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Water Pollution During Petroleum Industry Process

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ABSTRACT

The petroleum industry is one of the main industries in the world, mainly due to energy demand. However, the activity involves several steps, such as exploration, drilling, production, transportation, and refining of petroleum. All these steps can contribute to environmental accidents, such as accidental oil spills and chronic pollution. Water pollution during the petroleum industry process is quite frequent. Therefore, some procedures and solutions to prevent or clean the water are very important for environmental protection. During the primary extraction of petroleum, seawater or water produced by prior extractions is used. As a result, the water is contaminated mainly by heavy metals and some organics. To minimize the environmental liability of some places near the petroliferous wells, the correct treatment includes neutralization, dissolved air flotation, filtration, and activated carbon treatment.

1. INTRODUCTION

Water pollution nowadays occurs in daily life, industrial activities, and other processes due to human activities. It affects public health, humans, and ecosystems. Contamination may be called an undesirable effect of pollution in a water body. Generally, aquatic systems negatively affected by petroleum-induced pollution consist of a processing plant and industrial wastewaters, auto degradation of mineral oil from the terrestrial to the marine environment, and atmospheric precipitations by soil erosion [1].

Petrochemical processing occurs in the crude oil distillation process by a catalyst and in the motor vehicle sector in the exhaust system. Transportation and refining processes in the petroleum industry may lead to serious problems with respect to effluent and solid waste. According to crude oil chemical analysis, the dominant organic components containing harmful toxic metals (e.g., Pb, Cr, V, Ni, and Cd) are derivatives of the following elements: hydrocarbons, sulfur, trace metals, and organometallic complexes. In recent years, the oil sector has been exposed to more serious environmental risks because most of these elements are heavy metals [2]. The increasing demand for unleaded petrol in the automotive sector and the phenomenon of engine wear cause the release of heavy metals into the environment during the combustion of leaded petrol. In this chapter, the source, reason, and types of petroleum pollution, effects, and minimization of wastewater pollution during petroleum industry processes located in the Erzincan and Adana regions were discussed.

1.1 Definition of water pollution

Water pollution is an anthropogenic factor that significantly influences the quality of life and the environment. Water is a constantly renewed resource and represents more than 70% of the entire planet, but its quality is increasingly deteriorating. The tendency, as indicated by the process for the elimination of soil pollution, is to become irreversible.

1.1.1 Chemical pollution

Water pollution could be caused by chemical pollution when oil, grease, salts, or chemicals are found in the water. Chemical pollution could be from small or large amounts of chemicals, which could include enormous risks. Regardless of organic or inorganic characteristics, this type of pollution could have widespread results. This pollution could destroy the biological balance in nature. Vapors of the chemicals are spread into the atmosphere after being carried to the water source by air and could affect the towns and settlements around it. The influence of the effect is broad, and it is not certain. If the waste fluid that is polluted with toxic chemicals flows into the rivers or onto the ground, it could penetrate through the soil and affect the underground waters. Contaminated waste pours are a source of spreading contemporary toxic substances in nature more than any other source. In chemical pollution, much harm could have been caused immediately after the process or recently after a long period. As a result, it will be difficult to repair the damage caused by enacting the laws.

1.1.2 Oil spills

Oil spills are one of the main environmental issues caused by the storage and transportation of oil and petroleum products. Oil releases are reported as small and medium-scale events or as large-scale events. Although the number and capacity of sea-based facilities for storing and transporting oil have increased, maritime accidents remain relatively rare. However, as water culture and coastal towns are frequently

found in the surroundings of the ports and these accidents have a high environmental impact, they result in an enormous social concern.

Some important long-term occurrences need to be emphasized before presenting the main technologies developed to fight oil spills. One significant spill released 0.5-0.7 million tons of light crude oil, and another spill released 0.6 million tons of crude oil. A marine drilling platform blowout is the most studied event and released 4.9 million tons of oil.

