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Original Article

Biodegradation of low-density polyethylene by bacteria spp. isolated from oil basins

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ABSTRACT

Nine isolates of bacteria were isolated from three samples of oil basins in Al-Ahdab field/Wasit city/Iraq and tested its ability to degrade low-density polyethylene (LDPE) strips as the sole source of carbon after inoculated mineral salt media and incubated in a shaker incubator with 120 rpm at 30°C for 30 days. Results showed the weight loss percentage for LDPE strips by bacterial isolates EA1, EA2, EA3, EA4, EA5, EA6, EA7, EA8, and EA9 was 16.6%, 16.1%, 15.0%, 12.9%, 12.7%, 11.9%, 11.8%, 11.1%, and 9.09%, respectively.

Keywords: Biodegradation, low-density polyethylene, microorganisms

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INTRODUCTION

Plastics (polyethylene) are the synthetic organic polymers which are commonly produced from high-density polyethylene, one of the petroleum-derived products.[1] Due to their chemical structure containing strong single C-C and C-H bonds, waste management of low-density polyethylene (LDPE) is a growing concern today.[2]

Plastic pollution in most of the countries is caused because of poor and improper recycling and waste management systems.[3]

The increasing use of plastics, particularly packaging has become a significant source of environmental pollution and creating problems in solid waste management as well as lethal to wildlife and human due to its non-degradability in nature.

Several microorganisms have been reported to degrade polyethylene such as *Rhodococcus ruber*,[4] *Brevibacillus borstelensis*,[5] *Bacillus subtilis, Kocuria palustris, Bacillus pumilus*,[6] *Pseudomonas* sp.,[7] *Bacillus amyloliquefaciens*,[8] and *Serratia marcescens*.[9] The biodegradation of plastic materials is mainly depends on its hydrophobicity and the size of the polymer molecules.[4,10] The hydrophobicity of polyethylene prevents the formation of biofilm by the microorganism which in return prevents the adhesion and colonization on the polyethylene.[11,12]

MATERIALS AND METHODS

Collection of Soil Samples

Three samples of soil were collected from oil basins in Al-Ahdab field/Wasit city/Iraq, then samples were sealed properly, labeled, and transported to the laboratory. All the samples were processed within 24 h of collection.

Isolation of Bacteria

Isolation of bacterial isolates was done by serial dilution method and spread plate technique on nutrient agar. The plates were incubated for 24–48 h at 30°C. Colonies having different morphology characteristics were selected and subculture on nutrient agar.[13]

Screening of bacteria for biodegradability

All morphologically distinct colonies were selected and screened on minimal salt medium (MSM) containing K_2HPO_4 (0.1 g/l), KH_2PO_4 (3.0 g/l), NaCl (5.0 g/l), NH_4Cl (2.0 g/l), $MgSO_4$ (0.2 g/l), $CaCl_2.2H_2O$ (0.1 g/l), and KCl (0.15 g/l), and a known weight and size of LDPE strips were

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added as a sole carbon source after sterilization to avoid deformation. Flasks were allowed to grow in a shaker incubator with 120 rpm at 30°C for 30 days. After the incubation process, LDPE strips were removed and washed with sodium dodecyl sulfate solution, distilled water, and ethanol solution for half hour, then dried and measurement the weight.[14] Weight loss measurement can be determined by formula: [15]

$$\text{Weight loss \%} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

RESULTS AND DISCUSSION

Nine isolates of bacteria were isolated from three soil samples after cultured and streaking on nutrient agar [Table 1].

Weight differences were calculated between initial and final weight of LDPE strips incubated in a shaker incubator with 120 rpm at 30°C for 30 days after treating by isolating EA1, EA2, EA3, EA4, EA5, EA6, EA7, EA8, and EA9 was 3.0, 3.1, 4.0, 3.1, 4.7, 4.2, 5.9, 3.6, and 4.4 g and 2.5, 2.6, 3.4, 2.7, 4.1, 3.7, 5.2, 3.2, and 4.0 g, respectively [Figure 1]. The mass of the polymer material gets reduced as microorganisms take carbon from LDPE.

