An overview on carbon nanotubes as innovative absorbent for marine oil spill

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Abstract. Marine oil spills due to drilling activities is a serious problem worldwide because it poses a major risk to marine ecosystem. So far, researchers in the world continues to innovate materials to clean up marine oil spills. Among them, based on carbon nanotubes. Carbon nanotubes are known have perfect ability to absorb oil and neutralize substance. This study review provides the various types of carbon nanotubes that have best quality to absorb marine oil spills. Continue with various types of carbon nanotubes technology, which technology should be developed in the future by considering each advantage possessed by of carbon nanotubes in order to create product innovation that efficient and environmentally friendly because does not make some new pollution. Therefore, carbon nanotubes is a good choice material to clean up marine oil spills.

1. Introduction

The preservation of the marine environment and its biodiversity is one thing that is important for the survival of human life, either directly or indirectly. This is also supported in the Sustainable Development Goals (SDGs) program number 9 where underwater life is one of the seventeen focuses of attention. The sea has become a part of human life by distributing its existence as much as 97% on earth. On the other hand, the presence of offshore activities often contributes to marine pollution, for example oil spills. The activity of spilling a mixture of complex hydrocarbon compounds, both unintentionally and intentionally, has become one of the biggest contributors to hazardous materials for marine ecosystems [1]. In 2020 it was recorded that around 1000 tons of oil spills occurred with 3 medium scale incidents (7 – 700 tons) and zero cases with large scale (> 700 tons). It is recorded that from 1970 to 2020 more than 5 million tons of oil spills contributed to marine pollution [2]. Although there has been a decline in number of oil spill cases since the 1970s (shown in Figure 1), this does not justify that oil spill cases will not occur. This indicates that an oil spill is an unavoidable incident if offshore activities are still taking place. In the span of five decades, it was recorded that 50% of cases of major oil spills occurred in ship shipping activities on the high seas and 58% were caused by accidents and ship grounding activities. [2]. Not only these two things, but the threat of oil spills also comes from high seas oil exploration [3]. Threats to marine life will continue to occur as long as the oil spill occurs, such as the inhibition of growth and development, digestion, respiration, and reproduction in fish and marine mammals as well as possible swelling of their vital organs. [4]. Damage to coral reefs is also unavoidable if the oil spill continues to spread deeper and deeper. Oil spills have a crucial impact on the
aquaculture sector, such as the narrowing of fishing grounds for fishermen, thus having a substantial impact on their economic sector. [5].

Figure 1. Number of oil spills (medium scale and large scale) from 1970 – 2020 [2]

Based on SDG point number nine, namely innovation and infrastructure, this paper will provide an explanation of product innovation to overcome oil spills. The innovation product in question is the use of nanotechnology-based products, carbon nanotubes (CNTs). CNTs are known as hydrophobic materials, but have excellent oil absorption capabilities [6]. This advanced innovation of oil absorbent has greater porosity and absorption surface so that the absorption of oil will be greater than conventional methods and is more environmentally friendly and cost effective. Reflecting on the mitigation efforts that have been implemented so far, in situ burning, for example, the activity of burning the remaining oil spills in the affected area actually endangers the ecosystem and pollutes marine life and requires large costs. [7]. With the presence of carbon nanotubes, it is expected to be able to advance industrial independence in the field of innovation and infrastructure in terms of mitigating marine pollution, in this case oil spills.

2. Method of research

The literature review method was used to gather data on carbon nanotubes and marine oil spills for this paper. The literature used comes from pre-existing journals. Research methods contain a literature review, data collecting, data analysis, idea development, and conclusion. The flowchart of the research methods used is shown in Figure 2.

