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WASTE MANAGEMENT IN OIL AND GAS INDUSTRY: A COMPARATIVE STUDY OF INDIA AND RUSSIA

Krina Daruwala
WIPRO

ABSTRACT: The study aims to understand waste management in the context of the oil and gas industry by focusing on analysing the impact of waste on environment and the human life. Further, the study compares the waste management policies of two different countries, India and Russia. Finally, the study examines the different ways/strategies for better waste management in the oil and gas industry. The result found that India's Ministry of Environment, Forests, and Climate Change regulates hazardous waste through rules like the Hazardous Waste Management Rules, 2016, focusing on the oil and gas industry. In contrast, Russia's Rosprirodnadzor oversees waste management with broader laws. India's monitoring addresses soil, water, and air pollution comprehensively, while Russia's regulations encompass all environmental preservation aspects. Despite India having specified disposal facilities, Russia boasts a more developed waste management infrastructure with numerous disposal facilities.

Introduction

The proper handling, treatment, and disposal of numerous types of waste produced during the discovery, production, and transportation of oil and gas are all part of the idea of waste management in the oil and gas sector (Shahbaz et al., 2023). Hazardous substances, drilling muds, generated water, and other waste streams are examples of this waste. In order to comply with regulations, waste management in the oil and gas sector aims to reduce the harm that these waste streams cause to the environment and to people's health.

The oil and gas sector employs a number of waste management strategies, including safe disposal, waste reduction, reuse, and recycling. In the oil and gas sector, some typical waste management techniques include Reusing produced water, Drilling Waste Management, Hazardous Waste Management etc. The amount of waste generated during oil and gas exploration, production, and transportation makes waste management essential in the oil and gas sector. Solid trash, liquid waste, and hazardous waste are all types of waste produced by the industry. The improper management and disposal of these wastes can result in regulatory non-compliance, environmental contamination, and harm to human health.

The oil and gas industry faces enormous waste management challenges because of the volume of hazardous and non-hazardous waste it produces during operations. To reduce environmental damage, adhere to regulatory standards, and preserve the social licence to operate, effective waste management procedures are crucial. By highlighting the difficulties the industry has had managing waste and the tactics used to enhance waste management standards, this literature review attempts to give a general overview of waste management methods in the Indian oil and gas industry.

The study aims to understand waste management in the context of the oil and gas industry by focusing on analysing the impact of waste on environment and the human life. Further, the study compares the waste management policies of two different countries, India and Russia. Finally, the study examines the different ways/strategies for better waste management in the oil and gas industry.

Significance of Waste Management in Oil and Gas Industry

The amount of waste generated during oil and gas exploration, production, and transportation makes waste management essential in the oil and gas sector. Solid trash, liquid waste, and hazardous waste are all types of waste produced by the industry. The improper management and disposal of these wastes can result in regulatory non-compliance, environmental contamination, and harm to human health. The importance of waste management in the oil and gas industry can be discussed in detail as follows:

1. **Environmental Protection:** The oil and gas business contributes to environmental protection by properly managing waste. Using sustainable waste management techniques can aid in reducing environmental contamination, and the industry must limit its influence on the environment. For example, using generated water from the extraction of oil and gas as a substitute supply of water for other uses lowers the demand for freshwater resources and prevents the release of contaminated water into the environment (Drapier & Morillon, 2000)
2. **Compliance with Regulations:** The oil and gas sector is governed by several regulations regarding waste management, including those pertaining to the management of hazardous waste, the control of air and water pollution, and waste disposal. To avoid legal repercussions and reputational harm, compliance with these standards is essential. The industry can comply with these laws and lower the risk of regulatory infractions by using proper waste management procedures (Lodungi et al., 2016).
3. **Waste management is crucial for the oil and gas sector's efforts to conserve resources.** The sector produces waste that contains valuable materials that can be salvaged, used, or recycled. Recycling and waste reduction techniques can help the sector save money, protect natural resources, and consume less energy.
4. **Cost savings:** Adequate waste management procedures in the oil and gas sector can aid in lowering expenses associated with trash disposal, including transportation and landfill fees. Initiatives for recycling and waste reduction can also help to reduce the amount of garbage produced, which lowers the expenses of waste disposal.
5. **Corporate Social Responsibility:** The oil and gas sector must conduct its business in a way that is socially responsible. Effective waste management techniques can help to improve the reputation of the sector and foster stakeholder trust. Implementing sustainable waste management techniques can also show how dedicated an industry is to sustainability, social responsibility, and the environment (Frynas, 2009).