Bhone *et al.*[16] tested the process degradation of LDPE using four bacterial strains belong to *Pseudomonas*. The biological degradation was determined by the weight loss and morphological changes in LDPE.

Although several microorganisms have been reported to degrade polyethylene such as *Rhodococcus ruber*,[4] *B. borstelensis*,[5] *B. subtilis*, *K. palustris*, *B. pumilus*,[6] *Pseudomonas* sp.,[7] *B. amyloliquefaciens*,[8] and *S. marcescens*.[9]

Bacterial isolates were tested its ability to degrade LDPE strips as the sole source of carbon after inoculated mineral salt media (MSM) and incubated in a shaker incubator with 120 rpm at 30°C for 30 days. Results showed the weight loss percentage for LDPE strips by bacterial isolates EA1, EA2, EA3, EA4, EA5, EA6, EA7, EA8, and EA9 was 16.6%, 16.1%, 15.0%, 12.9%, 12.7%, 11.9%, 11.8%, 11.1%, and 9.09%, respectively [Figure 2].

In the study by Jose, 2015, physical and chemical alterations of green polyethylene plastic bags were observed with incubated for 30 days with exposure to *Pleurotus ostreatus*.[17] Odusanya *et al.*[18] have shown that some local bacterial isolates isolated from hydrocarbon-contaminated soils have the ability to degrade the long chains of LDPE polymers within the MSM.

The biodegradation of plastic materials is mainly depends on its hydrophobicity and the size of the polymer molecules.[4,10]

Table 1: Bacterial isolates obtained from oil basins of Al-Ahdab field/Wasit city/Iraq

No.	Soil samples	Number of isolates
1.	First sample	4 isolates
2.	Second sample	3 isolates
3.	Third sample	2 isolates

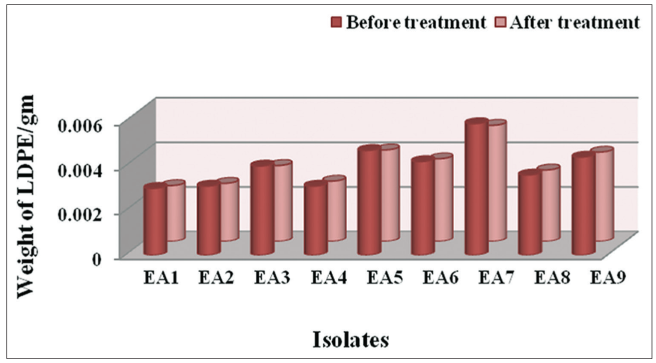

Figure 1: Weight of low-density polyethylene strips before and after treatment and incubating with 120 rpm at 30°C for 30 days

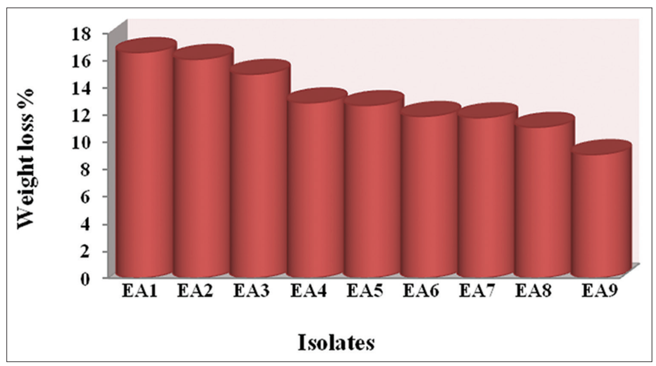

Figure 2: Weight loss percentage of low-density polyethylene strips after treatment and incubating with 120 rpm at 30°C for 30 days

The hydrophobicity of polyethylene prevents the formation of biofilm by the microorganism which in return prevents the adhesion and colonization on the polyethylene.[11,12] Biodegradation of polyethylene attention to increase the hydrophobicity for the efficient microbial adherence and obtained low molecular weight compounds with modified mechanical properties.[19]

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