As shown in Figure 2, the first stage is to review related journals that have been circulated before. To strengthen ideas, planning requires data that is by the related concepts. The data used in this paper is secondary data from valid sources. The sources are obtained from international scientific journal articles, ministerial regulation, proceedings, and SNI regulation. To make it easier to find the journal want to search, a search is performed by including keywords in the search field. Keywords used when surfing, namely carbon nanotubes, marine oil spill, offshore oil drilling, oil transporting by vessel, and SDGs. The data will be analyzed according to the ideas proposed after obtaining the necessary data. Furthermore, ideas are carried out development and innovation from the results of the analysis that has been obtained. After the development of ideas and innovations, it can be concluded that carbon nanotubes can be an alternative to overcome oil spills at sea.
3. Oil transporting by vessel

3.1. General information about oil transporting by vessel
The demand for oil and other products made mainly of oil for industrial purposes is quite increased from year to year, therefore, exploration for the process of taking crude oil and its distribution becomes very important and becomes the key to the successful fulfilment of oil products. In this case, the discussion was conducted by exploring the vessel as a means of marine transportation that will be used to transport oil products. Sea transportation that is the basis of transportation mode for oil distribution has increased a lot, both in terms of quality and quantity. Sea transportation is also one of the most popular modes of transportation for intercontinental products and world trade [8]. According to the International Tanker Owners Pollution Federation (ITOPF), there has been a doubling of oil transport from 1970-1980 [2]. With the increase in sea transportation, it is certain that there will be an increase in the number of ships and the density of sea traffic lanes, which will increase the risk of accident rates at sea [9].

3.2. Standard Operating Procedure during oil exploration transporting
Vessels, including cargo ships used for oil unemployment, have a high fuel consumption rate of almost 78% of the total [10]. The consumption of energy used can cause damage to environmental impacts, such as damage to greenhouse gas emissions, and also impact the economy. Standard Operational Procedure (SOP) is created as a standardized work and management system for workers to reduce the risk of work accidents. In addition to worker safety, the standard operational procedure is also mentioned
about an effective environmental management system to help organizations to control environmental damage caused by oil transporting work to help improve sustainable environmental performance [11].

3.3. Fuel ship transport permit
The permit to transport fuel into sea transportation for the distribution of oil is stipulated in the regulation of the Minister of Transportation of the Republic of Indonesia number 65 of 2019 concerning companies and ship agencies. Every ship that does work at sea in Indonesia must show a ship agency license [12].

3.4. Causes of tanker ship accident and Oil transport ship track
Reported from ITOPF 2020, the number of shipwrecks that caused severe oil spills (>700 tons) has decreased from 1970 by 24.5% to 1.8% in 2010. However, the oil spill will still be a serious problem for environmental and maritime industry issues [13]. It shown that there is a development in the maritime industry, which is proven by the increase in sea transportation lines with a decrease in shipwrecks that cause severe oil spills. With the rapid growth of sea transportation, it will be directly proportional to accidents between ships, both on a small and large scale, which can result in death, injury, economic problems, and environmental problems [9]. In addition to the increase in the ship population, the cause of shipwrecks can also stem from ship characteristics, type of operation, weather conditions and type of waterways [14]. The path passed by oil carriers in the world is quite wide, one of which is the world trade route where the line is the centre.

4. Offshore oil drilling

4.1. General information of offshore oil drilling
Offshore oil drilling is one of the energy resources utilization in filling the oil needs. Gasoline, petroleum, diesel, vehicle lubricants, liquefied petroleum gas (LPG), paraffin, and asphalt, as crude oil products, have been used in a massif for the welfare of human life. That operation utilizes a giant structure, a platform, as a place where drilling machines and oil products placed has created a lot of job fields, offered promising tax income for governments, boosted economic growth, and reduced dependence on oil import [15,16]. In addition to these benefits, some have questioned the risk of marine pollution and the impacts on marine biodiversity, in this case, the risk of oil spills resulted from offshore oil drilling [17]. Therefore, it is necessary to know how the overview of offshore oil drilling is carried out and what are the provisions need to be considered in carrying out such operations.

