

## **A Study on Biodegradation and Composition of Engine Oil Contaminated Soil**

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**Abstract**

Used engine oil is a type of engine oil that has reached the end of its useful life in the automotive industry due to changes in chemical, physical, and microbiological composition. It contains higher levels of inorganic and inorganic elements, as well as hazardous microorganisms, making disposal difficult. That's where biodegradation comes in. Microbial degradation/biodegradation is a very useful process for the breakdown of used motor oil since it degrades hazardous chemicals as well as harmful microorganism when executed properly. Bacteria, fungi, algae, and yeast can all help in biodegradation. However, bacteria, rather than other microorganisms, play the most important role in biodegradation. *Pseudomonas spp.*, *Enterobacter sp.*, and *Bacillus sp.* are the bacteria with the greatest ability to breakdown used engine oil from soil. Used engine oil is only discarded in drains, open areas, or waste water all over the world. Which has an impact on the environment, as well as aquatic pollution and health issues. When used engine oil comes in interaction with soil, it causes microbiological and chemical properties to change. This has an impact on the development of many plants in the soil. Hazardous metals such as Zn, Pb, Cr, Fe and PAH (poly aromatic hydrocarbons) as well as bacteria such as *Micrococcus*, *Rhodococcus*, *Bacillus sp.*, and *Paenibacillus sp.*, are found in used engine oil polluted soil.

**Keywords:** Used engine oil, biodegradation, used engine oil contaminated soil, *Pseudomonas spp.*, *Enterobacter spp.*

## Introduction

The oil acts as a lubricating medium for various automobile parts like engines and gearboxes. The first function of oil is to scale back friction and to produce a heat transfer medium [1]. Engine Oil in use degrade over time, the degree of this degradation relies on the environment and operating conditions where the oil was used, however, some extent is reached where the engine oil would not be able to perform its functions, Which we call as used engine oil/spent engine oil/spent lubricating oil [2].

One of the biggest sources of UEO is the automotive industry. The demolished car is expected to produce 65 billion to 130 billion tonnes of UEO, according to published data [3]. Oil waste arising still grow, almost doubling within the last 5 years, with variety of this growth possible because of the metal and petroleum-based mining activities, which are significant industrial engine users [4]. Engine oil features a good application within the car sector. However, the occurrence of various toxic metals like iron, steel, copper, lead, zinc, barium, and sulfur along with dissimilar hazardous Poly aromatic hydrocarbon (PAH) compounds within the used engine oil (UEO) creates headaches during its disposal [5]. Clearance of the used lubricant into drains, water drains, open vacant plots, and farms is also a typical practice especially by motor mechanics who change the oil from automobiles, power generating, and other machines. And still adequate attention has not been given to its proper disposal [6].

Microbiological degradation is an eco-friendly process that ends up in the breakdown and complete utilization of hydrocarbons in comparison to other processes like adsorption, volatilization, photolysis, and chemical degradation. Large sorts of microorganisms including algae, bacteria, fungi, and yeasts have the flexibility to degrade hydrocarbons [7]. Environmental pollution caused by petroleum and petroleum products has been identified as one of the most important current issues, particularly when it comes to large-scale spills, tank failures, and pipeline explodes. Hydrocarbons may reach the water level before getting adsorbed in the soil if this happens [8].

In most cases, released petroleum products form non-aqueous phase liquids (NAPLs), which then become the long-term source of aquifer contamination [9]. Soil contamination from used engine oil (UEO) is a growing environmental concern, particularly in large cities throughout the world. Because of the high amount of hazardous organic and inorganic chemicals in UEO, the ecosystem is at risk, and there are negative health consequences on biota and humans that must be addressed [10].

## Composition Of Used Engine Oil

Used engine oil is a brown to black oil that is extracted from vehicles when the oil is replaced [11]. Spent engine oils have a higher percentage of aromatic and aliphatic hydrocarbons, nitrogen, sulphur compounds, and metals (Zn, Pb, Cr, and Fe) than fresh oils, and some of these metals can dissolve in water and move through the soil easily, resulting in contamination of surface water and groundwater [12]. The oil is chemically transformed by oxidation, nitration, cracking of polymers and decomposition of organometallic compounds. Following up on this, the waste engine oil aggregates different contaminants like fuel (petrol or diesel), water, antifreeze, and insoluble particles, which principally originates from atmospheric dust, metals, metal oxides and combustion products [13].

Physical composition of UEO is given in below image.



Figure 1 Difference between used engine oil and new engine oil [1]

Due to pyrosynthesis and chlorodibenzofurans, it also contains larger percentages of alkyl benzenes, naphthalenes, methylnaphthalenes, and polycyclic aromatic hydrocarbons [11]. Over the last 20 years, evidence has steadily accumulated that used oils may contain carcinogenic elements, particularly some polynuclear aromatics (PNAs), also known as polycyclic aromatic hydrocarbons or PCAHs/PAHs. [14]

Here, the difference between concentration of metal in fresh oil and used engine oil is shown in Table 1.