Literature Review

The oil and gas industry generates various hazardous wastes during its operations. Here are some examples of hazardous wastes in the oil and gas industry:

1. **Drilling fluids:** During drilling operations, drilling fluids are utilised to lubricate and cool the drill bit. These fluids contain a number of dangerous compounds, including barium, chromium, and lead, which, if not handled appropriately, can contaminate the land and water.
2. **Produced water:** Produced water is a waste product of the oil and gas industry that contains a number of dangerous compounds, including radioactive substances, heavy metals, and hydrocarbons.
3. **Chemical and Solvents:** Several chemicals and solvents are used by the oil and gas sector for a variety of tasks, including cleaning and maintenance. These substances can be dangerous to both human health and the environment since they contain benzene, toluene, and xylene, among other hazardous substances.
4. **Radioactive Waste:** Oil and gas exploration, production, and transportation all produce radioactive waste. This trash contains a number of radioactive substances, including radon and radium-226, which, if not handled appropriately, can lead to cancer and other health issues.
5. **Contaminated soil and debris:** Throughout drilling and production operations, the oil and gas industry produce a range of contaminated soil and debris. These substances could include potentially dangerous substances like heavy metals and hydrocarbons, which could be harmful to the environment and human health. (Szymon Kalisz, 2022)

The oil and gas sector also produces non-hazardous wastes, which can be any number of things that don't seriously endanger the environment or public health.

Non-hazardous wastes in the oil and gas sector include, for instance:

1. **Scrap metal:** Throughout operations, the oil and gas sector produces a variety of scrap metal, including pipelines, tanks, and equipment. These substances are recyclable and reusable.
2. **Drill cuttings:** Rock pieces that are produced during drilling operations are known as drill cuttings. These substances can be recycled or dumped in landfills because they are typically regarded as non-hazardous.
3. **Produced sand:** Generated sand is a by-product of the oil and gas industry that can either be recycled or dumped in landfills.
4. **Non-hazardous chemicals:** Chemicals that may be recycled or disposed of in landfills are also used by the oil and gas industry. Examples include lubricants.

Waste Management Policies in India

The Indian oil and gas sector is a vital contributor to the country's economy, but it generates a significant amount of waste that can have adverse effects on the environment and human health. The sector is subject to various policies and regulations for waste management, which aim to reduce waste generation, promote recycling, and ensure safe disposal of hazardous waste.

Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016:

Hazardous and Other Wastes (Management and Transboundary Movement) Regulations, 2016. For the collection, transportation, and disposal of hazardous waste, including waste produced by the oil and gas industry, the policy offers a regulatory framework. The policy also stipulates the obligations of the generator, transporter, and operator of hazardous waste facilities, as well as rules for the handling and recycling of hazardous waste. (Hazardous Waste Rules, 2022)

A policy for the management of non-hazardous trash, such as domestic waste produced by homes and business entities, is set forth in the Municipal Solid Wastes (Management and Handling) Rules, 2000. The policy outlines standards for the collection, handling, and disposal of non-hazardous trash. The strategy also promotes the use of recycling and waste minimization techniques. (MUNICIPAL SOLID WASTES (Management and Handling), 2001)

The Water (Prevention and Control of Pollution) Act, 1974:

A law for the prevention and management of water pollution is the Water (Prevention and Control of Pollution)

Act, 1974. The State Pollution Control Board (SPCB) must give its permission before an industry, including the oil and gas industry, discharges effluent into a body of water, according to the policy. The policy mandates that industries treat their effluent before releasing it into water bodies and establishes requirements for the quality of wastewater emitted by industries. (Water Pollution, 2019)

The Air (Prevention and Control of Pollution) Act, 1981:

The Air (Prevention and Control of Pollution) Act, 1981 is a policy for the prevention and control of air pollution. The policy requires industries, including the oil and gas sector, to obtain consent from the SPCB before discharging emissions into the air. The policy also lays down standards for the quality of emissions discharged by industries and requires them to take measures to reduce their emissions. (THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981, 1981)