1.1.3 Sediment pollution

Dredging and relocation of canals are the main works that may cause this kind of pollution. Parts of rocks are taken from one place and dropped somewhere else. These places are never specified as good rocks for that location objectively, and soil and water pollution emerge. Both dredging and relocation of canal works are performed quite often during the petroleum industry process, especially during the construction of new heavy crude canals. Rocks produced during canal dredging works and used in a facility are not regarded as waste. However, canal dredging works often produce newly formed quartz together with the existing ones, preventing the continuation of existing species due to the limitations of certain coasts. In addition, they prevent seal, seahorse, and sea turtle species from continuing their lives. There is also a possibility that the existing vegetation, bird, reptile, and mammal species may disappear. Furthermore, pollution with suspended materials is significant during the sedimentation process.

Suspended materials give color to the water. Therefore, light does not penetrate the water, and plants cannot perform photosynthesis. Due to the lack of light reaching the plants, they die, and water cannot retain its oxygen, leading to a decrease in quality. Light does not penetrate the water, causing the temperature of the inner part of the water to increase. This temperature increase can lead to dense or enormous algal growth, and an increase in BOD values is observed as a result. These factors can cause thick coastal pollution. However, blue algae and red algae growth can be harmful to human health. Additionally, these plants can pose a problem, especially for the travel of people. Dredging sediment pollution can also decrease water penetration. When the sediment settles, pollution can cause water pollution. The saddest aspect of this expectation is that the location or depth of dispersal of suspensions over a long period will cause pollution, or this effect will persist.

Water is alive and from a zoological and vegetal point of view, it is the richest incubator of the ecosystem. Besides, water is the vehicle of numerous microorganisms, most of which are pathogenic, and responsible for endemic and epidemic contaminations [3]. The deterioration of the ecological balance of water represents a grave danger, not only for health but also for the progressive impoverishment of the environment.

Pollution of water today is an ensemble of residual and waste products carried by water, which are a consequence of the existence and development of human society. These products are insufficiently treated or not treated at all, and they are charged with a sum of chemical, biological, physical, and radiological pollutants. These pollutants determine definite consequences on the environment, the biological cycle, and the cycle of substances. If we consider the elimination of water pollution as specified by a WHO definition, water pollution should not and cannot be defined concretely, as we do in Physics. Knowledge and interventions are not able to influence the quality of interconnected beings and items that are involved in feedback processes [4]. Definition, then, becomes nothing more than a verbal and approximative expression, which serves to establish what the human mind can take into account and how the management can satisfy the requirements of the largest number of citizens within a sustainable development concept.

2. PETROLEUM INDUSTRY OVERVIEW

The petroleum industry includes the petroleum exploration and development and oil refining industry. Petroleum is an indispensable geological energy resource for human survival. We can't overemphasize petroleum's level of industry technology for receiving life materials and oil end-product purity. To process and separate petroleum, as with all industry sectors, the production of primary products is invariably combined with waste generation.

The exploration and development of petroleum oil production produce a large number of high-concentration petroleum production wastewater. A lot of pollutants from crude oil production will flow into the water, which can be the main source of pollutants in water flowing into the river, and its flow properties are more changeable. The Marlim Sul oil field is the largest deep-water field in Brazil, with a significant output of heavy oil, sand, water, and gas [5].

Water intrusion is the main factor restricting a single-well output in heavy oil production, and controlling the proportion of produced water is very important. Produced water is an important source of pollution; the characteristics of produced oily wastewater are more changeable than others. According to the actual situation of the petroleum industry, to meet the requirements of ultimate oil end-products cleanliness, it's necessary to design the thermal desalination unit and produce oily-water refining system [6].

The surface production equipment can be divided into two production lines: A and B production lines, separately. However, the two production lines have the same process. In this chapter, MMSS can be used to provide pure water as the coolant to desalt the produced water.

2.1 Extraction and refining processes

The extraction and refining of oil are the main stages of the petroleum industry. An oil refinery produces transportation fuels (gasoline and diesel) as well as many materials essential for life, such as fuels, lubricating oils, asphalts, and petrochemical feedstock. These materials are used significantly in other industries, such as the chemical, pharmaceutical, and food processing industries.

