What is the most effective method for cleaning oil, Dispersants or Absorbents?

Background

The company British Petroleum, otherwise known as BP, had a fairly sizable catastrophe take place on one of its drilling rigs 50 miles to the south-east of the Mississippi delta, the Deepwater Horizon, on the day of April 20th, 2010. An explosion and subsequent fire took place, killing eleven people out of the 126 workers on the drill. The fire lasted for two days, and on the 22th of April, the Deepwater Horizon sank into the ocean, dousing the fire and thus allowing the oil to flow freely from the oil well 5,000 feet below, and reach/remain on the surface. Though initial and governmental estimates of the amount of crude oil released were low, the Macondo well, a five storey high structure that allows access to the subterranean deposits of crude oil, is thought to have released around 4.2-5 million barrels into the Gulf of Mexico. This amount of oil covered around 75,000 square kilometers, reaching the coastline of at least four states, Louisiana, Mississippi, Alabama, and Florida.

Of course among the major concerns revolving around this oil spill is the ecological impact that this oil spill could have. It has been established that exposure to crude oil is extremely hazardous to all forms of life that come into direct contact or absorb it. It can cause many problems in the natural functions of organisms, interfering with natural processes of or physically damaging various cells, and can lead to health complications up to and including death. "*Birds can be exposed to oil as they float on the water or dive for fish through oil-slicked water. Oiled birds can lose the ability to fly and can ingest the oil while preening. Sea turtles such as loggerheads and leatherbacks can be impacted as they swim to shore for nesting activities. Turtle nest eggs may be damaged if an oiled adult lies on the nest. Scavengers such as bald eagles, gulls, raccoons, and skunks are also exposed to oil by feeding on carcasses of contaminated fish and wildlife.*"[1] These species are only a few of the coastal and aquatic lifeforms that interact with or come close to the surface

of the water, meaning that they will be in direct exposure to the crude oil. The unfortunate event that crude oil was released into one of the most bio-diverse regions in the world, could have some very dire consequences. In addition, there is significant concern about the chemical dispersants that are being used, as "*Oil spill dispersants do not actually reduce the total amount of oil entering the environment. Rather, they change the inherent chemical and physical properties of oil, thereby changing the oil's transport, fate and potential effects. Small amounts of spilled oil naturally disperse into the water column, through the action of waves and other environmental processes. The objective of dispersant use is to enhance the amount of oil that physically mixes into the water column, reducing the potential that a surface slick will contaminate shoreline habitats or come into contact with birds, marine mammals, or other organisms that exist on the water surface or shoreline.* "[1] The use of dispersants, should this information be correct, would then not only affect the coastal habitats, but virtually all aquatic lifeforms within the Gulf of Mexico. In its essence, the use of dispersants on crude oil is a conscious compromise between the effects the dispersed oil has upon the surface and coastal organisms, and the effects that it will have upon the species that live underneath the Benthic zone, creating an inverse relationship between the harm that comes to one as compared to the other. However, the magnitude of the spill is such that the oil has already done great harm to the biotic environment of the Benthic zone, and the future and present use of dispersants would come to affect life within various if not all levels of the water column. The full effects of these dispersants along with the crude oil are not fully known, but it is believed that they may have physiologically negative effects that could be transferred from one generation of organisms to the next. Thus, various members of a species could be affected, not only those who came in direct contact with the oil and dispersants. In addition, there has been some concern that the dispersant-encased oil will enter the Thermohaline Circulation, also known as the Global Conveyor Belt. It is a submerged current of water that travels all around the world and surfaces at various regions with nutrients brought up from the bottom of the ocean, and so these regions are intense with bio-diversity. "*Scientists estimate that it takes one section of the belt 1,000 years to complete one full circuit of the globe. However slow it is, though, it moves a vast amount of water -- more than 100 times the flow of the Amazon River.*"[2], meaning that these ecological concerns could still exist within the next millennium, and be transferred into other regions with a relatively high level of bio-diversity.

It is often the case that there is an inverse relationship between the economic gain that resource extraction procures, and the ecological effects that it has. However, the extraction of crude oil from the Macondo Well, and the subsequent BP Oil Spill has transformed into a situation that does not benefit coastal communities economically, and much less environmentally. "*In a preliminary assessment of the economic damage released on May 17, 2010, Moody's Investors Service suggested that while Louisiana, Mississippi and Alabama may experience short-term economic booms related to clean-up efforts, that will give way to longer term deteriorating revenue for coastal communities. Cities and counties in those Gulf states are likely to experience a decline in property tax values, which will mean a reduction in services or a*