Environmental Impact Assessment (EIA) Notification, 2006:

A policy for evaluating the probable environmental effects of development projects is the Environmental Impact Assessment (EIA) Notification, 2006. The policy mandates that before beginning any project or operation, all companies, including the oil and gas industry, must receive environmental clearance from the Ministry of Environment, Forest and Climate Change (MoEF&CC). The policy also outlines the information that must be included in an EIA report as well as the steps for completing EIA research. (MINISTRY OF ENVIRONMENT AND FORESTS, 2006)

The Petroleum Rule, 2002:

The Petroleum Rules, 2002 is a policy framework that regulates the safe handling, storage, transportation, and distribution of petroleum products in India. The rules were framed under the Explosives Act, 1884, and were last amended in 2018. The Petroleum Rules, 2002, cover a wide range of activities related to the petroleum industry, including refining, storage, transportation, and marketing of petroleum products.

Here are the key provisions of the Petroleum Rules, 2002:

Licensing: The rules require every person who wants to undertake any activity related to petroleum products to obtain a license from the Chief Controller of Explosives. The license is valid for five years and is renewable. The license specifies the type of activity that the licensee is authorized to carry out.

Storage: The rules provide guidelines for the safe storage of petroleum products. The storage tanks and containers

must be constructed and maintained in such a manner that they can withstand the pressure, temperature, and other conditions that arise during storage. The rules also specify the minimum distance between storage tanks and the maximum quantity of petroleum products that can be stored.

Transportation: The rules provide guidelines for the safe transportation of petroleum products. The transportation of petroleum products must be done in vehicles that comply with the requirements specified in the rules. The vehicles must be equipped with fire extinguishers, spill kits, and other safety equipment.

Fire safety: The rules require the licensee to take all necessary measures to prevent fires and explosions. The licensee must provide firefighting equipment and training to the employees. The licensee must also conduct regular fire safety audits and submit reports to the Chief Controller of Explosives.

Reporting: The rules require the licensee to maintain records of all activities related to petroleum products. The licensee must also submit annual returns to the Chief Controller of Explosives. The returns must provide details of the quantity of petroleum products handled, stored, transported, and marketed during the year.

The Petroleum Rules, 2002, aim to ensure the safe handling, storage, transportation, and distribution of petroleum products in India. The rules provide a comprehensive framework for the regulation of the petroleum industry and help in protecting public safety and the environment.

The Oilfields (Regulation and Development) Act, 1948:

This policy regulates the exploration, development, and production of oil and gas resources in India. The act mandates the preparation of environmental impact assessments and the implementation of environmental management plans to mitigate the impacts of oil and gas activities.

In addition to these regulations, the oil and gas sector in India has environmental management recommendations from the Ministry of Environment, Forests, and Climate Change. The guidelines contain advice for the identification and assessment of environmental hazards, the execution of environmental management strategies, and the monitoring of environmental performance.

The Global Reporting Initiative (GRI), which establishes rules for sustainability reporting, also applies to the oil and gas sector in India. The GRI requires enterprises to report on their environmental performance and to disclose their management strategies for waste management.

In conclusion, India has a comprehensive set of policies and regulations aimed at mitigating the environmental impacts of the oil and gas industry. These policies mandate the use of best available technologies and practices for waste management, and require companies to prepare environmental impact assessments and implement environmental management plans to mitigate the impacts of their activities.

Waste Management Methodologies

The oil and gas industry has created a variety of strategies to manage waste, with a focus on lowering waste creation, recycling and reusing garbage when possible, and disposing of waste sustainably. The Indian oil and gas industry has used the following waste control techniques:

- I. Source Reduction:** By using best practises, the sector focuses on lowering waste generation at the source. For instance, to reduce the quantity of drilling waste produced, oil and gas industries use closed-loop drilling methods. To lessen the amount of produced water generated during oil and gas production, the sector also uses water management techniques.
- II. Reuse and Recycling:** Wherever possible, the Indian oil and gas industry prioritises waste reuse and recycling. Drilling waste, for example, might be utilised as a component in cement manufacturing or for land reclamation. Refinery waste can be recycled and reused as fuel or feedstock in other industrial processes.
- III. Treatment:** To manage various types of waste, the sector employs a variety of treatment procedures. Oily sludge, for example, can be treated using thermal desorption or bioremediation procedures. Reverse osmosis, biological treatment, and chemical treatment can all be used to treat produced water.
- IV. Disposal:** To dispose of hazardous waste in an environmentally friendly manner, the industry employs a variety of approaches. Land disposal, incineration, and deep well injection is among the methods available. To ensure waste disposal is safe and sustainable, the sector adheres to the norms and guidelines established by the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs).