During the extraction process, the oil is removed from the rock, and there is a considerable amount of water present. This water has high salinity and contains calcium, magnesium, and other metals that are considered inert scale and corrosion agents. If no action is taken to treat it at the extraction site, this water can harm the environment when it returns to a watershed [7].

The refining process also generates residues that can become effluent. Typically, refineries are large-scale plants that are not feasible for installing wastewater treatment systems due to their size and the characteristics of the effluent.

They generate not only domestic but also industrial wastewater.

At each stage of the problem under analysis, a method already proven in the scientific literature will be addressed, listing an alternative in the last section. For oil produced in fields with free water, produced water accounts for over 90% of the waste generated throughout the productive life of wells. This oil is separated from the water upon arrival at the production unit and transported to storage tanks [8].

According to DeLeo Jr. and Patterson, the method used to treat the produced water depends on its quality, how it will be used, and environmental standards. At the wastewater collection point at the production unit (usually a collection tank), the wastewater can flow by gravity to the water treatment systems. Alternatively, if the tanks are not yet full, a pump can suck the wastewater from one or more tanks and send it to the treatment system. DeLeo Jr. and Isebor have listed several methods, both onshore and offshore platforms, in order to minimize, treat, or eliminate effluent. Some of them are biological treatment, chemical treatment, a combination of biological and chemical treatment, ion exchange, physical-chemical treatment, hydrocyclones, flotation, filtration, and desalting [9].

Some equipment described by the above authors were Autoclave (API Type), Flotation Cell, Gravity Separators (API), Solids Separator, and Hydrospace Desalter System. Some of these methods and equipment for treating oilfield water are expensive, especially regarding offshore plants. It is more feasible, technically and economically, to develop a system that is at least partially implemented in a microgravity environment.

3. SOURCES OF WATER POLLUTION IN THE PETROLEUM INDUSTRY

Water pollution in the petroleum industry is mostly known due to incidents that occur during the exploration, production, transportation, and refining of crude oil. These unintentional releases of large quantities of crude oil or refined products, including toxic light hydrocarbon components, lead to dangerous consequences in surrounding natural water bodies. More disasters and greater adverse environmental impacts occur due to regular discharges of produced waters dissolved oils and heavy metals, and refining effluents containing benzene and Poly Aromatic Hydrocarbons (PAH). Water pollution originating from the petroleum industry is very diverse and comes from different sources.

Each day, a great number of incidents of operational spills occur and lead to the undesirable release of the formation process and cooling waters, oily wastewaters (formation separator water, emulsion water, precipitated solids pressed water, starting box distillation and cooling water, transportation estuary press water, etc.), due process and produced water from the installation process, which is usually diluted, neutralized, and reinjected into the formation. Tank farm oily drainage, etc., are considered as other discharges of the formation process. Oily waste, neutralized or desalinated water from refiners, storage tank water accumulated in interceptor wells, and draining waters originating from purifier systems and residue pressing waters, etc., are considered as some other types of discharges from the refining process [10].

When accumulated waters originating from these discharges are not treated, these waters are considered wastewater/substances and are treated and disposed of in terms of packaging & labeling and transportation, etc., according to the Regulations, 2010 issued depending on the certain stages of the activity they are subjected to. During this period, discharges into waters without treatment may lead to water pollution. In view of the medical and ecological aspects, it may cause pollution of the environment and adjacent territories with dangerous parasitic and pathogenic infections, which present a risk to public health.

From the aspect of potential fire and explosion hazards to the environment, as well as the accumulated toxicity of poisonous substances in the bottom, water-soaked species of foreign oil are considered as environmental risks.

After being dissolved and accumulated in the water environment, the toxicity of the toxins contained in the droplet water, including heavy metal compounds, is enhanced and causes longer evidence of pollution, especially hard and expensive washing and cleaning. Considerable costs to the municipal infrastructure related to receiving and treating surface water from process discharges into the environment, construction, and maintenance of neighboring territories are spent.