4.2. How is the offshore oil drilling carried out?
Offshore oil drilling has the same drilling principle as onshore, namely drilling through rocks which identified that the sedimentation of organic materials that have accumulated for a long time then due to high heat and pressure those organic materials are converted into oil and gas exist. [18]. The only difference is the geographical location so that additional elements are required in offshore oil drilling, there are marine riser, subsea wellhead, and subsea blow-out preventer (BOP) [19]. Offshore oil operations commonly start with drilled phases. Drilling starts when the drill bit is spudded into the rig floor carrying steel pipe behind until the drill assembly has already injected and the wellhead is right above the seafloor. The drill bit continues drilling along with the drill string (drilling system consists of drill pipe, stabilizer, drill collar, bottom hole assembly, and a bit) to the further sediments. At the same time, “mud” is pumped down into the drill pipe then through the drill bit to lift the drill cuttings (rock fragments have been drilled together) through the space between the wellbore wall and the drill string and keep the bit and well lubricated [17]. In this process, vibration usually occurs due to pressure between the drilling string and the drilling mud, the contact of the drilling string with the wellbore, and the bit with the wellbore which can damage the drilling equipment, drilling string also its stabilizer [20]. After the entire assembly has settled and the surface casing has paired through the wellbore, cementation should be done to preserve a permanently secure casing place [21]. The deeper the drilling process is carried out, the higher the hydrostatic pressure from rocks received, thus, the BOP and the
riser are locked on the wellhead. As the pressure controller to prevent uncontrolled “kick” or blow-out from formation fluid flow, the BOP, a system that has a chain of valves controlling the well, has a critical role in securing all employees, equipment, and work environment [22]. Following the drilling process would be continued downward the part of another rock accompanied by those looping processes as shown in Figure 3.

![Drilling Process Diagram](image)

**Figure 3.** Sediment drilling process on the seabed [17]

4.3. *What kind of platform that should be considered?*

There are two types of units for drilling rigs, fixed units and mobile units. Fixed units (shown in Figure 5) in which the deck is supported by a giant steel structure known as jacket are supposed to steady upon their location and commonly used for moderate water depth with longer-term production from the reservoir. Meanwhile, mobile units are easily relocated and supposed to be used in moderate to very deep-water depth (500 ft to 10,000 ft) as the well geographical situation is considered [19]. There are several types in mobile units, namely swamp/drilling barges, jack-up rigs, drillships (floater), and semisubmersible rigs. Each of them has the terms of specific uses. For offshore oil drilling, jack-up rigs (shown in Figure 4) are suitable for the 500 ft seafloor under the surface as it have restricted leg anchored to the sea floor and can be dragged to the spot location [19]. On the other hand, semisubmersible drilling rigs are more flexible as they have to deal with unpredictable sea conditions at 10,000 ft above the seabed with the help of structures such as pontoons supporting the deck area, in this case, the principle of buoyancy is needed for stabilization of the platform rig legs at the unstable sea [19,23]. Similar to semisubmersible drilling rigs, drillships are designed to drill at very deep depths (2000 – 10000 ft) and face severe weather conditions. A mooring system and dynamic positioning system (DPS) are integral in drilling success. In shallower water conditions, the drillships are moored on the seabed with 6 to 12
anchors. After the water depth gets deeper, *drillships* rely on **DPS** as a positioning adjustment. This system in the form of a thruster connected to a satellite is useful for controlling the angular movement of the ship so as to prevent movement due to the agitated waves [24]. *Semisubmersible drigs* and *drillships* are shown in Figure 5.

![Figure 4. Jack-up rigs [25]](image)

![Figure 5. (a) Fixed units, (b) Semisubmersible units, (c) Drillships [19]](image)

### 5. Marine oil spill and its mitigation

#### 5.1. Causes of oil marine spill

Currently, spilled oil poses a serious problem at sea. Not a small amount of oil spilled onto the surface of the waters. Oil spills can be caused by two factors, namely natural factors and human activities. Natural factors occur due to the release of petroleum from petroleum-producing rocks at the bottom of the ocean. In addition, another thing that causes the spill of oil is the result of human activity itself. Spills can occur for various reasons during the process of exploration, extraction, and transportation, such as overpressure, mechanical failure, pipe corrosion, ship collision [26].

