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Comparative study of Using Vegetable Wastes and Cattle Dungs for Degradation of Low Density Polyethylene Material and Visualized through FTIR Analysis.

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ABSTRACT

Low density polyethylene wastes accumulating in the environment have posed an ever increasing ecological threat. In this investigation, the degradation of LDP were analyzed after 7 months of incubation period and the LDP samples were treated cattle dung and kitchen vegetable wastes and compared with control. The rate of degradation was studied through FTIR analysis. Further this study confirmed that the microorganisms present in the cow and sheep dung have more degrading ability of low density polyethylene material than the microbes in the kitchen vegetable wastes under controlled environmental condition.

Keywords: LDP, FTIR, Vegetable waste, Microorganisms.

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INTRODUCTION

Polymers are non-degradable and stable organic compounds whose huge applications and simultaneous increasing accumulation in the ambient environment causes a major threat to the living systems. With the development of new synthetic polymers, plastics have found applications in every field of life. They are recognized as major solid waste, environmental pollutants because of their semi- permanent stability in the environment [17]. Among these low densities polyethylene is one of the most used polymers in the society [9]. LDP materials are strong, lightweight and durable thus are widely used for manufacturing various containers, dispensing bottles, plastic bags and various molded laboratory wares. It brings a lot of convenience to people's life but, at the same time it also brings long term harms [15].

A worldwide increase in the use of these materials has generated issue of solid waste disposal [13]. Almost 60,000 to 95,000 chemicals, including synthetic hydrocarbons like HDPE, LDPE plastic are in commercial use[5]. Polythene wastes represent a serious concern for the environment because of its recalcitrance to microbial attack [8], due to their short time on earth; nature has not been able to design new enzymatic structure that can attack these synthetic polymers. This has brought concern about how to degrade those [3].

The physical forces such as temperature, moisture, pressure etc, deal with causing mechanical damage to the polymer. Although many types of biodegradable plastics are available like, photodegradable and starch linked but bacterial degradable plastics are of great interest [2]. The microbial degradation is widely accepted and is still underway for its enhanced efficiency [20]. The potentiality of microbes as agents for degradation of several compounds this indicates biological treatment as the major promising alternative to attenuate environmental impact caused by pollutants. The microbes are using these degraded compounds as nutrient source that mean carbon and energy source [12].

In the present study, an attempt was made to analyze the degradation of low density polyethylene in the natural environment, *i.e.,* the microorganisms normally present in the cattle dung's and vegetable wastes were subjected to degrade the LDP through soil burial technique. Surface changes and its degradation rates were studied after seven months of the incubation period. Fourier Transform Infrared Spectroscopy (FTIR) has been well known powerful tool to study the polymer degradation quantitatively [10-14]. The high sensitivity towards the chemical changes and controlled probing depth of the technique are vital functionalities to capture the initial degradation characteristics at the polymer surface [11-21]. Hence, FTIR spectroscopic evidence was taken to confirm the biodegradation of low density polyethylene materials.

MATERIALS AND METHODS

Sample Collection

LDP Materials

Fresh low density polythene carry bags were used for this study and they were obtained from the paper market of Thiruchirappalli, Tamil Nadu, India. LDP bags were cut into (3x3 cm) pieces and then washed with 70% ethanol for 30 min, then followed by distilled water, and air dried for 15 minutes in the laminar air flow chamber and then used for future studies.

Cattle Dungs

Each five kilogram of cow dung and sheep dung was collected from the local area and stored in zip lock covers and they were used.

Vegetable Waste

About ten kilogram of kitchen vegetable waste was collected from the houses located at Thuraiyur, Thiruchirappalli (Dt.), Tamil Nadu.

Inoculation of LDP Materials In Cattle Dungs

Each five kilogram of cow and sheep dung was mixed well and it was kept for one hour incubation, then LDP pieces were mixed with the said cattle dung.

Inoculation of LDP Films in Vegetable Wastes

Each five kilogram of kitchen vegetable waste was mixed well and it was kept for one hour incubation, then LDP pieces were mixed with the said kitchen vegetable waste.

Formation of Pit

About one meter depth digs were prepared and introduced the mixture of LDP pieces with the compost of cattle dung's and vegetable wastes. The materials were allowed to degrade naturally under controlled conditions for 7 months. Water was sparkled for few days and allowed for incubation.

FTIR Studies

Fourier Transform Infrared Spectroscopy analysis was used for detecting the formation of new functional groups or changes in the amount of existing functional groups. After the incubation period, the film was collected and washed with water and then followed by ethanol to remove debris and again washed with distilled water to remove excess precipitation and then allowed it to dry. The surface changes made on LDP pieces were analyzed through FTIR studies.

RESULTS AND DISCUSSION

The LDP samples were introduced into the pit with the compost of cattle dung and vegetable waste separately. The humidity of the compost was maintained at 35-45% by periodical sprinkling of water throughout the period of study. The degradation of low density sample during composting could be taken as an indicator of degradation. Surface changes were recorded after seven months of incubation period and the results were analyzed through FTIR studies.