The origin of the oil and the leakage of oil products from a technological process should lead to changes in the physical, chemical, and biological properties of the surrounding environment. Water pollution can include chemicals such as organ chlorides, organ phosphorus insecticides, herbicides, and dibenzodioxine. The most dangerous pollutants are chlorinated pesticides and dibenzodioxins. In the petroleum and gas production process, as well as during fuel delivery for airline fueling, water discharges such as produced water, oily wastewaters, neutralized or desalinated water, and tank farm oily water are inevitable [11].

Dietary ingestion from chemically contaminated water bodies might cause an increased human health cancer risk. Therefore, the effective treatment of such waste is considered essential not only for environmental protection but also for public health.

3.1 Wastewater discharges

Water pollution prevention and control requirements were developed mainly for onshore petroleum production facilities. Generally, the requirements developed are based on the application of the best practical control technology currently available for wastewater discharges, which target the following types of wastewaters: oil recovery and/or produced water, industrial process waste streams, contaminated storm runoff, cooling water, and sanitary waste. Regulatory requirements that establish limitations on the content of significance in the industry, apart from an update that included offshore facilities, did not report significant changes [12]. Concentration limits that cover a representative set of wastewater discharges from various sources for the offshore and marine environment. Then, even for research purposes, maximum concentration limits can be considered by the priorities of interest that specialists in the area present a sustainable development solution (Figure 1).

In addition to contributing significantly to the deterioration of water bodies, the inappropriate handling of these effluents also motivates the determination of maximum concentration limits for other parameters, and advances are still needed in relation to the environmentally appropriate concentration limits of NPDES in some countries, which need to be

established with even greater attention. This is mainly due to the fact that the limits for certain regions of the world may be less restrictive, increasing negative impacts on identified priority aquatic life in the receiving water body, as well as on human health and welfare, biological and chemical oxygen requirements, nutrients, and contaminants. Significant limitations are also associated with conditions, schedules, monitoring, and revocation action records. The effluent guidelines that specifically target the petroleum extraction industry manufacture, store, and discharge significant quantities of wastewater, coastal and offshore states, and several industrial groups support a minimum federal regulated program [13].

4. IMPACT OF WATER POLLUTION

The increasing in average industrial activities demands the increased needs some natural resources, including water. The water used in the world is divided into four categories such as public water supply, self-supplied industrial water, irrigation, and livestock. The largest increase in rate use of increase comes from irrigation, with a drop in the proportion of total use, which would be 55 to 80% by 2040. At that time, industrial self-supply will grow at a rate of 116%, followed by consumption at 22%. Livestock will have an 8% annual growth for that rate. The mode of water use chosen by the industry has a high percentage and there is a tendency to be increases. Taking into account the specifications between the two modes, the ones that will have the highest trend and that already have a high percentage are the following: cooling, medium heating and heating, steam, desalination, and boiler consumption and while bathing is not used for showering. The origin and the influence of the water pollution that the petroleum industry generates greatly depend on the various processes implemented by these and on the characteristics of the raw materials sources that each process uses. However, the main impact of the water pollution generated by refining is in the chemical and energy consumption operation cost [14].