#### 5.2. Impact an oil spill on the area

The spill of petroleum into the sea has an impact on the surrounding ecosystem, such as coral reefs, fish, organisms, and seabirds in the vicinity. The impact that occurs can be direct or indirect. In addition to having an impact on marine life, the spill of oil can have an impact on the economy. Spilled oil at sea causes enormous losses, including cleaning costs of the spilled area, equipment costs, spilled oil losses, etc. The impact can be seen in the Table 1.

| Marine biota     | Effects that occur                                                                 | Reference |
|------------------|------------------------------------------------------------------------------------|-----------|
| Fish             | 1. Exposure to high concentrations of polycyclic aromatic hydrocarbon (PAH) in water columns.  
                        2. Inhibit the growth and development of fish                                      | [27]     |
| Coral reefs      | 1. Heavy oil will cover focus, and cause death or sub-lethal effects on algae      | [28]     |
|                  | 2. Damage the spawning place of the fish                                            |           |
|                  | 3. Fish become inedible because it is dangerous for the body                        |           |
| Seabirds         | 1. Causes death                                                                     | [26]     |
|                  | 2. Damage organs when entering the body                                              |           |
|                  | 3. Oil can damage feathers on the body of birds                                     |           |
| Planktons        | 1. Oil exposure can cause immediate mortality, acute toxicity, decreased feeding, delayed egg production, slow hatching rates, reduced swimming speeds, reproductive abnormalities in planktonic copepods. | [29]     |

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5.3. Technology currently used to deal with oil spills and the effectiveness
Currently, oil spills can be addressed by physical methods and chemical methods. Handling of petroleum spills in the sea, namely by using Oil booms and in situ techniques. Judging from the handling done, there are no very powerful techniques to overcome marine oil spills. The treatment is done just to hold the oil so that it does not spread more widely. The technology used today, namely:

5.3.1. Oil booms
Oil booms are technologies that are currently widely used. This technology works to hold spilled oil from spreading more widely. This technology is like a floating wall and is controlled by a tow ship. After that, a skimmer is needed to suck up the petroleum spilled in the sea. However, this technology is not too flexible to follow the pattern of the sea. This technology is less effective when the ocean waves are too high.

5.3.2. In situ Burning
In situ combustion is the burning of a portion of oil that is carried out in the reservoir to obtain heat. The heat resulted in a decrease in viscosity value, development, and distillation of oil with the effect of gas drive and solvent extraction so that the spread of oil spills did not expand. The handling that is still being used to tackle petroleum spills is still not effective. The handling of the treatment causes new pollution and more use of costs. Now, innovations are needed that are more flexible and cost less. The use of innovations from Carbon nanotubes can be the right solution in handling petroleum spills.

6. SDGs number 9: industry, innovation, and infrastructure

6.1. General information about Sustainable Development Goals (SDGs)
In general, Sustainable Development Goals (SDGs) are global action plans agreed upon by world leaders, including Indonesia, to end poverty, protect the environment and reduce inequality. SDGs contain 17 goals and 169 targets that are expected to be achieved by 2030 as shown in the Figure 6

![Sustainable Development Goals](image_url)

**Figure 6.** Sustainable Development Goals, 17 Points of Sustainable Development Goals [30]

On this topic, we will focus on SDGs number 9 which to build and develop a resilient infrastructure, support inclusive and sustainable industrialization, help development, and create innovation.
6.2. Why focus on SDGs number 9? And what relevance between SDGs number 9 with marine oil spill?

Because it is reviewed from the objectives of SDGs number 9, the success of industry, the marine oil spill in Indonesia will hinder achievement of these goals. In addition, marine oil spill in Indonesia will cause a lot of adverse effects if left in the short or long term. The mass death of fish due to lack of oxygen and carbon dioxide poisoning, as well as damage to mangrove ecosystems and marine ecosystems are examples of the adverse effects of marine oil spill. The government and oil companies are still lacking in innovation tackling marine oil spill, so the underwater life preservation system cannot be achieve the Sustainable Developments Goals (SDGs).

6.3. Analysis/ information the impact of using carbon nanotubes to resolve oil spills on the development of infrastructure, industry, and information.

Marine oil spill is a problem that is considered a serious threat to the environment around the world, including Indonesia. This will hinder the development stage of industry and infrastructure, it also pose a potential hazard to marine ecosystems and aquatic life. So, we need to create an innovation that can overcome these problems. The government itself has used several ways to deal with marine oil spill, including the use of oil booms or oil pumping equipment, and in situ burning.