necessary increase in revenue to maintain current credit rating levels."[1] One can then conclude that these coastal communities will be severely affected in terms of the economic opportunities and resources available to them. As their property will no longer be considered pristine location for urban residence as a direct result of the health hazards of crude oil/dispersants, so will it no longer be considered prime real estate for commercial development. These communities could be affected through the loss of visitors and investors. As time goes on, these issues could come to grow exponentially, as one by one communities become commercially stagnant. However, the economic effects of the BP Oil Spill might be more significant than we believe them to be. "*The economic impacts from the spill originate in the communities affected by the spill, but then ripple throughout the entire nation. Commercial fishermen in the Gulf harvested more than 1 billion pounds of fish and shellfish in 2008. In addition, there are approximately 5.7 million recreational fishermen in the Gulf of Mexico region who took 25 million fishing trips in 2008. Fisherman in areas closed to fishing, or whose catch are harmed by the spill, feel the immediate effects, as do hotels, restaurants and other businesses that are tied to tourism, conventions and recreation in the Gulf Coast. The reduction in the harvest of oysters, shrimp and other seafood caused prices to rise sharply in the weeks following the spill, which in turn caused food prices to rise in restaurants as far away as New York City. The mere threat of oil caused thousands of hotel cancellations in the run-up to the usually hectic Memorial Day weekend.*"[1] Hence, not only are the communities of the Gulf affected, but by the loss of the availability of sea-fish and other aquatic organisms that reside within the Gulf of Mexico, the most culturally or at least most culinary diverse communities would also perceive the rise in prices of various dishes. The southern coastal communities may become a dead zone for tourism and investing, creating a large dip in their exports of consumable goods, which then could cause the United States to import more of their material goods from other nations thereby lowering the amount of money within the U.S. I believe that it is quite logical to assume that the interconnectedness of our economic prosperity is of a more significant nature than most are aware of, as exemplified by the fairly broad impact of the most recent recess in our economy due to the housing market crash, among other things.

As the quality of the environment along with the availability of the most important resource in our society, money, decreases, so does the lifestyle of the people who live in the

regions most directly affected by the oil spill. "*Public officials have failed to sound an alarm about the public health threat because three federal agencies - DHHS, EPA, and OSHA - cannot find any unsafe levels of oil in air or water. Perhaps the federal air and water standards are not stringent enough to protect the public from oil pollution. Our federal laws are outdated and do not protect us from the toxic threat from oil - now widely recognized in the scientific and medical community. BP is still in the dark ages on oil toxicity. BP officials stress that, by the time oil gets to shore, it is "weathered" and missing the highly volatile compounds like the carcinogenic benzene, among others. BP fails to mention the threat from dispersed oil, ultrafine particles (PAHs), and chemical dispersants, which include industrial solvents and proprietary compounds, many hazardous to humans. If oil was so nontoxic, then why are the spill response workers giving hazardous waste training? Our federal government should stop pretending that everything is okay. What isn't safe for workers isn't safe for the general public either.*"[3] Thus is the statement made by Riki Ott, a marine toxicologist, who is also a published author of two books related to the Exxon Valdez Spill. As she points out, crude oil and the chemicals used to 'clean' the oil are of significant concern for the health of the coastal population. It is agreed that direct and even indirect contact with these substances can cause various health complications to marine biology, and are also of significant concern to the health of the human population that is exposed to said chemicals. "*Corexit 9500 is known in prior scientific studies to pose a high level of toxicity to primary producer biota in the water column; in addition, it has been shown to accelerate the uptake of certain likely carcinogenic minority components present in petroleum*

such as napthalene. The dispersants used are approximately 10,000 times more lethal to biota than crude oil itself. Corexit 9500 and Corexit EC9527A, manufactured by an Illinois company, both contain 2-butoxyethanol, a chemical known to cause respiratory and skin irritation effects in humans. These dispersants have been banned for use by the United Kingdom, due to known biological effects on people and natural systems."[1]

The ultimate and specific consequences of the largest ecological disaster to happen in relation to the extraction of natural resources are yet to be fully known. However, what is known, is that they will be negative, and they will be dire. What this will do to accelerate the degradation of our environment must become one of our most important concerns in the present age, and thus should be extensively investigated, and all available methods to revert the damage made by the

BP Oil Spill must be employed in order to slow or stall if not outright stop the downward spiral that is the condition of our environment. Though some efforts have been made to control the reach of the crude oil, like the use of booms, absorbent pads, or dispersants, we must come to a solution to this problem that is far more effective. This brings us to the education of the generation(s) soon to inherit these responsibilities, such as my generation, and so we come to study the BP Oil spill in AP Environmental Science. In an experiment representative of the various clean-up methods employed by various agencies and entities, we will compare two different methods of cleaning in order to discern which would be the most effective.