The FTIR spectra of LDP sample in composting techniques showed the peak value in 3331.72 cm-1 is amino group but gets increased after some microbial growth, then the carbonyl index of the film, showing an increase after exposure and decreased, however, some band revealing a bending deformation, and another band indicates a rocking deformation due to microbial growth.

The carbonyl absorption bands can be observed in the range of 1,710−1,750 cm^{-1} is break into 1634.09 cm^{-1} and 1636.56 cm^{-1} respectively because of the formation of ketone or aldehyde C = O groups by the action of microorganisms.

In this study the FT-IR spectra showed the band in the range of 1,710-1,750 cm^{-1} which indicates the deformation of a ketone or aldehyde groups by the action of microorganisms presents in sample 1 and sample 2. The formation of new C-O stretching frequency at 1,710−1,750 cm^{-1} and a broad absorption peak assigned to stretching vibration of –OH also indicated polymer degradation. Additionally, new absorption bands between 3800 - 3100 cm−1 and 1900 - 1500 cm^{-1} of the spectra were observed in the bacterial isolates treated low density polyethylene and this is may be due to the formation of hydroxylated compounds and carboxylated compounds respectively.

The band at 719.20 cm^{-1} is aliphatic chloro compound, it is slightly decreased into 715.39 cm^{-1} in sample 3 and 713.82 cm^{-1} in sample 2 respectively, due to microbial growth, the microorganisms grow in surface, but not break the bond completely and however it makes slight changes. The carboxylate band is completely removed in sample 2 and 3.

A band around 1019.04 cm^{-1} revealed a rocking deformation but it is however showed bending deformation due to microbial growth, the deformation is good in sample 1. The carbonyl band corresponding to the ketone and ester carbonyl groups and it is a typical product of oxidative degradation of polyethylene[6].

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The amino groups get increased, but the band at 1461.11 cm^{-1} get decreased into 1418.22 cm^{-1} in sample 3 and 1414.68 cm^{-1} in sample 1, due to the presence of microorganisms present in both samples. New bands like 3813.51 cm^{-1} and 3880.34 cm^{-1} were formed in sample 1 due to the presence of microorganisms. The surface of plastic materials has turned from smooth to rough with cracking. This may be due to the extracellular secretion of some compounds by the microbes that may break the complex molecular structure of plastics[7].

However the degradation in sample 3 shows good when compare to sample 1, so far that the microorganisms present in the sample 1and 3 have the ability to degrade low density polyethylene when its enriched with carbon sources for their viable growth and maintenance of humidity for long time duration.

FTIR Analysis:

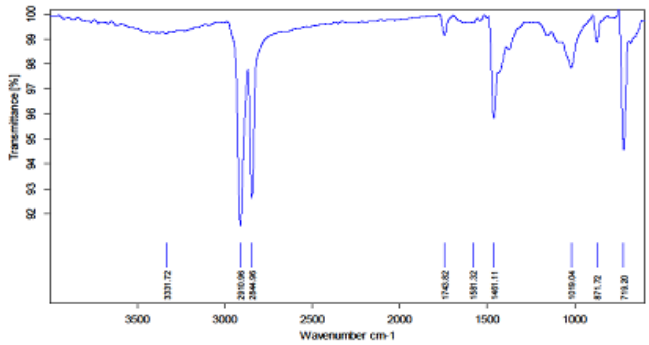

Figure 1: FTIR spectrum of LDP sample in control soil after incubation (7 months)

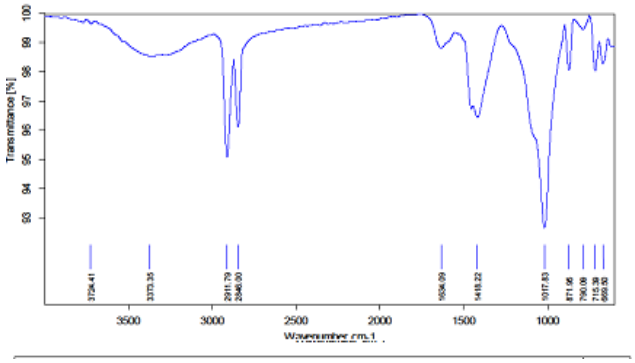

Figure 2: FTIR spectrum of LDP sample in cattle dung after incubation (7 months)

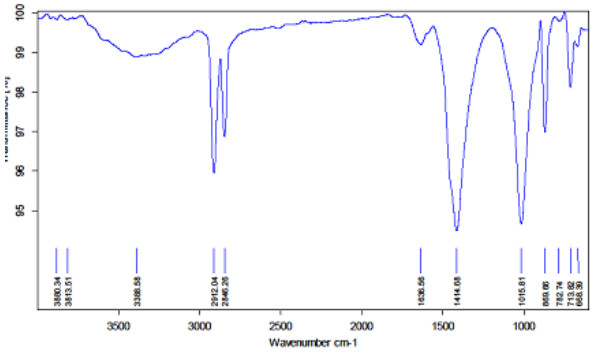

Figure 3: FTIR spectrum of LDP sample in vegetables waste after incubation (7 months)

