Managing Drilling Sludge and Other Wastes Occurred in Oil Industry in Developing Countries with the Reverse Logistics Implementation

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Abstract
In recent decades, reverse logistics has been a topic of interest for organizations and researchers. However, there is still disbelief in reverse logistics in most companies rising from uncertainty about it. Implementing reverse logistics requires big investment which scares top managers as they are sceptic about potential benefits it can bring to a company. Although, due to international and local regulations about green economy companies are more interested in green supply chain management which also increases competitiveness of businesses and builds positive image. Building reverse logistics network can increase the profit, cut the costs of the companies and save the nature. There is a gap in research conducted in managing waste in oil sector with reverse logistics, especially in developing countries. However, oil and gas sector is among leader industries with considerable recycle and reuse opportunities with the help of implementing reverse logistics properly as this sector generates a large amount of waste. The article aims to describe the potential benefits of reverse logistics for business in oil industry with explanation of the treatment of drilling sludge and ways to manage it efficiently. This study's findings suggest proper waste management for oil sector with implementing reverse logistics system in oil industry which is beneficial both for researchers and practitioners by providing more clarity and better understanding, and it opens more room for future investigation and discussions.

Keywords: reverse logistics, green supply chain, oily waste, drilling sludge

1. Introduction

Supply Chain Management (SCM) is managing the flow of goods and services since they are produced as a raw material until turned into final products and delivered to the final consumers. The success of a companies is correlated with its efficiency in Supply Chain Management. When supply chain is well managed, companies will increase their profit and cut the operating costs. (Shilpa et al., 2015).

While talking about Supply Chain Management and distribution, logistics should be mentioned as well. Logistics is a narrower concept than Supply Chain Management, and it is basically a strategy guideline and structure to establish a single approach for product and information flow into a business. As Vacar Anca (2019) described, logistics now is an important part of SCM and it includes the planning, implementation and monitoring of the flow, handling of goods and resources in order to satisfy consumers' demands.

Some companies start to get aware of the importance of logistics and supply chain management in their business recently. Therefore, not every companies is familiar with reverse logistics concept while it should be considered as an independent branch and taken seriously. Although some companies implement reverse logistics efficiently, a thorough understanding of the advantages of reverse logistics deployment in developing markets remains a lack for various manufacturing firms (Mohamad Amin Kaviani et al., 2020).

For two main purposes, reverse logistics management matters in supply chain management; reverse logistics merely eliminates the waste produced by companies in the first place. Secondly, a well-managed reverse logistics network will save substantial costs for suppliers and warehouse installations.

Reverse logistics can be defined as a process of planning, implementing, and controlling the flow of products, finished goods and information from the final destination to the back in reversed direction for purposes as satisfying customers, reusing and recycling products for extra profit and cost reduction or disposal. As it is mentioned before, it is not aimed only for making profit and reducing expenses, but also protecting environment. Disposal processes should be done in a right way in order not to harm the nature.

One of the main sectors which can be harmful for environment if not obeyed the international and local environmental rules is oil field. Reverse logistics in this sector is so vital to save the nature and make profit from used oil products. Drilling cutting is one of those oil products that occur after drilling operations and contains chemicals which can be recycled and reused, otherwise bare disposal of it can be harmful for the environment. Unfortunately, in most of developing oil producing countries this factor is neglected and can cause for big phenomenon for nature in the future if not considered early.

2. Research Method

This is an analytical policy study examining the implementation structure of the reverse logistics in oil sector. In order to research this mechanism and system secondary sources were used and analyzed. Secondary information was obtained by analysis of the existing scientific studies which is available online relevant to the subject. Practice of successful international oil companies were viewed in order to find possible recommendations to implement efficient reverse logistics in petroleum industry. Life Cycle Assessment (LCA) method was utilized

which is internationally standardized by the International Organization for Standardization (ISO) through the 14040 series of standards. This research aims to achieve a deeper understanding of implementing reverse logistics on business. Qualitative method has been used in this study in order to collect data as it is more versatile and flexible throughout the data mining.
The overall aim is to discuss viewpoints of reverse logistics understanding, benefits businesses can get by implementing RL and right design to build it for oil companies in developing countries to manage drilling sludge and other wastes efficiently, following these to draw conclusions based on existing literature and in this systemic context.