Metals	Concentration of metals ( $\mu\text{g g}^{-1}$ ) in	
	New engine oil	Used engine oil
Pb	0.480	3091.50 (100) <sup>b</sup>
Zn	1482.00	1128.50 (100)
Cu	0.204	6.04 (100)
Ni	ND <sup>a</sup>	0.556 (100)
Cr	ND	1.000 (100)
Cd	0.087	0.479 (100)

Table 1 Concentration of metals in new motor oil and in used engine oil [1]

a is ND = Not determined.

b is the numbers in parentheses indicate the percentage of metals recovered in the various fractions.

### Contamination Of Soil By Used Engine Oil

#### How Soil Contaminated?

The pervasiveness of soil pollution because of aimless release and reckless treatment of utilized engine oil from and in the automobile workshops [15].

#### Impact On Soil And Its Surrounding Areas After Contamination By UEO

At the point when soil is contaminated, the environment is altered, and agricultural exercises are influenced [16]. As a result of the deliberate spillage of spent engine oil at motor maintenance shops, the soil microbes are constantly changing. The colour and texture of the soil are modified, resulting in the growth of diverse microbial flora in an effort to minimize the petroleum product waste [17]. Soils polluted with spent engine oil had reduced soil microbial activity and reduced oil fertility status [18].

### Physical Composition Of UEO Contaminated Soil

Spent engine oil diffused into the soil on contact with the soil resulting in the formation of waxy oily scum texture. The arrangement of the oily scum blocks oxygen and availability of water to biota also because the formation of hydrophobic micro-aggregates with clay surfaces in the soil [19]. You can visualize UEO contaminated soil in below image.



Figure 2 Appearance of used engine oil contaminated soil [2]

### Chemical Composition Of UEO Contaminated Soil

The impact of spent engine oil on influence with the soil ranged from the reduction of nutrients exclusively Nitrogen and Phosphorus, inhibition of microbial activities [19]. With an increase in used engine oil concentration, the MDD (Maximum dry density) for granular soils reduced from  $1795 \text{ kg/m}^3$  to  $1698 \text{ kg/m}^3$ . The OMC (optimal moisture content) readings fell from 15.3% to 10.9 percent. For uncontaminated soils, the unconfined compressive strength (qu) value was  $204 \text{ kN/m}^2$ . At a 10% oil concentration, this was reduced to  $140 \text{ kN/m}^2$  [20]. According to study conducted by [21] on effect of soil before and after contamination of used engine oil, in which concentration of heavy metals is given in Table 2.

Concentration (l/kg soil)	Fe	Cu (ppm)	Zn	Pb	Ph
0.0 <sup>a</sup>	3.57	3.20	1.36	0.29	4.6
0.2	83.50	4.80	1.88	0.53	4.6
0.4	134.00	7.00	2.13	0.55	4.5
0.6	228.00	8.60	2.59	0.7	4.7

0.8	301.00	12.10	2.81	0.81	4.7
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Table 2 Concentration of heavy metals in soil before and after contamination [2]

a= before contamination of soil

### Microbial Composition Of UEO Contaminated Soil

Soil microbial communities play a significant role within the biodegradation of various petroleum derivatives, including hydrocarbons. Sometimes, the interception in bacterial communities is caused by interference of used/ fresh oil. As per research, Species belonging to the genera *Micrococcus* and *Rhodococcus* was noted because the major autochthonic microorganisms being available in soil tainted with new car oil, whereas species of the genera *Bacillus sp.* and *Paenibacillus sp.* were identified within the combination treated with waste oil [22]. And furthermore according to [23] which proposes that the presence of microorganisms and fungi diminished with expanding soil profundity. The proportion of C:N:P ought to be kept up with at 120:10:1 to advance microbial development and movement. It is conceivable that after a delayed season of soil pollution, the ideal proportions of inorganic to organic fundamental supplements, for microbial activities, have been changed [24].

### Effect Of UEO Contaminated Soil On Plants

Heavy metal toxicity and insufficient soil aeration to growing plants are associated problems to soil polluted with spent engine oil. The degraded soil results in low crop yield and reduced crop quality [18]. Oil penetrated and accumulated in plants, causing cell membrane damage and cell content leaks, according to [25] in oil-polluted soil, cereal growth was also inhibited, resulting in chlorosis of the leaves and dehydration of the plants.

Heavy metals found in considerable quantities in used engine oil, such as vanadium, lead, aluminium, nickel, and iron, may be stored in soil as oxides, hydroxides, carbonates, exchangeable cations, and/or attached to organic matter. Such heavy metals may cause an accumulation of important organic (carbon, phosphorous, calcium, magnesium) and non-essential (magnesium, lead, zinc, iron, cobalt, copper) elements in soil, which can then be translocated into plant tissues [26]. Not only that but, the coating of foliage and sediment that clogs the pores and suffocates the respiration and feeder roots is indeed the main cause of oil-induced negative impacts on mangrove plants. Furthermore, hydrocarbon components with low molecular weight, such as petroleum hydrocarbons, may permeate plant roots and cause root membrane damage [27].