In addition to these waste management approaches; the Indian oil and gas business focuses on educating and training its staff in waste management best practises. In addition, the sector works with research institutions and technology providers to develop and deploy novel waste management solutions.

Generally, the Indian oil and gas industry acknowledges the need of sustainable waste management and has developed a variety of approaches to limit waste generation, reuse and recycle trash, and dispose of garbage in an environmentally sustainable manner.

Waste Management in Russia

One of the biggest producers and exporters of oil and gas worldwide is Russia. Yet, the development and processing of these resources generate enormous amounts of waste, which can have detrimental consequences on the environment if not managed effectively. Guidelines for the management of drilling wastes, generated water, and oil sludge have been established by the Russian Federation's Ministry of Natural Resources and Environment. These guidelines highlight best practises for waste management, including the use of recycling and reclamation technologies to limit waste volumes.

One example of a company in Russia that is implementing advanced waste management practices is Gazprom Neft. For the management of drilling fluids, the business has created a closed-loop system that enables the reuse of up to 90% of the fluids. The business has also put in place a produced water treatment and disposal system that makes use of biological treatment techniques. Nonetheless, despite ongoing difficulties, efforts are being made to reduce the negative environmental effects of these activities in Russia's oil and gas industry waste management.

Waste Management Policies in Russia:

Federal Law "On Production and Consumption Wastes": Companies are required by this regulation to create waste management strategies and get disposal permits. Additionally, it specifies standards for waste classification and disposal standards.

Federal Law "On Environmental Protection": The legal and regulatory foundation for environmental protection in Russia is established by this law. It contains guidelines for managing garbage, including how to keep an eye on how it is produced, moved, and disposed of.

Regulations for the Management of Oil and Gas Industry Wastes: Guidelines for the management of drilling wastes, generated water, and oil sludge have been established by the Russian Federation's Ministry of Natural Resources and Environment. The use of recycling and reclamation technologies to reduce waste volumes is one of the best practises for waste management that are outlined in these guidelines.

National Waste Management Strategy: The Russian government has developed a national waste management strategy that includes measures to reduce waste generation, promote recycling and reuse, and improve waste collection and disposal practices.

Industry-Specific Waste Management Programs: In order to adhere to the rules and policies established by the government, several oil and gas businesses in Russia have created their own waste management systems. With the help of these programmes, waste creation may be decreased, waste treatment and disposal can be improved, and recycling and reclamation technologies can be encouraged.

Overall, these policies and regulations demonstrate a commitment by the Russian government and the oil and gas industry to manage waste in an environmentally responsible manner.

Waste Management Methodologies in Russia

Many approaches are used in Russia to manage oil and gas waste, with the goal of minimising waste creation, improving waste treatment and disposal, and boosting the use of recycling and reclamation technology. Among these approaches are:

- I. **Waste Classification:** The Russian Federation's Ministry of Natural Resources and Environment has issued rules for the classification of waste from the oil and gas industry. These regulations divide waste into four categories: hazardous, non-hazardous, radioactive, and mixed trash. Each group has unique treatment and disposal requirements.
- II. **Waste Reduction:** Numerous Russian oil and gas businesses have introduced waste reduction strategies, such as optimising drilling practises to reduce the amount of drilling fluids and cuttings produced. Additional solutions include using closed-loop systems to recycle drilling fluids and improved water treatment technology to reduce the amount of produced water.
- III. **Waste Treatment:** In Russia, oil and gas waste is routinely treated using physical, chemical, and biological processes. Filtration and separation are examples of physical procedures, while oxidation and precipitation are examples of chemical methods. Microorganisms are used in biological processes to breakdown organic molecules in trash. Treatment methods are chosen based on the type of waste and the level of contamination.
- IV. **Waste Disposal:** The disposal of oil and gas waste in

Russia is regulated by the Federal Law "On Production and Consumption Wastes" and the Federal Law "On Environmental Protection." These laws require companies to obtain permits for waste disposal and to dispose of waste in authorized facilities. Authorized facilities include landfills, treatment facilities, and industrial waste disposal sites.