In the current era, there are many new innovations that are more useful for tackling marine oil spill in Indonesia. Carbon nanotubes are one of the innovative materials that are able to bind oil twice more effectively than oil absorbents and can also neutralize toxins carried by oil spill. Modified carbon nanotubes can absorb up to 180 times their weight of oil, which is certainly more effective and efficient than commercially available adsorbents for cleaning marine oil spill in Indonesia [31,32]. In addition, another advantage of carbon nanotubes is that in the future it will have a bright future because it has many benefits in terms of effective and efficient separation of oil or water, removal of contaminants and organic dyes, contaminants emerging from industrial wastewater, oil absorption, and photo catalysis to keep surface water free from pollution and contamination.

The presence of carbon nanotubes is expected to advance the independence of the industry in terms of innovation in the field of environmental pollution management, in this case marine oil spill. With the use of carbon nanotubes to overcome marine oil spill in Indonesia, it will help industry owners and also the government in tackling marine oil spill. It is also expected to produce environmentally friendly materials for industries that have a direct impact on marine ecosystems.

7. Carbon nanotubes

7.1. General information about carbon nanotubes

Carbon nanotubes are micrometre-scale graphene sheets that rolled into cylinders and covered with circular fullerene [33]. Carbon nanotubes have been categorized into 3 groups based on their type of the walls. As reported by Jiajia [34]. Carbon nanotubes are classified into single-walled carbon nanotubes, double-walled carbon nanotubes, and multi-walled carbon nanotubes. The specific gravity multi-walled carbon nanotubes are higher than the other nano materials such as fullerene. Fullerene specific gravity is 1.7 g/cm³ and the carbon nanotubes specific gravity is 1.8 g/cm³ [33].

Due the reason that carbon nanotubes have a high number of specific gravity with complex porous cavity structure, than carbon nanotubes are the best absorbent material that can be applied in contaminant-polluted environment. In addition, carbon nanotubes also good absorbent to surmount polycyclic aromatic carbon, dioxin, and benzene [33]. Thus, the use of carbon nanotubes to clean up marine oil spills is a correct and wise solution because it is effective and environmentally friendly. Carbon nanotubes can be modified to aerogels or sponge to clean up the oil spills [35].

7.2. Various type of carbon nanotubes for the new technology as oil absorbent and ability of various type carbon nanotubes used for removal oil spill
The major focus in this research is to development nano-materials that from one of the broad benefits of carbon nanotubes that can clean up marine oil spills, carbon nanotubes has various type that can used for clean up the oil spills. In the allotment of cleaning up marine oil spills, each type of carbon nanotubes has different quality and absorption capacities. Further information about types of carbon nanotubes shown in Table 2.

| No | Type                                | Mass (g) | Density (mg Cm⁻¹) | Sorbate                | Absorption time (minutes) | Absorption capacity (g g⁻¹) | Desorption                   | Reference |
|----|-------------------------------------|----------|-------------------|------------------------|---------------------------|-----------------------------|-----------------------------|-----------|
| 1  | Carbon Nanotubes microfiber sponge  | 45       |                   | Heptane and pump oil   | 43                        | 43                          | Distillation or squeezing    | [36]      |
| 2  | Multi-Wall Carbon Nanotubes         | 0.2      |                   | Gasoline, Kerosene and Diesel no 1 and no 2 | 120                       | 10.5                        | Heating treatment            | [37]      |
| 3  | Carbon Fiber Fabric                 | 0.018    | 7.5               | Diesel and crude oil, Gasoline, olive oil, and pump oil | 15                        | 92.3                        | Squeezing and distillation   | [38]      |
| 4  | Carbon aerogels                     | 1        | 18.5              | Less than 1            | 26                        | 26                          | Squeezing and distillation   | [39]      |

Figure 7. Carbon Nanotubes Microfiber Sponge [36]
Figure 8. The SEM of Multi-Walled Carbon Nanotubes [37]
Figure 9. SEM of Carbon Fiber Fabric [38]

Figure 10. Process of Carbon Aerogels in absorbing and desorbing oil [39]