End Notes

1. Cutler Cleveland (Lead Author);C Michael Hogan PhD., Peter Saundry (Topic Editor) "Deepwater Horizon oil spill ". In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth December 5, 2010; Last revised Date December 10, 2010; Retrieved January 9, 2011 http://www.eoearth.org/article/Deepwater_Horizon_oil_spill?topic=50364
2. Horton, Jennifer. Deep Ocean Currents (Global Conveyor Belt). How Stuff Works. http://science.howstuffworks.com/environmental/earth/oceanography/ocean-current3.htm
3. Ott, Riki. The Big Lie: BP, Governments Downplay Public Health Risk From Oil and Dispersants. CommonDreams.org. http://www.commondreams.org/headline/2010/07/07-4

Images

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Hypothesis

If we use the liquid based detergent and cotton balls to clean oil, then the liquid based detergent solution dispersant will have the best result in cleaning oil from the surface of the water because the cotton balls will interact with water along with oil, whereas the detergent will cause only the oil to clump into denser particles, effectively causing the condensed chemical-encased oil particles to sink and disperse along the water column.

Materials(per trial)

(Detergent)

Liquid based Detergent - 30 milliliters
Water - 300 milliliters
Oil - 50 milliliters
Tray - 1
Funnel - 1
Coffee Filter - 1
Graduated Cylinder - 1
Scale - 1

(Cotton Balls)
Cotton Balls - 6
Water - 300 milliliters
Oil - 50 milliliters
Tray - 1
Funnel - 1
Coffee Filter - 1
Graduated Cylinder - 1
Scale - 1

Procedure(3 Trials per Cleaning Agent)

Detergent

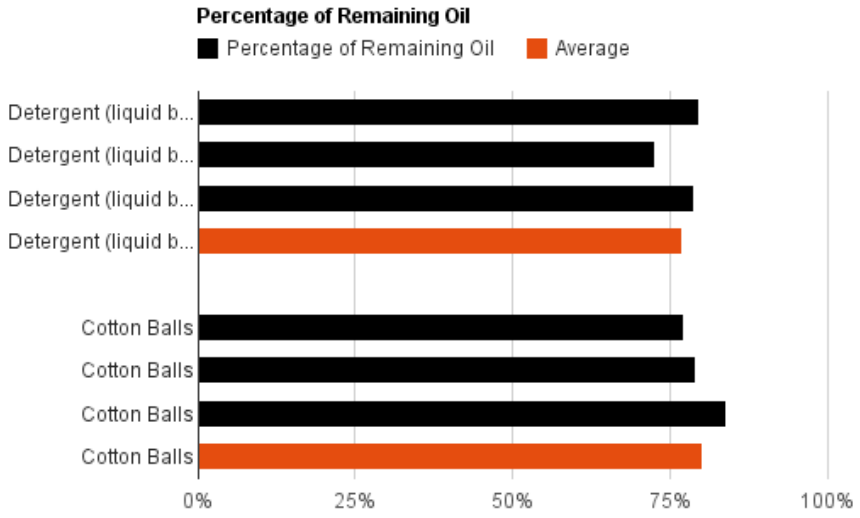
1. Prepare working space and chart for recording information.
2. Attain water and measure 300 milliliters using graduated cylinder, and pour into tray.
3. Attain the initial oil level of 50 milliliters, and weigh using scale, making sure to compensate for the weight of the graduated cylinder. Then pour into tray
4. Attain 30 milliliters of liquid based detergent.
5. Record information of initial water level, initial oil level, and initial level of cleaning agent.
6. Add cleaning agent to tray and wait for 3 minutes.
7. Place the coffee filter in the funnel, and use it to isolate the liquid oil remaining on the surface of the water that is inside the tray, carefully avoiding the clumped oil at the bottom of tray by carefully pouring surface oil from tray to funnel.
8. Remove the coffee filter from funnel, keeping the amount of retained oil intact, and measure weight using the scale.
9. Record the weight of the remaining oil.
10. Clean materials and work space, and dispose of remaining oil and residue.
11. Repeat steps 1-10 for 2 more trials.

Cotton Balls

1. Prepare working space and chart for recording information.
2. Attain water and measure 300 milliliters using graduated cylinder, and pour into tray.
3. Attain the initial oil level of 50 milliliters, and weigh using scale, making sure to compensate for the weight of the graduated cylinder. Then pour into tray.
4. Attain the 6 cotton balls.
5. Record information of initial water level, initial oil level, and number of cotton balls.
6. Add cleaning agent to tray and wait for 3 minutes.
7. Remove the cotton balls from tray if present, place the coffee filter in the funnel, and use it to isolate the liquid oil remaining on the surface of the water that is inside the tray by carefully pouring it from tray to funnel.