According to study conducted by [28] on Effect of Used Engine Oil on the Growth of three Capsicum pepper species, shows the effect of UEO contaminated soil on the germination of plants after the 10 days sowing seeds, which illustrated in Table 3.

Variety of Pepper	Treatment of Waste engine in soil (%w/v)				
	0 (control)	1	3	6	9
<i>C. frutescens</i>	66.7	29.8	No growth	No growth	No growth

<i>C. Chinense</i>	61.7	23.3	No growth	No growth	No growth
<i>C. annum</i>	25.0	10.9	No growth	No growth	No growth

Table 3 Percentage germination of *C. frutescens*, *C. chinense* and *C. annum* after 10days of sowing seeds [3]

### Biodegradation By Bacteria

Biodegradation is one of the most promising technologies in use today, with benefits such as cost effectiveness and the capacity to restore an environment without inflicting significant damage [29]. Microorganisms have been found to have the ability to degrade oil, according to several researches. Bacteria are important in the breakdown of hydrocarbons. The ability of microorganisms to use hydrocarbons to meet their cell growth and energy needs is the driving factor underlying hydrocarbon biodegradation [30]. Members of the genus *Pseudomonas* have a better potential than other genus in utilizing these hydrocarbon pollutants for development and thereby cleaning these polluted regions, according to [31].

Not only *Pseudomonas spp.*, but recent literature reports have revealed members of the genus *Enterobacter* from environmental sources as effective PAH (Polycyclic aromatic hydrocarbons) degraders that can withstand a variety of stressors. This implies that *Enterobacter sp.* is a member of a metabolically active and diversified group of bacteria that can successfully digest organic contaminants while also surviving hazardous intermediate compounds [32]. According to [33], *Pseudomonas spp.* are found in 80 percent of soils and have the following biochemical characteristics: tiny, spherical, slightly elevated, and produce pyocyanin, a blue green water soluble pigment that diffuses into the medium. The bacteria were likewise indole negative and oxidase positive, oxidizing glucose in an oxidation fermentation test. They were also motile and aerobic rods that were non-spore producing, gram-negative, and catalase positive.

[34] describes a simple method for determining the potential of a pure bacterial culture or a mixed culture to degrade used engine oil from soil. The methods and materials used are mentioned below;

### Method

- Uv/vis spectrophotometer
- Gas chromatography
- Hewlett packard 5890 series ii gas chromatograph equipped with flame ionization detector (fid) and 30 m long hp-5 column (internal diameter, 0.25 mm; film thickness, 0.25  $\mu\text{m}$ ).
- Nitrogen as carrier gas.
- Liquid-liquid extraction

### Material

- Glycerol: nutrient broth (1:1)
- Luria-bertani agar with very low percentage of PAH (0.005%)
- Physiological saline (0.9% NaCl)
- The mineral salt medium (MSM) ( adjusted with 7.2 ph)
- Trace elements solution (1 ml<sup>-1</sup>)

### Use Of Used Engine Oil

According to [35] we can use used engine oil in these areas;

- The used engine oil can be combined with fuel oil having a high sulphur level.
- This blended fuel oil is used in electrical power producing facilities.
- By applying sufficient heat in a pressurized tank, the thermal cracking of used engine oil breaks large hydrocarbon molecules into smaller ones.
- Large molecules with a higher viscosity are formed in this way.

### Impact Of Used Engine Oil On Health

Used motor oil has been linked to cancers such as skin squamous cell carcinoma, scrotal cancer, bladder cancer, and lung cancer [36]. Long-term exposure to high oil concentrations can lead to liver and kidney problems, as well as bone marrow damage [11].

### Conclusion

The majority of used engine oil is disposed by auto mechanic shops. Biodegradation is a very effective approach to degrade used engine oil from soil, with bacteria performing the majority of the biodegradation. But soil can't always be deteriorated for some reasons. To prevent interaction between used motor oil and soil and water sources, we may claim that an appropriate disposal system is essential. Which protects the environment, marine life, and human health. We might be able to utilize used engine oil through recycling, but recycling petroleum is expensive. As we know, there are many unidentified bacteria around us and in soil contaminated with UEO, which piques our curiosity in finding them. Perhaps we can discover novel bacteria that combine the skills of both *Pseudomonas*, *Enterobacter sp.* and save money and time. There are also various infections that are produced by old engine oil, and we must avoid coming into close touch with it. Spreading awareness about the pollution caused by old motor oil among automotive mechanics might also assist to decrease spills.

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### Conflicts of inter

The authors declare no conflicts of interest.

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