The physical shape of the carbon nanotubes microfiber in Figure 7 is irregular with the fibers sticking out. It has good quality in absorption capacity and can desorb by distillation and squeezing method. For
multi-walled carbon nanotubes, the SEM results in Figure 8 show it has quite a lot of gap which will full when it absorb oil [37]. However, the SEM results of carbon fiber fabric in Figure 9 show that there are more gap, this indicates the absorption capacity of this material is greater than other types. It has longer absorption time than the carbon aerogel in Figure 10. Carbon aerogels are the fastest on the absorption time because of the physical shape. An illustration of the absorbing until desorbing process of the carbon aerogels can be seen in Figure 10

7.3. Conventional technology used to deal with marine oil spill and excellence of carbon nanotubes sorption technology toward oil spills removal

Prior to advances in the use of carbon nanotubes to clean up marine oil spills, oil spills was cleaned with nano porous sorbent, such as graphene [40], magnetic nano particles [41], bioremediation with active bacteria [42], photochemical oxidation [43], and in situ burning [44]. The problem, each technology has a limit of ability that still causes bad side effects. These limit of ability need some innovation for fast, effective, sustainable, and ecosystem friendly to avoid the danger effects by marine oil spills [45].

Among the inorganic materials such as active carbon [46], there are several organic material such as hucks, cotton [47], and bagasse [48]. Organic materials certainly has a low impact on the marine ecosystem, but it has significant drawbacks such as low buoyancy, the oil spills not correctly absorbed, and low hydrophobic quality so it affects to the absorption capacity [49]. Over the past decade, the technology used to deal with marine oil spills has been appropriate because it focuses on limiting the spread of oil spills, the success rate of oil recovery, and how it affects the marine ecosystem. It needs the newest innovation of the material that continuous develop [50].

As we know, specific gravity of graphene is under carbon nanotubes. Even though graphene contains carbon, the absorption is not good as carbon nanotubes. As well as in situ burning, in situ burning can clean up the oil spill but this technology creates a new pollution to the environment. As shown in the table 1, carbon nanotubes-based materials such as carbon nanotubes microfiber sponge, multi-wall carbon nanotubes, carbon fibre fabric, and carbon aerogels can be used for oil absorbent materials that efficient, effective and environmentally friendly because its reusable.

8. Project implementation concept

8.1. Main concept which equipped with illustration picture

The concept that the author brings is to realize the use of carbon nanotube-based products as the main material used to deal with marine oil spills. For initial processing, carbon nanotube powder is processed into fibres and then the fibres will be reprocessed into carbon nanotube fabric sheets. The cloth made from carbon nanotubes is then cut to a predetermined size and dimension and then linked to a buoy, this is intended so that oil spills that occur in the area can be handled effectively and efficiently and maintain the sustainability of marine ecosystems with carbon properties. owned by the product. With this concept, the oil produced in carbon nanotube sheets can be reused by related companies so that losses due to oil spills can be minimized. Illustrations showing the detail of carbon nanotubes-based fabrics, the manufacture of carbon nanotubes-based fabrics, and the application of oil-absorbing products from carbon nanotubes can be seen in Figure 11, Figure 12, and Figure 13.
8.2. **Best impact for the environment by using carbon nanotubes as the oil absorbent**

Resolution to the problem of water contamination is considered important so as not to damage marine ecosystems. Features that make physical remediation as an act of water contamination, especially in the sea are of particular concern to environmental activists as well as the government. The cause of this contamination is due to oil exploration, sea transportation, and industrial operations in the world [51]. Tackling oil spills efficiently and being able to recover a considerable quantity of oil with minimally damaging marine ecosystems or not at all is indispensable for this case [51]. The use of carbon nanotubes-based products as the handling of oil spills at sea due to oil exploration is believed to be a new idea that is more effective and efficient in handling oil spills so as to reduce the effects of damage to marine ecosystems. With the use of carbon nanotubes-based products, it will cope with oil spills in a superior way, namely with highly effective performance in the absorption and recovery of organic oil and solvent products [35].

