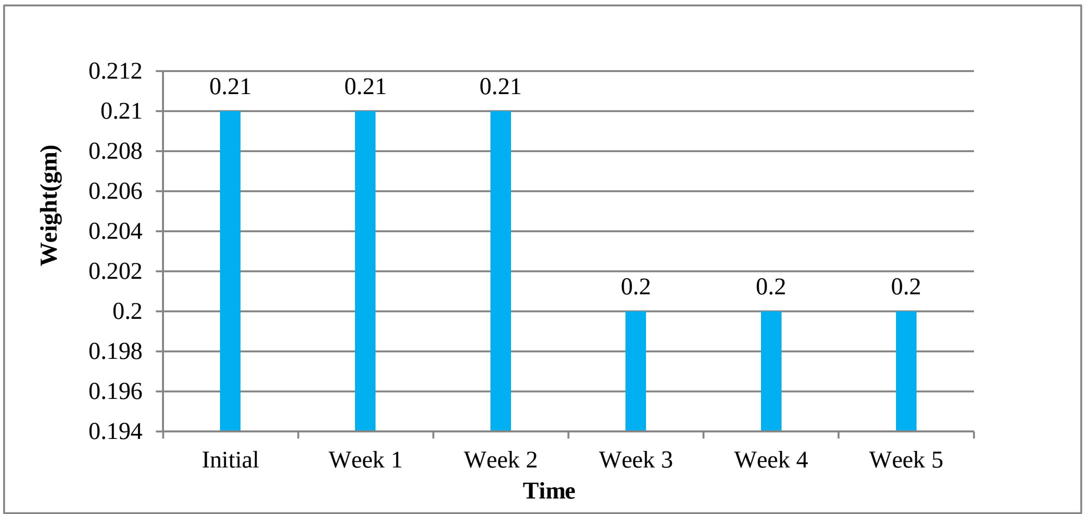

Fig 17: Degradation of sample 7

It is observed through figure 11 to 18 that with increase the time of degradation, the weight reduction was found up to 3 weeks after 3 weeks, there is no change in weight of the specimens. It may be happened due to polyester is a non-biodegradable material. So, minimum degradation was found 4.76% and maximum degradation was found 12.50%. Hence, it may be said that the degradation rate for cotton/polyester composite should be 4.76% to 12.50%. The founded degradation rate is lessin cotton/polyester composites because the majority of contact surface is covered by the non-degradable polyester resin.

CONCLUSION

The cotton/polyester composite has degradation rate of 4.76% to 12.50%with respect to weight of composites within five weeks. After three weeks, the degradations are negligible because polyester is not degradable material. Hence, partial biodegradation is observed for the Cotton/PolyesterComposites.The degradation rate is less in cotton/polyester composites because the majority of contact surface is covered by the non-degradable polyester resin.

REFERENCES

[1] K. Mohanty, M. Misra, and G. Hinrichsen.1999. Biofibres, biodegradable polymers and biocomposites:An overview.
[2] J. Sahari and S.M.Sapuan. 2011. Natural fibre reinforced biodegradable polymer composites.
[3] Lawrence T. Drzal, A. K. Mohanty and M. Misra.Bio-composite materials as alternatives to petroleum-based composites for automotive applications.
[4] Patricia A. Wagner, Brenda J.Little, Kevin R. Hart, and Richard I. Ray.1996. Biodegradation of composite materials.
[5] Nathalie Lucas, Christophe Bienaime, Christian Belloy, Michele Queneudec, and Françoise Silvestre.2008. Polymer biodegradation: Mechanisms and estimation techniques.
[6] Dr. Rolf Joachim Muller. Biodegradability of Polymers: Regulations and Methods for Testing.
[7] Kestur G. Satyanarayana,Gregorio G.C. Arizaga, and Fernando Wypych. 2009. Biodegradable composites based on lignocellulosicfibers—An overview.
[8] A.C. Albertsson, and S. Karlsson.1994. Chemistry and Technology of biodegradable Polymers.
[9] Udo pagga. 1997. Testing biodegradability with standardized methods.
[10] Maurizio Tosin, Miriam Weber, MichelaSiotto, Christian Lott, and Francesco Degli Innocenti.2012. Laboratory Test Methods to Determine the Degradation of Plastics in Marine Environmental Conditions.
[11] Asha V. Yabannavar and Richard Bartha. 2017. Methods for Assessment of Biodegradability of Plastic Films in Soil.
[12] R. Mohee, and G. Unmar.2006. Determining biodegradability of plastic materials under controlled and natural composting environments.

[13] https://dir.indiamart.com/impcat/banana-fibre-yarn.html (accessed 25 July 2017).
[14] http://www.yarnsupplierindia.com/(accessed 25 July 2017).
[15] https://dir.indiamart.com/impcat/flax-yarn.html(accessed 26 July 2017).
[16] https://www.hempbasics.com/shop/Category/HempYarn(accessed 25 July 2017).
[17] https://www.pinterest.com/pin/569072102885357641/(accessed 27 July 2017).
[18] https://dir.indiamart.com/impcat/sisal-yarn.html(accessed 26 July 2017).