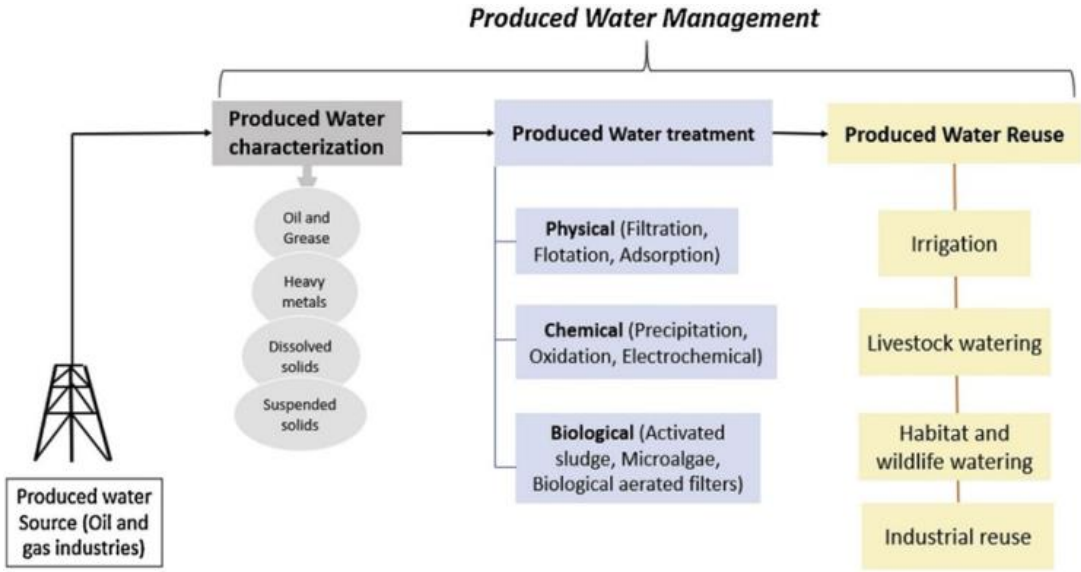

Figure 1. Produce water treatment and reuse

4.1 On aquatic ecosystems

When oil penetrates aquatic ecosystems, it begins to affect the zooplankton group. This can happen through direct exposure to the water column, as the zooplankton is an important part of the food chain. It can also happen through the ingestion of sediments and other elements of the trophic chain. The ingestion of oil by zooplankton is relatively high and can lead to immobilization, mortality, or a reduction in food quantity for other organisms in the food web. Zooplankton is particularly vulnerable at the beginning of its life and can remain in a resting egg state for a long time. This makes them a long-term reservoir of contamination and contributes to the enrichment of sediments with hydrocarbons [15].

When oil enters an aquatic ecosystem, most of the by-products from the degradation process disperse in the water column or adhere to organic matter in the sediment, contributing to its stabilization. However, some of the floatable complex resin substances with aromatic content, such as phenophylls and thiopyroleefin, are highly toxic to different types of aquatic organisms. Mussels, spcifically pinnas, act as living filters and remove oil, especially soluble fractions with nutrients, from the aquatic environment [16]. This can change their structure and reproductive abilities, which in turn directly affects the breeding of other organisms in the ecosystem. The entire population of mussels will only be exposed to the discharge of butyl phenols seasonally, which are also reproductive inhibitors. However, the most sensitive organisms in the breeding hydrobiocenosis are diatomic ears, as they are essential for the complex microalgae.

4.2 Impact on ecosystems

The biological effects of water pollution from petroleum industrial processes have been the subject of many studies, which have reported, for example, reduced growth rates, mortality, lower reproductive success, and alterations in the higher levels of biological organization such as the occurrence of morphological, physiological, and phenological changes, and alterations in the gene expression mechanisms of affected species. However, one basic question that arises from each of the studies is whether their results have an effect on natural populations and entire ecosystems. The conclusion from the

work that has been done focusing on the whole ecosystem is that the changes observed, in general, are related to the ecological status of affected systems and may also have indirect negative repercussions on human health [17].

Studies conducted at large geographic scales verified that the water pollution caused by the petrochemical and petroleum industries reduces the biological diversity of stream and river systems. This observation is plausible because the roles that the biological communities play in the energy, biogeochemical, and hydrological processes in ecosystems contribute decisively to their ecological status [18]. Therefore, the loss of their diversity implies that the number of tasks fulfilled and processes taking place becomes reduced, altering the functioning of systems. This situation has direct and indirect impacts on the productivity, resilience, stability, and environmental services supplied by ecosystems. The causes of the reduction of the diversity of aquatic communities are complex, but exposure to chemical pollutants is an important pressure that must be minimized. The losses of functional pathways and feedback between species, such as those between the primary producers and the detritivorous and predator organisms, favored by large human-made impacts within environments, decrease the ability of these systems to be resilient in the face of future disturbances and show altered ecological trajectories, possibly reflecting an impairment of the health of communities and ecosystems.