8.3. **Target community who get benefit by using this innovation**

8.3.1. **Government.**

The area of the sea based on United Nation Conversation the Law of the Sea (UNCLOS) on December 10, 1982 which reached 6,400.00 km². If carbon nanotubes-based products are realized and applied to cope with oil spills in the sea, then the government will benefit such as a maintained marine ecosystem, so as to support the tourism sector that can contribute to the country's income and impact the economic sector.

8.3.2. **Entrepreneurs involved in oil exploration.**

The realization of carbon nanotubes to overcome oil spills at sea, will certainly bring benefits for entrepreneurs who move in the field of oil exploration. This is because in addition to absorbing oil spills in the sea, carbon nanotubes-based products can also recover oil spills at sea to be reprocessed by related companies. In addition, carbon nanotubes are also a recyclable material so that they can be used to the maximum.

8.3.3. **Fisherman.**

With a livelihood in the sea, of course marine oil spill will have a big influence on marine ecosystems, which will certainly affect the income of fishermen. If it is left unchecked, then the marine ecosystem will be damaged and the fish that will later be caught have poor quality, can even die. Therefore, with the realization of carbon nanotubes to overcome marine oil spill in the Sea of Indonesia, fishermen will benefit in the form of marine ecosystems that are maintained and avoid pollution due to marine oil spill, so that the fish produced will be better quality.
8.3.4. Parties who can help implement this oil absorbent innovation.
Related parties that will succeed the formation of oil absorbent products based on carbon nanotubes, including the government of the Republic of Indonesia, especially the Ministry of Marine Affairs and Fisheries, the Ministry of Transportation, and the Ministry of Health conduct cooperation to realize the idea. Furthermore, experts in the field of oil and gas aimed at designing plans, making products, as well as the operation of ideas, and lastly, the company involved in the oil exploration project, in this case related to the purchase and management of shares.

9. Conclusion
Oil exploration in Indonesia causes the risk of marine oil spill in the Indonesian sea to increase. In addition, offshore oil drilling also presents considerable risks to marine pollution and its impact on biodiversity. The adverse impact is the destruction of mangrove and marine ecosystems, such as fish, coral reefs, and others. The handling that is still applied by the government is considered ineffective because it causes new pollution and requires a large cost. We need a solution that can solve the problem effectively and not cause any new damage. Innovation of carbon nanotubes as a product that will be used to overcome marine oil spill in Indonesia can be the right solution.

Carbon nanotubes are excellent adsorbers when applied in contaminant-contaminated environments. Carbon nanotubes in the form of powders are processed into fibers and then into sheets. Fabric-based carbon nanotubes are then cut to such dimensions and associated with buoys. With this concept, oil produced in carbon nanotubes sheets can be reprocessed by the relevant company so as to minimize losses due to oil spills. Another advantage of carbon nanotubes is that it does not cause pollution and binds more oil so that it is more efficient than other methods.

The occurrence of marine oil spill hinders the achievement of SDGs number 9 goal which is to succeed the industry, develop infrastructure, and create innovation. The government and oil companies are still less innovating in tackling marine oil spill so the underwater life preservation system cannot be said to meet the Sustainable Development Goals (SDGs). The presence of carbon nanotubes is expected to advance the independence of the industry in terms of innovation in the field of environmental pollution management, in this case marine oil spill. With the use of carbon nanotubes to overcome marine oil spill in Indonesia, it will help industry owners and also the government in tackling marine oil spill. It is also expected to produce environmentally friendly materials for industries that have a direct impact on marine ecosystems.

Related parties that will succeed the establishment of oil absorbent products based on carbon nanotubes are the government of the Republic of Indonesia, especially the ministry of marine affairs and fisheries, the ministry of transportation, and the ministry of health to work together to realize the idea. Furthermore, oil and gas experts aimed at designing, creating products, and operating ideas, and finally, companies involved in oil exploration projects, in this case related to the purchase and management of shares. While the parties who benefited with the realization of carbon nanotubes as a solution to overcome the marine oil spill are the government, entrepreneurs involved in oil exploration, and fishermen.

Acknowledgement
The paper was supported by PKM Center Universitas Negeri Malang, Universitas Negeri Malang, and Directorate General of Higher Educational, Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, who has provided an opportunity in the Student Creativity Program (PKM) for the 2021 funding year.

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