

Translation from Arabic transcript.

How Does Biotechnology Help Clean Up The Environment?

Dr. Amjad Khalil- KFUPM

Segment 1

Start with video about one of the worst oil spills in the recent history

Hi, my name is Amjad Khalil, associate professor in the Department of Biology at King Fahd University of Petroleum and Minerals. In this lesson I would like to shed light on an important environmental issue, pollution and contamination resulting from oil spills in the seas and oceans. In this lesson we will discuss how biotechnology help clean up the environment.

Now that you have seen the scope of an oil spill and the damage it causes, how would you clean the ocean/environment? Sit in groups and think creatively about ways to solve the problem. What are the consequences of oil spills on animals and plants?

Segment 2

Crude oil contains volatile substances that have low boiling points. These substances evaporate immediately. This reduces the spill by 25%, but releases toxic substances into the atmosphere. The remaining oil is very thick and sticky, and it adheres to anything it touches including rocks, sand and marine life. Biotechnology provides solutions to a wide range of marine pollutants. These are achieved through microorganisms, which have unique abilities. Different types of microorganisms can degrade crude oil. Some work faster and more efficient than others, depending on the environmental factors surrounding them as well as other internal factors such as enzyme expression.

Biotechnology can be defined as the use of living organisms or their products to improve human health and the environment.

How could these little, tiny organisms that many think of as a nuisance help us clean the environment? In groups, what chemical element does bacteria need to grow and is it abundant in oil?

Segment 3

Biodegradation is defined as the use of biological matter such as microorganisms to accelerate the removal of contaminates (such as oil spills) from the environment. Biodegradation is seen as an environmentally friendly response to an oil spill since it converts oil into a harmless product such as carbon dioxide and water. Bacteria contain enzymes that are capable of degrading hydrocarbons, the most abundant component in crude oil. Bacteria use the complex hydrocarbon as a sole carbon source, breaking it down and converting it into CO₂ and water.

As you can see in this animation, a fossil fuel hydrocarbon degrades into water and carbon dioxide.

Where do these bacteria come from? Are there different types of these bacteria? How can we isolate such types of bacteria? Sit in groups and answer the questions

Segment 4

These bacteria are mainly considered indigenous bacteria, they are present in oil. There are many types of these bacteria. Can you name some of them? Bacteria vary in their ability to degrade crude oil.

This segment will take place in a laboratory dedicated to isolating bacteria from oil-contaminated soil samples. The lab assistant will progress in accordance with the following steps:

- 1- We have about 10 gm of contaminated soil with crude oil to be mixed with 100 ml of the minimal media in 500 ml flask.
- 2- The mixture in the flask will be incubated at 30 °C in a shaker incubator for 3-5 days.
- 3- 0.1 ml aliquots of the liquid media of the flask will be transferred into nutrient agar plate (rich of media necessary for bacterial growth).
- 4- Nutrient agar plates will be incubated at 30 °C for 24-48 hrs.
- 5- Now you can see the bacteria grown on the nutrient agar plates which are coming from the contaminated soil sample.
- 6- These bacteria are considered to be oil degraders because they isolate the oil from the contaminated soil.
- 7- Now, we will show that this microorganism will be transferred from a nutrient agar plate into an agar plate containing only crude oil as the sole carbon source.
- 8- These agar plates will be incubated at 30 °C for 5-10 days.
- 9- Now, it is very clear to us that bacterial growth on the crude oil agar plates indicates that these microorganisms can use crude oil as a sole carbon source.

How many bacteria are needed to be able to clean a spill of a typical scale? How can we improve the degradation ability of bacteria? Sit in groups and answer the questions.

Segment 5

In this segment we start by showing the graph of the bacterial growth (know as growth curve) and then I will describe the growth concept.

The bacteria will grow on its special growth media and it will consume the necessary nutrients. Typically the first organism splits into two daughter organisms, which then each split to form four, and then eight, and so on. Within a few hours, the number of bacteria becomes very huge and could reach millions. This large number of bacteria will be enough to clean a large oil spill. Bacterial division and growth depends on the availability of food (crude oil).

It is known that the addition of certain nutrients such as other carbon sources (sugar for example), as well as nitrogen and phosphorus increase the degrading ability of the bacteria. It is very important to monitor such process and see how these additional materials enhance the biodegradation process.

What other biotechnological tools can enhance the biodegradation ability?

Segment 6

Genetic engineering (biotechnology) can be used as one of the modern tools and one of the methods by which we can enhance the biodegradation ability of the bacteria. The idea is based on the theory of *one gen- one protein hypothesis*; this gene is responsible for the protein. The steps of producing genetically modified bacteria capable of degrading crude oil more efficiently than the normal strains are summarized as follows:

- 1- Identify and isolate the genes coded for the enzymes responsible for the biodegradation.
- 2- Clone this gene into a special vector called plasmid.
- 3- Transfer this vector into new bacteria.
- 4- Test the ability of these new bacteria to degrade the crude oil in the contaminated sites.

Segment 7

After we saw how microorganisms play a very important role in cleaning up the environment by degrading the complex hydrocarbons in crude oil, we need to develop other natural ways to clean the environment. These include wave action, sunlight, and natural water dispersion. Biological agents increase the rate of biodegradation. During these processes, fertilizers and microorganisms are applied to oil, which break it down into simpler compounds. Other ways to remove oil from the water's surface include booms and skimmers as well as sorbent materials, which absorb oil in varying degrees, some by up to 50%. On top of all this we have to realize that the environment is our responsibility and we have to work hard in keeping it clean and protect it from any hazardous materials. For these reasons, conducting research in biotechnology is very important to discover new ways of cleaning the environment.

Thank you

Amjad Khalil