5. REGULATIONS AND MITIGATION STRATEGIES

An effective way to reduce environmental pollution near the production well is by complying with environmental standards. The regulatory agencies have established maximum acceptable limits for the release downstream for different parameters such as organic compounds, oil, turbidity, heavy metals, and phenols. The discharge of oil precludes reception by public WTP or any other method of disposal such as ponds or soil in the onshore facilities. Modern onshore oil production systems should be equipped with oil-water separation processes. In onshore drilling, the law establishes the maximum limits of direct and indirect disposal. The water after the oil-water separation process undergoes further purification in a water treatment plant (WTP). After this step, the water may be disposed of in the sea through a sea outfall or reused for special purposes, such as the production process or irrigation. Therefore, the concern about those industrial contaminants and methods for their control has increased in the past years [19, 20].

Regulations and mitigation strategies are particularly focused on the prevention of the discharge of organic compounds and oil in water because it directly affects the drinking water production near the production units. The last document on oil-well waste liquid discards dates from 1980 and is the standard 441/80 of the FEPAM. Relatively recently, a specific resolution was developed by the Brazilian Minister of Environment, number 357 from 2005. This resolution includes the limits for different parameters during both drilling and oil lifting processes. There are up to four distinct standards for the different stages, based on pH and parameters soluble in the waste for oil lifting and parameters present in the used mud for drilling. These Brazilian regulations define the maximum quantity of each parameter in the discharged water, its measurement method, and its associated roundness limits. They also define the maximum distance, the methodology for the dispersion model calculation, and the residence time of the water. Such residence time will determine the maximum allowable variation of each physical parameter from the oil separation station until the limit of the dispersion model. The previous regulations mentioned allow, in some cases, the disposal of toxic substances present in produced water [21].

5.1 Environmental regulations

The environmental regulations that govern the hydrocarbon activity in Mexico confine the discharge of hydrocarbon wastes that are located within the General Law of Ecological Balance and Environmental Protection, the Hydrocarbons Law, the Regulation of Industrial Safety, Health, and Environmental Protection in the Activities of the Hydrocarbon Sector, the NOM-001-SECRE-2010, the NOM-005-SECRE-2010, Environmental Impact and Risk Management Guidelines for Oil and Gas Exploration, Exploitation and Terrestrial Composting, the Guide of industrial pretreatment construction, the limitations for discharges of pollutants to bodies of water provided in the General Law of Ecological Balance and Environmental Protection, within the Official Mexican Standard NOM-002-SEMARNAT-1996; and, of the International Treaty for the Control and Management of Ballast Water and Sediments.

However, reliable data on the discharges and the population receiving hydraulic fracking discharges are lacking. Likewise, companies do not have detailed control over well discharges or other sources of potential pollution. The ownership and treatment of produced water from unconventional extraction are major concerns not covered by existing regulations. Therefore, in the near future, a migration is observed to extend, extend, or combine the regulations found in the Clean Water Act for all water discharges that are not directly related to hydraulic fracturing, which include operating flows, stormwater discharge, and others. The assumption that existing regulations are sufficient to provide 'the same level' of protection for water sources in an area that is technologically transforming is uncertain and could have severe implications since water discharges exceed the current rule.

6. CASE STUDIES

This chapter has reported the main critical and non-critical factors concerned with the process of water pollution in the petroleum industry. The main difficulties with this kind of problem are related to the specific local characteristics, which mean a peculiar situation in each industry that makes the common environmental rules a little pretentious by nature. It is necessary that the managers are concerned with the several non-critical tasks as a result of the penalty and good penalties management aim. The training of the staff for caring with the equipment and the environment is as important as a regular inspection program and a preventive maintenance program. Such consideration about water-oil separation is very important in environmental management, and the company and its staff need to be prepared to work with such important concerns.

