Bioremediation of Oil Spills

Alison Hawkins

Outline

Introduction

Regulations

Inland vs. Ocean

Methods

Bioaugmentation

Biostimulation

Case Studies

Advancements

According to the EPA, “oil releases threaten public health and safety by contaminating drinking water, causing fire and explosion hazards, diminishing air and water quality, compromising agriculture, destroying recreational areas, wasting nonrenewable resources, and costing the economy millions of dollars.”

Introduction

- Occur frequently throughout the world
- Require quick action

Regulations

- EPA
- Coast Guard

Inland vs. Ocean Spills

Differences:

- Who is in charge of cleaning it up
- Who causes the spills
- Attention
- Size of spill

Similarities:

- Threat to populations
- Require quick action

Methods

Physical

Chemical

Biological

Bioremediation

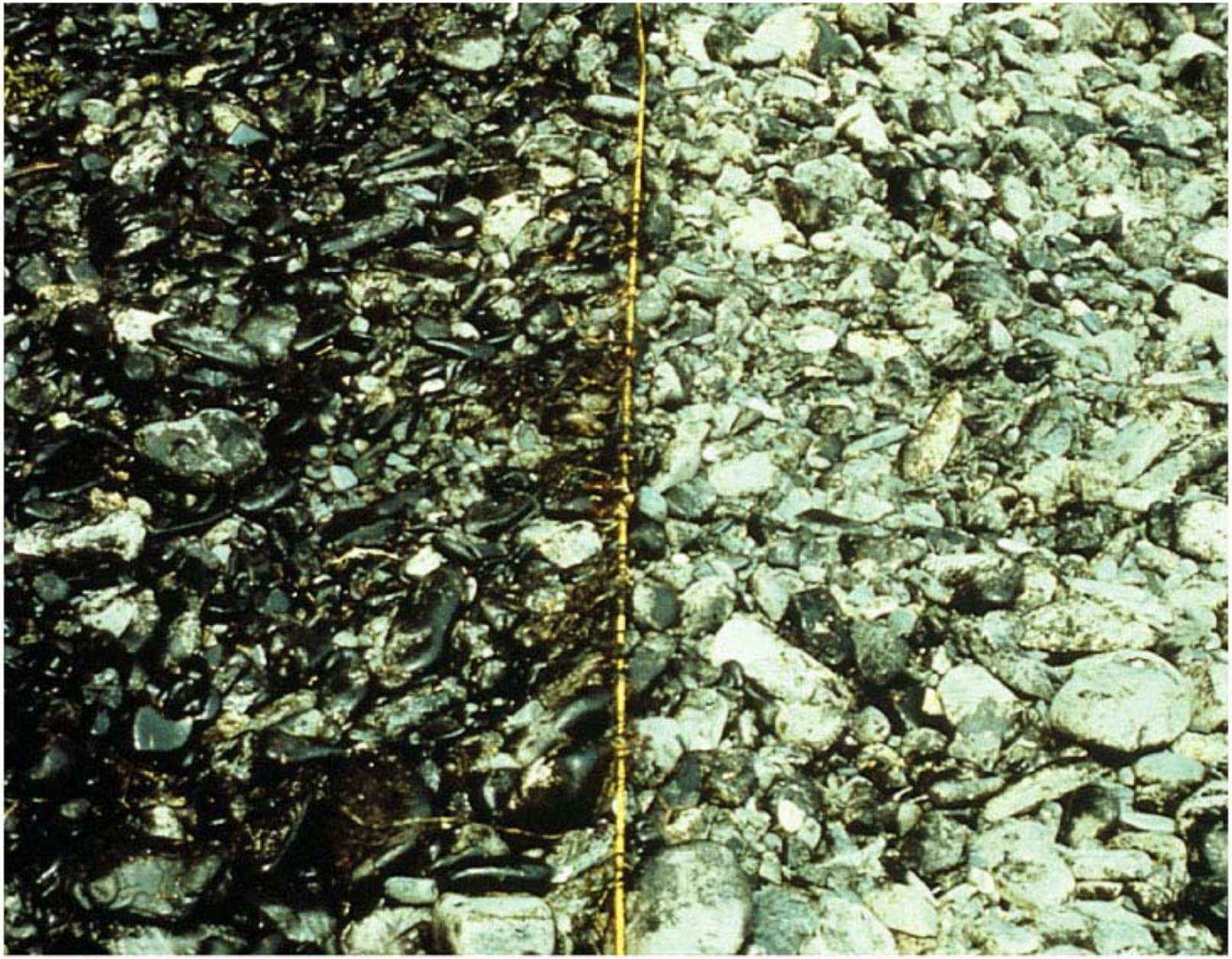
Bioremediation: the use of microorganisms to decompose pollutants into simpler compounds