3. Body of paper

3.1. Understanding Reverse Logistics

Reverse logistics, a fairly recent logistics idea, has become more and more important as a successful and viable market strategy. Reverse logistics provides businesses and supply chains endless resources in different fields with the help of activities such as, collecting end-of-life products, industrial long-lasting goods and several kinds of wastes, managing hazardous wastes, recycling and many other activities (Gupta, 2013). Because of end-of-life products, attention and responsibility towards environment has been increased. Now, companies do not only consider forward logistics, but also Green Supply Chain by adding reverse logistics too (Kazemi et al., 2018).
By integrating reverse logistics to supply chain, companies can increase the value of their resources and decrease waste which means extra profit due to recovery of used products.
Unfortunately, because of the lack of knowledge and practice about reverse logistics, some companies miss the chance to take advantage of this business branch. Because of the environmental rules and regulations of governments and to save the nature, companies must take care of waste management and proper disposal. Without reverse logistics companies fulfill this task with extra cost, however it could be more efficient.
As logistics and supply chain management plays a crucial role in economy, reverse logistics is also important and lucrative branch of economy. All processes starting from resource allocation and storing to transportation of goods to the final destination are components of logistics. However, reverse logistics is planning, implementing and controlling the flow of products in a reversive direction for different purposes such as, reusing, recycling, repairing and disposing (Shaligram, 2009). Unfortunately, not all companies consider benefits of reverse logistics and take advantage of it, as it is cost saving if implemented right.
Reverse logistics helps to recover assets and products and also discarding materials in a correct way. It aims to return assets back to the life cycle and add them additional value such as legal, ecological, economical and location using different reverse distribution channels. All these can be succeeded with a proper reverse logistics strategy and a plan (Saurab, 2015).

3.2. How Drilling Sludge Occurs

While drilling operations, oil companies pump drilling water or mud down in well in order to get drill cuttings and other different kind of metals which are heavy to the surface. Following this process separation of drilling cut and fluid starts. The same fluid after being re-injected is used again for the further drill cutting lifting. The drill cuttings that mentioned are solid now

and needs either to be disposed after some treatments or kept in containers or waste pit for future operations and discarding. If the drill cuttings are not discharged properly into sea, this action puts marine life in danger. Because of the emission of internal combustion engines occurred air pollution can be unhealthy both for animals and humans, side effects will create a vegetative disruption and soil acidification as well. Hydrogen sulfide is one of the most dangerous elements released to air which is able to be fatal for living things.

Unfortunately, it is hard to reinject drilling cuttings in offshore, dispose and transport them to onshore plants. That is because of lacking enough space in offshore and governmental and international regulations concerning offshore drilling operations. Therefore, most of wastes occurred in the sea are sent back to the seashore facility in order to be treated and dispatched. Onshore fields have more opportunities to deal with waste.

So called solids control equipment is commonly used by drilling companies. It takes drill cuttings from the top of the drilling mud shortly before the mud reaches the recirculation pot again. Here not only drill cuttings are removed but also some type of gases and other materials. The early elimination of these solids prevents the structure and the separation unit from accumulating and blocking in solid size. The types of drilling fluid play crucial role here.

As mentioned above, drill cutting go to surface with the help of pumped fluid through drill string and drill bit. When drill cuttings come to the surface unwanted solids are separated from the drilling water with special solid control machines. It provides maximum recovery of drilling fluid for recycling and reusing purposes. The clean water which is recovered is not thrown away but used again for lifting other cuttings and this circulation continues. After separation solid component remains as a waste stream which needs to be disposed. Entities have three options to dispose it such as, discharging into the sea, transporting to onshore or reinjection into the formation. 2 options are mainly used: offshore discharge and hauling it to seashore so outsourced companies can take it from there. When wastes are brought to onshore, they are either bought or disposed by recycling companies. According to Ahammad et al. (2017), drilling companies usually have 2 options to dispose the waste: onshore and offshore discharge. Before choosing the method, companies should make environmental and economic analysis. If the discharging method is offshore disposal, companies do not need storage facilities. The most economical and operationally safe method of disposal is offshore discharging the waste in the sea or ocean as it does not demand extra equipment than companies have on the rig according to international terms. If the drill cuttings are aqueous based there is no need for any treatment before discharging them into the sea. However, non-aqueous based liquids and fluids require a special treatment in order to protect environment which is regulated with international and local laws with a certain environmentally accepted level. Main factors to be considered before choosing which method to apply on disposal are features, capacity and sensitivity of the receiving environment, compounds and ingredients of potential elements in the waste and of course the volume of the waste stream.