The present study focused the degradation of low density polyethylene by using soil burial technique. The microorganisms found colonized on the surface of LDP sample causing some physical changes like some

band arose and de arose, is the evidence in this study by FTIR analysis. It is used as an analytical technique in many biodegradation studies performed by [8-6] observed the changes in the polyethylene structure with subsequent bacterial inoculation and they were analyzed by Fourier Transform Infrared Spectroscopy in the frequency range of 4000 – 800 cm^{-1}.

FTIR results showed formation of aldehyde, alcohol, carboxylic acid, aromatic, alkene and ether group formation indicating degradation of polyethylene by isolated bacteria [16]. All these results confirmed the polyethylene degradation.

CONCLUSION

This study confirmed that the microorganisms present in the cattle dung and vegetable wastes have the potential to degrade low density polyethylene samples effectively when it was incubated under natural conditions. The FTIR analysis clearly showed that microorganism attaches the film and makes surface changes like a new band arose and somewhat other band get decreased very well.

The result of this investigation showed that in the near future, the microorganisms present in the cattle dung and vegetable wastes can be used to degrade LDP wastes very efficiently.

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REFERENCES

[1] Agamuthu P, Faizura N. Waste Manag and Res 2005; 23(1): 95-100.
[2] Anjana Sharma and Amitabh Sharma. J Scientific and Industrial research 2003; 63(1): 293-296.
[3] Araceli Loredo-Trevino, Gilberto G. Advances in Bioscience and Biotechnology 2011; 2(1): 52-58.
[4] Carol D, Karpagam S, Kingsley SJ, Vincent S. Indian J Exp Biol 2012; 50(1): 497 – 501.
[5] Guptha SB, Amritha Ghosh and Tapas Chowdhury. World J of Agricultural Sciences 2010; 6(2): 138-140.
[6] Ibiene AA, Stanley HO and Immanuel OM. Nigerian J of Biotechnology 2013; 26(2013): 68-79.
[7] Kavitha R, Anju Mohanan K and Bhuvaneswari V. Int J of Plant, Animal and Environmental Sciences 2014; 4(3): 601-610.
[8] Kiatkamjornwong S, Thakeow P and Sonsuk M. Polym Degrad Stab 2001; 73(2): 363-375.
[9] Kathiresan K. Revista de Biologia tropical 2003; 51(3): 629-634.
[10] Luiza J, Elena G, Lulia R, Marius G, Mariana C, Anicuta S, Marta S and Gelu V. Morphological Aspects 2008; 1(1): 1-9.
[11] Meerina Paul D and Santhosh Kumar. Int J of Pharma and Biosciences 2013; 4(4): 386-391.
[12] Merlatti C, Perrin X, Aragon E and Margaillan A. Polymer Degradation and Stability 2008; 93(1): 896-903.
[13] Mc Clelland JF, Jones RW, Bajic SJ, FT-IR Photoacoustic Spectroscopy. In: Griffiths JMCaPR, editor. Handbook of Vibrational Spectroscopy: John Wiley &Sons, Ltd; 2002.
[14] Meerina Paul Das and Santosh Kumar. Int J of Pharmacy and Technology 2013; 5(2): 5567-5573.
[15] Naima A, Safia A, Ishtiaq Ali M, Saadia, A, Bashir A and Geoffery R. African J of Microbiology Research 2010; 4(14): 1537-1541.
[16] Perrin FX, Merlatti C, Aragon E, Margaillan A. Progress in Organic Coatings 2009; 64(1):466-473.
[17] Pramila R and Vijaya Ramesh K. J of Micrology and Biotechnology Research 2011; 1(4): 131-136.
[18] Sowmya HV, Ramalingappa, Krishnappa M and Thippeswamy B. An Int J of Advances in Polymer Science and Technology 2014; 4(2): 28-32.
[19] Takayoshi S, Takako S, Makiko E, Haruyuki K, Katsuyuki U and Chiaki K. JAMSTEC Rep. Res. Dev 2010; 11(1): 33-41.
[20] Tirupati S, Aakula S, Venkata Subbaiah, K and Saigo pal DVR. Research J of Pharmaceutical, Biological and Chemical sciences 2014; 5(2): 1694-1706.
[21] Umamaheswari S and Murali M. Elixir Chem. Engg 2013; 64(1): 19159-19164.

[22] Usha R, Sangeetha T and Palaniswamy M, Int J of Libyan agriculture research center 2011; 2(4): 200-204
[23] Zhang Y, Barber A, Maxted J, Lowe C, Smith R Li T. Progress in Organic Coatings. 2013; 76:131-6.