- V. Recycling and Reclamation:** Numerous Russian oil and gas businesses are employing recycling and reclamation technologies in order to reduce waste volumes and the environmental impact of their operations. These technologies include centrifuges for separating drilling fluids, bioreactors for treating generated water, and land farming for biodegrading oil sludge.

Overall, the methodology for oil and gas waste management in Russia involves a combination of waste reduction, treatment, disposal, and recycling and reclamation technologies, aimed at minimizing waste volumes and reducing the environmental impact of the industry's operations.

Findings

The Indian oil and gas industry faces various waste management difficulties, which can have an impact on the environment and the health of local residents. The following are some of the industry's major challenges:

I. Lack of Infrastructure:

One of the industry's biggest issues is a lack of suitable waste handling infrastructure. This includes the lack of appropriate waste treatment and disposal facilities, as well as inadequate transportation and storage facilities. As a result, the business may turn to ineffective trash disposal methods such as open burning, which can pollute the air and water.

II. Regulatory Challenges:

The Indian oil and gas business is highly regulated, and the industry must adhere to a variety of laws and regulations, including environmental rules, safety standards, and licencing requirements. These rules might make it difficult for the industry to execute appropriate waste management procedures, such as acquiring waste disposal facility permits.

III. Complex Waste Stream:

The oil and gas sector produces a diverse range of waste streams, including hazardous waste, generated water, drilling debris, and refinery trash. These waste streams necessitate particular treatment and disposal technologies, which can be costly and difficult to execute.

IV. Health and Safety Risk:

Poor waste management procedures can endanger the health and safety of workers and communities. Exposure to hazardous material, for example, can cause respiratory problems, skin irritation, and other health problems. Accidents, like as spills or leaks, can potentially have serious effects on the environment and human health.

V. Limited Public Awareness:

A fundamental challenge in the oil and gas sector is a lack of public knowledge and comprehension of waste management issues. This can lead to opposition to garbage disposal facilities and other waste management practices, causing projects to be delayed and costs to rise.

VI. Cost Implications:

Adopting good waste management procedures can be costly, and the industry may incur financial consequences when managing waste streams. The cost of waste treatment and disposal facilities, transportation costs, and compliance costs can all have an impact on the profitability of the industry. (das, 2013)

The Russian oil and gas industry has a number of waste management difficulties. Some of the most significant difficulties are as follows:

I. Lack of Infrastructure:

Russia's waste management infrastructure is poor, particularly in distant locations where many oil and gas facilities are located. This can make it challenging to transport waste to treatment and disposal facilities, as well as to find acceptable waste management solutions.

II. Inadequate Funding:

The Russian oil and gas industry is facing financial difficulties, which may limit investment in waste management technology and infrastructure. As a result, waste management procedures may be poor, raising environmental concerns.

III. Regulatory Compliance:

While there are waste management standards in existence in Russia's oil and gas industry, there are issues about their implementation. Certain businesses may fail to comply with regulations, posing environmental and public health dangers.

IV. Legacy Trash:

The Russian oil and gas industry has a legacy of trash from previous activities that can be difficult to manage. Some of this trash may be dangerous, and suitable treatment and disposal facilities may be unavailable.

V. Public Perception:

Many members of the Russian public are sceptical of the oil and gas business, concerned about the environmental impact of the company's actions. This might make designing waste management solutions that are acceptable to all parties difficult.

VI. Lack of Expertise:

Effective waste management solutions necessitate competence in a variety of sectors, including engineering, environmental science, and policy development. In some parts of Russia's oil and gas industry, such expertise may be in limited supply.

Overall, the waste management difficulties confronting Russia's oil and gas industry are complicated and diverse. Solving these issues would necessitate investments in infrastructure and technology, as well as strong regulatory monitoring and a commitment to establishing long-term

waste management solutions.

VII. Waste Management Policy Comparison between India and Russia

We have already discussed the waste management policies of the Oil and gas industry in detail in the previous section. The final comparison of the policies is described in the below mention table.