After carefully re-injection and other treatments of discharged waste, companies use a pipe which is called “downcomer” to dispose so-called fluids. Following process is being accumulated in various degrees in the sea as disposed residue will remain on sea ground. If the residues and waste is thick then accumulation process will take longer than thin one. The impact of drill cuttings to the water is insignificant as they can easily settle down and water solubility of the base fluids is limited. A huge pile of cuttings and its residual liquid load are a

challenge for the decommissioning of the facility. Dislocation of a pile and elimination of the base will greatly increase the risk for harmful effects in the broader aquatic ecosystem.
Implementing this method is not costly per unit volume treatment and some companies do not have any onshore facility liabilities. There are some benefits in operations as well when companies choose off-shore discharging such as, not having transportation costs, low safety risk, personnel and equipment needed. Furthermore, there is not any environmental problem at onshore sites but on seafloor biology, low energy is used and it is not polluting air with emissions. Although this model does not require too much operational costs, it has costs of analysis of disposals and potential effects.
Basma Y. (2007) mentioned that recent stringent rules do not permit the disposal directly into the sea of hazardous waste. Therefore, reinjection process of drill cuttings and disposing after that becomes common practice. This technology transforms solids into tiny fragments, adds water and other liquid and mixes them to form slurry, later injects the slurry with high pressure into underground so that it can disperse the rock. There are two commonly used methods to inject the slurries: via the annulus of the well or pumping into a disposal well. The function of disposal wells is easily transporting the fluid waste to an underground geologic formation which will not have side effect on environment.
Solids and cleaned cuttings should be transported to onshore later. Finally, it can be sent for reusing, recycling or disposing as land-spreading. Mostly non-aqueous drilling wastes are disposed with this way as it is harmful for environment because of its toxic nature. Companies should consider the distance between platform and seashore and costs of chattering a vessel to transport wastes.
On onshore, oil and gas companies have more options to dispose the waste due to availability of space. Commonly used method of discharging is burying the waste. There are also additional ways to dispose the waste, but most of the companies outsource this service. There are different practices to deal with wastes by oil and gas companies. The easiest way to discard the waste on onshore is basically onside burial. Waste can be buried in natural or man-made wells and landfills. This method is very cheap and does not require expensive technology and equipment. However, this way is not always good in case of environment. Contaminants of wastes should be considered carefully as they can be comprised of salt, oil, metals, chemicals and other toxic elements which can be harmful for water resources and nature.
Disposing companies may have private landfills to treat with cuttings and other kind of wastes. Wastes are placed in a containment field and it is designed to cover and contain the waste there. While using landfills companies consider the quality of the design and materials, plus geological features of the land underlying. Wastes lay there for a long time; therefore, it can be seen as a storage not destroying site. Landfills are usually able to receive wastes from different drilling sites and are operated by offsite commercial operators.

3.3. Results and Discussions

Because of higher materiel prices, increasing international regulatory demands, a lack of funding and global warming, organizations are compelled to acknowledge the value of environmental activities not only the reverse logistics which bring companies sustainability, but also the whole supply chain. Implementing reverse logistics activities provides

organizations with a strategic advantage in a competitive global world. Oil and gas sector is among leader industries with considerable recycle and reuse opportunities. Because of legal, economic, social and environmental concerns, reverse logistics grabs attention of many organizations all over the world. Reverse logistics is able to help companies to solve the resource scarcity problem as it closes the loop of supply chain. In order to have effective reverse logistics practice, companies should establish appropriate communication between different staff ranks. Since reverse logistics activities were hardly applied by organizations as a result of strategic preparation measures and the established model, it can be concluded that government plays a major role in removing obstacles, by formulating strict rules and regulations. The government should also close the gap in improved and effective reverse logistics operations between the organizations and the industry. The industry extensively needs to improve motivational legislation, promotions or advantages in order to be encouraged to adopt reverse logistics activities.

There are several reasons why some oil companies do not have a proper reverse logistics system. Firstly, awareness of benefits about reverse logistics should be increased among top management and employees. Companies are sceptic about investing in product recovery management and reverse logistics as it has high initial investment costs and low ROI for short-run. It is necessary to use statistics and data of waste management in order to have a clear idea about current costs. Thus, the companies can calculate and estimate future investment costs and profits after implementing reverse logistics. With comprehensible view companies will be able to see main advantages of reverse logistics and alternative costs as a result of lacking it which would increase awareness about reverse logistics. There is a disbelief about the capability of green activities to boost the economy of the companies as it generates many uncertainties. With right tools, software and technology this kind of uncertainties can be eliminated. Clearly, reducing or removing obstacles to reverse logistics adoption would cut the cost of the companies, protect the environment, boost the organization's productivity, increase profits, market share and so on.