8. Remove the coffee filter from funnel, keeping the amount of retained oil intact, and measure weight using the scale.
9. Record the weight of the remaining oil.
10. Clean materials and work space, and dispose of remaining oil and residue.
11. Repeat steps 1-10 for 2 more trials.

Cleaning Agent	Initial H_2O Level	Initial Oil Level	Initial Cleaning Agent Level/ Amount	Initial Oil Weight	End Oil Weight	Percentage of Oil Remaining
Detergent (liquid - based)	300 mL	50 mL	30 mL	42.7 g	34 g	79.625%
	300 mL	50 mL	30 mL	42.7 g	31 g	72.599%
	300 mL	50 mL	30 mL	42.7 g	33.5 g	78.454%
Average						**76.892%**
Cotton Balls	300 mL	50 mL	6 balls	42.7 g	33 g	77.283%
	300 mL	50 mL	6 balls	42.7 g	33.8 g	79.156%
	300 mL	50 mL	6 balls	42.7 g	35.8 g	83.840%
Average						**80.093%**



Conclusion

It actually was relatively difficult to discern which cleaning method was best, on account of the similarity of the results between the two cleaning agents, the cotton balls and the detergent. On the first trial of the two cleaning agents, we found that the percentage of oil remaining was larger in the trial corresponding to the detergent, by around 2.342% , a number that in a scale of millions of barrels could make an enormous impact. In the second trial, we found that the amount of remaining oil was larger in the cotton balls than in the detergent's trial, by around 6.557%, thereby proving the initial belief that the detergent would work better as a cleaning agent. In addition, the third trial once again proved that the detergent works best as a cleaning agent by cleaning a higher percentage of oil in comparison to the cotton balls, by 5.386%. Therefore, one can conclude that the cleaning agent that works best is the detergent, which if one takes the average of all trials one finds the detergent to to be 76.892% ineffective, lower by 3.201% than the 80.093% ineffectiveness of the cotton balls. I suppose that this would mean that my initial hypothesis that the detergent would be more effective would be correct, as the cotton balls, according to our trials, are slightly less effective. However, it is difficult to prove this theory if one takes the scale of the experiment fully into account. There is nowhere near enough data to come to a final verdict, due to the minuteness of a high school experiment compared to the real world. The 3.201% difference in the averages of the cleaning agents is not a significant enough difference to be of much consequence outside of a science classroom. Had the experiment been more extensive in its exclusion of unwanted variables and had a more substantial amount of trials, this conclusion may have been more accurate. Those variables could be anything from the unintentional inclusion of dispersed oil mixed within the water column, to the spilling of oil from the surface of the water outside of the coffee filter, to the methodology of how the cleaning agents were introduced in terms of consistency (or lack of it). The trials we did could have been (and most likely are) influenced by human error on the part of a group of inexperienced teenagers, and most likely does not reflect the true magnitude of the difference in

the effectiveness of these two cleaning agents. One significant factor that could have influenced the data is the interaction of the oil with the items that hold it. Oil has a relatively high level of viscosity, meaning that it is 'sticky.' This means that as the oil is being taken out of its container, some oil remains behind. This could potentially throw off the data by removing a certain amount of oil that was supposed to be included in the final measurement. Also, as the water poured from the container could have interacted with the coffee filter in such a way that it is possible that it affected its ability to filter. This could have allowed some of the oil to go through the filter, removing a certain amount of oil from the final measurement and affecting the accuracy of our data. Any number of these unintended influences could have been avoided if we were to use a more controlled environment, like a professional lab, rather than a high school level classroom/lab. As part of a controlled environment is the controlled measurement of all the substances used in the experiment, including consistent puring rates and the use of identical measuring tools. We also did not use a control, meaning that the experiments we did comparing the efficiency of dispersants versus absorbents were not compared to a third set of experiments measuring the average amount of oil that did not **naturally** disperse. Additionally, as part of the controlled environment we did not use were materials that would allow for the unhindered movement of the oil from one container to the next.

Of course, certain questions arise out of the experiments, mostly as to the nature of the two cleaning agents. We know of course, that absorbent pads essentially soak up the surface oil slick, thereby removing it from the environment once the absorbent pads themselves are removed. Dispersants, on the other hand, do not physically remove the oil from the environment. Instead, it disperses the oil along the water column, and that causes one to question if dispersants should be used at all, since they do not seem to effectively 'clean' the oil, as it is not removed from the environment. Wouldn't that just mean that the dispersants do nothing to change the amount of oil floating within the oceans? What is the rate of efficiency of the removal of 100% of the surface oil by the dispersant Corexit as a ratio of oil quantity versus dispersant quantity? Was the use of dispersants by the EPA really an effort to clean up the oil, or was it merely a P.R. campaign, one meant to soothe the concerns of the general population but not really deal with the problem?