Degradation: the process of microbes breaking substances down into water, CO_2, and other compounds

Prime goal

Two types

Secondary treatment tool



Bioaugmentation

Bioaugmentation: addition of microbes to supplement the current population to degrade oil and other hydrocarbons

Bacteria	Fungi
Achromobbacter	Allesheria
Acinetobacter	Aspergillus
Actinomyces	Aureobasidium
Aeromonas	Botrytis
Alcaligenes	Candida
Arthrobacter	Cephaiosporium
Bacillus	Cladosporium
Beneckea	Cunninghamella
Brevebacterium	Debaromyces
Coryneforms	Fusarium
Erwinia	Gonytrichum
Flavobacterium	Hansenula
Klebsiella	Helminthosporium
Lactobacillus	Mucor
Leucothrix	Oidiodendrum
Moraxella	Paecylomyces
Nocardia	Phialophora
Peptococcus	Penicillium
Psedomonas	Rhodosporidium
Sarcina	Rhodotorula
Spherotilus	Saccharomyces
Spirillum	Saccharomycopisis
Streptomyces	Scopulariopsis
Vibrio	Sporobolomyces
Xanthomyces	Torulopsis
	Trichoderma
	Trichosporon

Table from Gordon

Bioaugmentation

- Unable to degrade certain contaminants
- Polluted environments, 10% of resident microbe population are degraders
- Other requirements must be met
- Microbes have a peak concentration
- Microbes must compete to survive
- Genetically altered microbes

Biostimulation

- Biostimulation: addition of nutrients to aid in the growth of the indigenous microbe population
- Major nutrients: carbon, nitrogen, phosphorous, oxygen, and water
- Main concerns are oxygen supply and temperature
- Nutrients must be available and in contact with microbes

Biostimulation

1 g hydrocarbon requires 150mg N and 30mg P

C:N:P = 100:5:1

Fertilizer

- Rate of release
- Washout effect
- Type of nutrients

Type of nutrients	Advantages	Disadvantages	Applications in the field or field trials
Water soluble	Readily available Easy to manipulate for target nutrient concentrations No complicated effect of organic matter	Rapidly washed out by wave and tide Labor-intensive, and physical intrusive applications Potential toxic effect	Alaska (Pritchard *et al.*, 1992) Delaware (Venosa *et al.*, 1996)
Slow release	Provide continuous sources of nutrients and may be more cost effective than other types of nutrients	Maintaining optimal nutrient release rates could be a challenge	Alaska (Pritchard *et al.*, 1992) Nova Scotia (Lee *et al.*, 1993)
Oleophilic	Able to adhere to oil and provide nutrients at the oil-water interface	Expensive Effectiveness is variable Containing organic carbon, which may compete with oil degradation and result in undesirable anoxic conditions	Alaska (Pritchard *et al.*, 1992) Nova Scotia (Lee *et al.*, 1987, 1989,1995a &b)

Table from Zhu et al

Advantages

- Less expensive
- Natural process
- Not disruptive to surrounding ecosystems
- Does not require moving oil to another location
- Continues to improve conditions

Disadvantages

- Bioaugmentation not very effective
- Success depends on proper nutrients and environmental conditions
- Takes time to evaluate site
- Takes time to see results

Exxon Valdez

- Oil tanker received 1.26 million barrels of oil (54 million gallons) in Alaska
- Bottomed out on rocks of the Bligh Reef in Prince William Sound
- 8 of the 11 cargo holds on the ship broke and within 5 hours, 11 million gallons of oil had spilled
- 80% of oil remained on the ship