In order to build sustainable reverse logistics system, companies should hire professionals who have worked in this field and are able to design the right measured design for the companies. Bringing professionals also creates opportunities to train employees and increase their practical awareness about reverse logistics activities. Using practical knowledge of employees and discussion with them before integrating to reverse logistics is important as they are aware of operations and values of the companies. Shift to reverse logistics will cause to resistance among employees. Involving them in new operations would overcome this barrier as they will understand their importance and role in the process as well. This will avoid oil companies losing its employees.

It is important to examine the level of awareness about reverse logistics advantages in practice in the enterprise and to analyze the main fields and goods of the organization which can make a profit by applying reversed logistics. Most of the wastes occurred in drilling process of oil companies can be recycled and reused by companies later, and that will decrease the need and cost of raw materials. Household and general wastes, empty metal and plastic drums, sludge, wastewater, oils and chemicals can be counted as mentioned items that can be recycled. Instead of this, companies either sells them to other entities with cheap price or spend money on their disposal without reusing. Disadvantage of this act is spending extra money and missing the chance to benefit from product recovery and recycling benefits.

Drilling sludge contains drilling fluid and drill cuttings. The mud is separated from drilling sludge with shakers. In order to avoid muds from dropping to the ground speed of shakers should not be so fast. Therefore, with the separation of soil and drill cuttings, base oil and other reusable chemicals can still be found in the waste. With building proper facility and equipment, oil companies can utilize that waste and use as a raw material or sell it as it is possible to recover base oil and water from drilling fluid. Despite that soil waste can be disposed effectively and with low cost instead of transporting it to onshore and then realizing disposal by other organizations. Thus, oil companies can dispose solid waste to new drilled or old dead and empty oil wells to fill them. With this method companies will not transport those wastes to onshore or dispose to the sea which means reduction of costs and saving environment. It is used by leading companies; they drill additional well for disposing purposes near the oil well and fill it with pressure by drilling sludge.

The planning process for the forward logistics network for both distributors and suppliers starts with network design containing number of facilities in the network, locations of them, target customer area to be served and its size. All of that factors are considered in reverse logistics decision, plus considering how to better take account of the various nature of materials in the reverse direction.

In oil and gas industry reducing the generation of waste with better management is vital. Reverse logistics network will help companies to deal with wastes occurred while drilling effectively, and get some benefits such as increased revenue, reduced running expenses, supplies, waste collection and recycling costs, energy costs and facility clean-up, improved quality of operations, improved social image, and it should be customized for each company individually. Company based reverse logistics will start with initial waste sorting and separation by employees on offshore drilling installations and platforms.

In drilling sector, in order to bring rock clips to the surface and for the lubrication and cooling of the drilling bit, companies use drilling mud, which is also called drilling fluid. Because of economic and environmental purposes, oil and synthetic based muds are normally washed and reused again for the same operations. There are some larger drilling cuttings which are removed in shakers with several vibrating screens or sometimes by passing through centrifuges. Cuttings are centrifuged and the rest of mud are removed and dried afterwards. Shakers are not moving fast in platforms, as companies does not want the fluid to drop from shakers. After separating reusable drill mud, the rest dried cuttings are sent to onshore in order to be disposed which is done by other companies. However, that dried drilling cuttings still contain some reusable chemicals, oil-based and synthetic-based drilling fluid and other items. Depending on the company's strategy there are 2 solutions in order to reduce the amount of waste to be transported and recover more reusable drilling fluid with using capital expenditures (CAPEX) and operational expenditures (OPEX) methods. With the CAPEX method, company can invest on new vacuum dryer system which is more successful in drying the drill cuttings than the traditional centrifugal dryers. Thus, the weight of waste will decrease and contaminants utilized. In order to dispose the dry drilling cuttings, either the company digs another hole near oil well which is costly and hard, or dispose the cuttings to existing dead oil wells. Considering that the drilled area is not new and there are several old open oil wells, it is reasonable to dispose the dried drill cuttings to the hole to fill it. With this method, companies will avoid the transportation cost and meet the environmental goal. If a company chooses to use OPEX method, then transportation cost will rise. Thus, drill cuttings

dried with traditional way, needs further treatment on onshore facility to utilize the waste which can be built nearby sorting and dismantling area. Later on, outsourced disposing companies can take the non-reusable waste and dispose with burying method.