Parameters	India	Russia
Responsible Body	Ministry of Environment, Forests, and Climate Change (MoEFCC)	Federal Service for Supervision of Natural Resource Usage (Rosprirodnadzor)
Name of Regulations	1. Hazardous Waste Management Rules, 2016. 2. National Green Tribunal (NGT) Guidelines.	1. Federal Law on Industrial and Consumer Waste. 2. Federal Law on Environmental Protection.
Legal Framework	More recent and specific to hazardous waste management.	More general and covers all types of wastes.
Hazardous Waste Management	Specifically designed to regulate the management of hazardous waste generated by the oil and gas industry.	Covers all types of waste, including hazardous waste generated by the oil and gas industry.
Monitoring and Reporting	India's regulations are more detailed and address soil, water, and air pollution.	The regulations in Russia are more comprehensive and address every area of environmental preservation.
Disposal Facility	Dispose waste to specified facility with limited advancement.	Russia has a more developed waste management infrastructure, with more facilities available for waste disposal.

Table 1: Waste Management Policies Comparison

Conclusion and Recommendations

One of the biggest and most important contributors to the production of waste on a global scale is the oil and gas industry. Waste management in the oil and gas business is a complicated process that needs a broad strategy to handle the particular problems this industry faces. This dissertation's goal was to examine the waste management procedures currently used in the oil and gas sector and to pinpoint areas that might use modification to increase sustainability.

According to the research, it is clear that the oil and gas sector produces a lot of wastes, which calls for careful management to lessen negative effects on the environment and cut costs. In order to address the waste management difficulties faced by the sector, it is essential to embrace sustainable waste management practises like the 3Rs (reduce, reuse, and recycle), apply cutting-edge technologies like pyrolysis and gasification, and implement efficient waste management policies.

However, effective waste management in the oil and gas business depends on cooperation between regulators, other stakeholders, and the industry itself. The dissertation has emphasised the demand for greater stakeholder involvement and the creation of waste management procedures in the oil and gas industry that are more in line with the circular economy.

In conclusion, waste management in the oil and gas industry is a critical issue that requires urgent attention from all stakeholders. The adoption of sustainable waste management practices, the use of innovative technologies, and the development of effective policies and regulations are essential steps towards achieving a more sustainable and efficient waste management system in the industry.

Recommendations:

There are considerable waste management difficulties in India's oil and gas industry, but there are also potential to enhance waste management methods and create value from waste. Following are some waste management prospects in the Indian oil and gas industry:

- **Implementing a waste hierarchy approach**

The waste hierarchy method places prevention, reduction, reuse, recycling, recovery, and disposal at the top of the list of waste management solutions. To limit waste production and optimise resource recovery, oil and gas companies should place a high priority on waste avoidance and reduction, followed by measures like reuse and recycling.

- **Resource Recovery**

Several industrial waste streams contain exploitable resources such as hydrocarbons, metals, and other elements. The industry can reduce trash generation and gain value from waste by recovering these materials.

- **Circular Economy Practice**

Implementing circular economy methods like closed-loop systems, material reuse, and product lifecycle extension can assist the industry in reducing waste and improving resource efficiency.

- **Renewable Energy Generation**

Biomass and wastewater waste streams can be used to generate renewable energy, such as biogas and biofuels. This can assist the industry in lowering its carbon impact and improving its energy security.

- **Advanced Technology**

Innovative technologies such as improved materials, 3D printing, and digitalization can help the sector decrease waste, enhance resource efficiency, and generate new business models.

- **Stakeholder Engagement**

Working with stakeholders such as local communities, regulators, and non-governmental organisations (NGOs) can assist the industry in identifying potential for waste reduction and value generation, as well as building trust and improving the social licence to operate.

- **Conducting regular waste audits**

Waste audits can assist oil and gas firms in identifying the types and quantities of waste produced, as well as opportunities for waste reduction and resource recovery. This data can be utilised to create and refine waste management strategies.

- **Investing in waste-to-energy technologies**

Waste-to-energy technologies can help companies in the oil and gas industry to recover energy from waste and reduce their reliance on fossil fuels. These technologies include anaerobic digestion, gasification, and pyrolysis, which can convert waste into biogas, syngas, and bio-oil, respectively

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