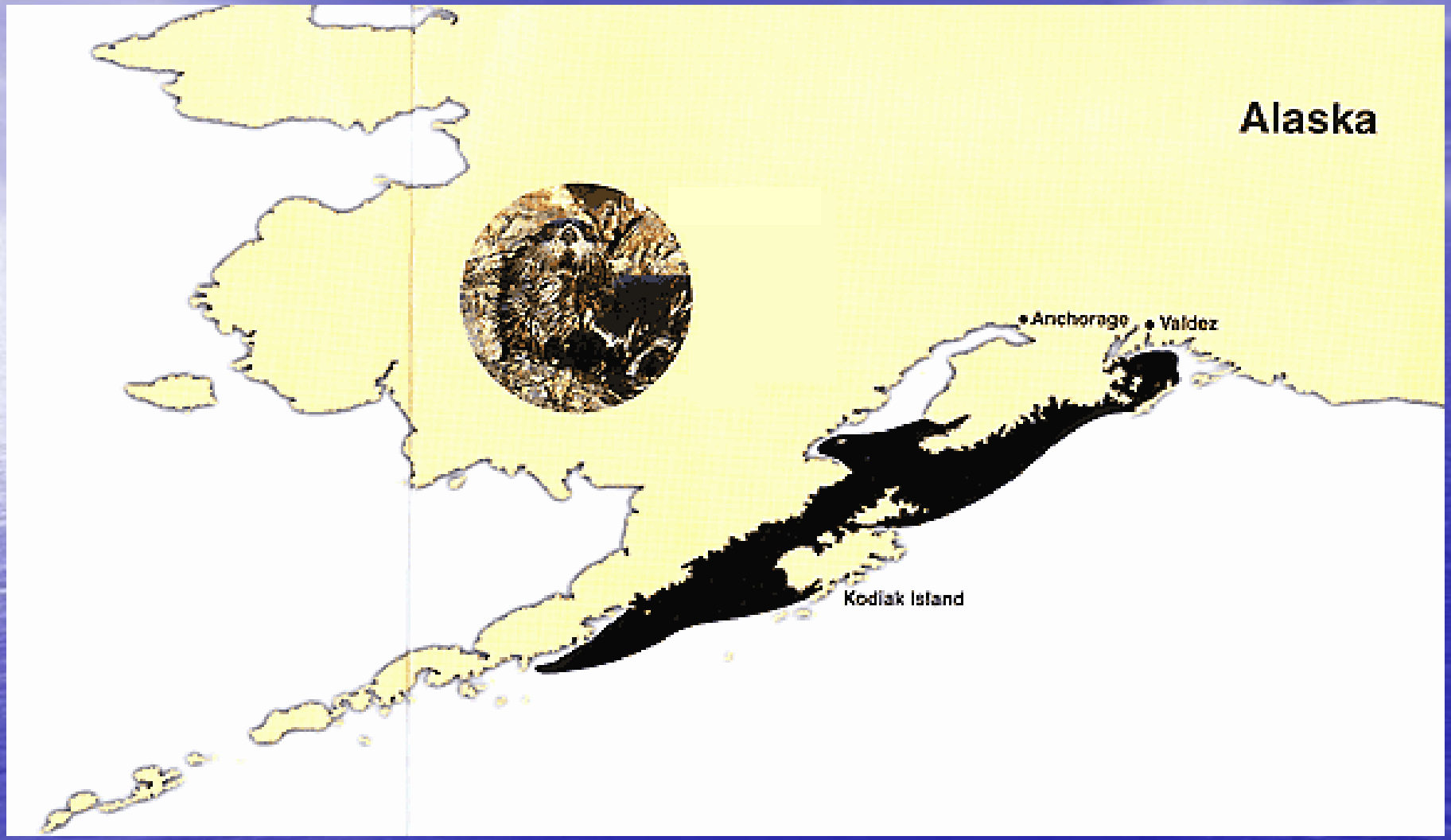


Figure from Gordon

Exxon Valdez

- Needed to remove remaining oil and cleanup the spilled oil
- Had to consider surrounding ecosystems
- Many methods tried
- 3 years later, the Coast Guard discontinued the effort
- EPA asked if they could use experimental technology

Exxon Valdez

- Analysis of different test plots
- Used biostimulation
- Oleophoric fertilizer
  - 10,000 fold increase of oil-eating microbes
- Within two weeks, saw a change in amount of oil on the rocks and beaches
- Tests showed this was due to fertilizer
- Increase test area

Ashland Oil Spill

- Four million-gallon storage tank collapsed
- Oil flowed from the tank, across a parking lot, through a s… Mongahela River into the Ohio River

Figure from EPA

Ashland Oil Spill

- Half the size of the Exxon Valdez spill
- Larger impact on populations
- Killed thousands of waterfowl and fish, closed 15 municipal drinking water intakes, and disrupted drinking water supply for 2.7 million people.
- Mechanical methods were used
- Only 20% of oil was recovered

Spill Effects

- Sparked public awareness
- More stringent regulations and laws enacted – Oil Pollution Act of 1990
- Helped encourage the use and advancement of bioremediation

Advancements

Information gained includes:

- Determining the effectiveness of bioremediation agents
- Statistical proof that bioremediation enhances disappearance rate of crude oil
- Minimum N concentration necessary

Difficult to perform controlled experiments

Conclusion

- Oil spills can happen anywhere
- Require quick reaction time
- Various methods available
- Bioremediation is an emerging process that needs to be analyzed farther to see the true effectiveness of the process

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Questions?