In order to reach the cost effectiveness, economic balance of income from recycled waste minus expenditures on collection and landfill charges should be considered. The separation of recoverable objects from scrap at drilling installations could be possible by individual collections, which will reduce the amount of sorting later on onshore. If testing and grading facility will be close to the port, it would decrease the transportation cost from offshore platforms, specially by sorting valuable items from scrap. Investing on test equipment may require more centralized operation. There are various influencing parameters, such as transport costs, volume of collection and the rate of scrap which can be balanced by using advanced IT for testing remotely. In onshore facility with the help of solid waste sorting machine, oil companies can save more resources instead of burying them in landfills or burning. It is very difficult to process wastes together because of the diverse nature of solid waste. In the meanwhile, certain waste can be recycled and has high future values. Therefore, it was very convenient to have a solid waste sorting system that can filter different waste based on materials and potential values.

After separation of reusable wastes, companies will need to transport them to warehouse. Outsourcing the transportation can be an option for delivering the valuable wastes to warehouses, from there to buyers, and useless scrap to disposing companies if companies do not have appropriate trucks in the port to transport the waste. According to negotiations, it is possible to agree with buyers to come and take wastes from warehouses with their vehicles which would save a company from transportation costs. Other left-over wastes which can not be recycled or reused should be disposed in a proper way. They consist hazardous and non-hazardous wastes. Companies that do not have reverse logistics practice including proper disposal processes should outsource that service as well in order to efficiently manage the waste. Disposing firms provide a full range of waste treatment that might meet the diverse demands of oil and gas companies.

In the facility of waste management, it is beneficial to have a baler machine. It is intended to automate the process of recycling waste products such as aluminum, paper, plastic, carton and glass by compressing them into a cube block. Recyclable products are stored, transported and processed much better with blocks provided by a recycling baler. Compactors and balers have become urgently needed for companies seeking to extend the processes of waste recycling and disposal while decreasing costs and saving space. Transport and recycle companies get paid for the volume of waste which is not pressed and takes more space. Bringing the mentioned machine will help companies to avoid this extra expenditure and even reduce the need for bins.

Considering the logistics practice of leading companies in oil and gas sector, it is recommended to integrate with companies which provide vessels. In this case, applying single software system is required in order to seamlessly share logistics data between companies. Developed logistics streamline will help organizations to move shipments safe, fast and cost-efficiently and optimize resources. Logistics management is a time-consuming and difficult process. With the help of one single digital platform, demand for the telephone calls and paper works will decrease, and operations will be easier along with the opportunities of minimizing errors and miscalculations. Exchange of data between companies

will optimize the transportation by ships and avoid vessels to move empty. That is because transportations will be planned beforehand and with the help of accessible data, routes will be schedulled in an efficient manner. The software would enable continuous assessment, predictive planing, as well as economic freight and transport of people by integrating the usage of revolutionary enterprise inteligence tools with big data and artificial intelligence. Software eliminates inefficiencies immediately, avoids under-use and corresponds supply and demand. All involved companies will have the full summary all the time. Comprehensive monitoring of all freight movements across the supply chain will be facilitated with streamlined connectivity for rig operators, vendors and coordinators. While using the software, in the system it will be visible for carrier and the company what is inside the shipped containers. Status of containers will be managed by service orderer whether it is a transportation of waste or equipment and etc. Ship preparation and monitoring practices and the visualization of deck and bulk conditions are supported by software. It also enables the vessel network to optimize resources and facilitates the exchange of vessels with other operators. The AI route optimizer will actively update the route and operating options for oil companies based on existing and potential scenarios which will help the company to make optimal tactical decision.

4. Conclusion

Reverse logistics network should not be viewed as a separated division but rather as a part of broader supply chain structure. The combined interaction and alignment of these various systems is one of the main logistical problems in the management of closed-loop supply chains. Synergies in transport, collection and recycling can be seen in particular. Simultaneously, these possibilities provide a problem of compatibility, because reverse logistics network is not build from zero but is implemented in addition to current logistics systems. Of course, it does not mean that traditional logistics and reverse logistics activities have to always be combined, however, there is a potential synergy between them which can contribute to the company to boost the economy. One of the most critical features of the design of reverse logistics network is it has a multi-institutional character, and it should not be neglected. In addition, like other network design models, reverse logistics also should be controlled by central decision maker. However the interaction of various actors with different objectives and different market influence is one of the major driving forces for logistics networks. That is because, it might also be useful to address the reverse logistic network design from this point of view as well.

Reverse logistics can provide companies with a significant competitive advantage and should be recognized as an important matter with regards to sustainably resource management and environmental advantages. With the help of well established reverse logistics system oil companies can benefit from cost reduction, profit gained from efficient operations and usage of waste, also increase the social image with saving the nature. While reverse logistics is able to boost sustainability and promote green manufacturing, several barriers and challenges still exist that hinder the progress of initiatives in this field, particularly in developing countries.

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