Alarm signal lights up: the equipment used for this process is an old technology type, fed by gravity and phase level that avoids the use of pumps and creating tank conditions like retention capacities for hazardous waste, introducing weapons of mass destruction load into the environment, such as the

increase of environmental risk level, possibility of saturation (leakages). Requirements and needs of inspection during design and construction, a mission of the maintenance and inspection crew, preventing risks that can happen, such as the thermal load at tanks, that could support losses or a death state of the biodiversity near their locations. That is the result of the oil separation and water residence time enhancement in the pond, causing turbidity, high organic load, loss of oxygen, and removing the conditions necessary for the relay of flora or aquatic species during the water course.

In conclusion, some environmental protection means, such as the quantity and quality of the used materials, and even the location of the plant's first unit, need to be considered. The design and the construction need to be fitting to nature's gifts, caring with the treatment and residence time of the waste to be decided. The operation must control the limit variables (water, oil, sediment, and passing time), and the maintenance must get the feel for and be concerned with the common enforcers of water pollution spills. The final concern must be the use of disengaged tenet energy waste, according to secondary laws in diminishing returns use, in other words, stop with the increase of electrical power use in avoiding atmospheric pollution, instead of increasing the environment load with fossil hydrocarbon waste. If some of these rules are not followed in the project constraints, the first fight ground on petroleum waste needs to be considered in its productive environment to decrease the negative effect of waste by itself. Care and combining the technology must be the concerns of the concerned group.

Table 1 and Figure 2 show the sum of all ionic contents of Amukpe well-head WSF before and after exposure to *Pistia stratiotes*.

Table 1. The sum of all ionic contents (As the total salinity)

WSF %	Before	After	Difference
25	123.33	245.50	121.17
50	151.25	263.70	112.43
100	206.26	385.80	197.54

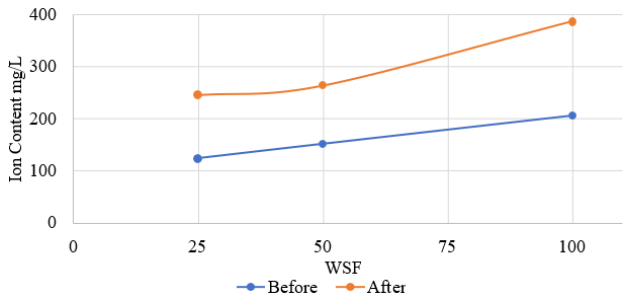

Figure 2. The sum of all ionic contents (as the total salinity)

Table 2 and Figure 3 show the sum of EC and TDS (as total salinity) of the WSF of Amukpe well-head crude oil before and after exposure to *Pisitia stratiotes*.

Table 3 and Figure 4 show the sum of EC +TDS (as total salinity) of the WSF of Ogini well-head crude oil before and after exposure to Azolla sp.

Table 2. Sum (EC+ TDS) (As total salinity)

WSF %	Before	After	Difference
25	145.83	191.10	45.27
50	167.62	263.40	95.79
100	220.35	374.56	154.21

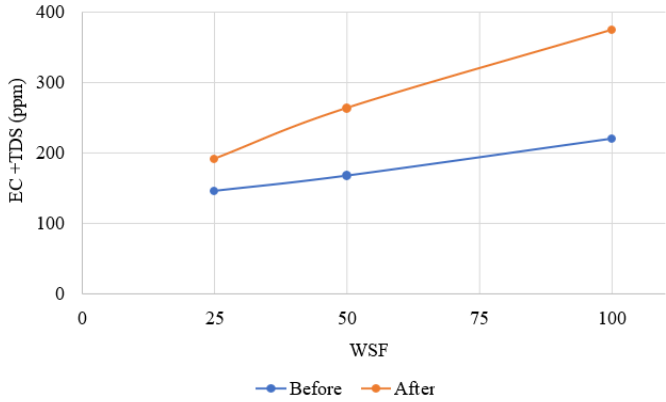

Figure 3. Sum (EC+ TDS) (As total salinity)

Table 3. Sum of (EC + TDS)

WSF %	Before	After	Difference
25	14.60	287.28	264.68
50	21.40	340.38	318.94
100	36.02	455.00	418.98

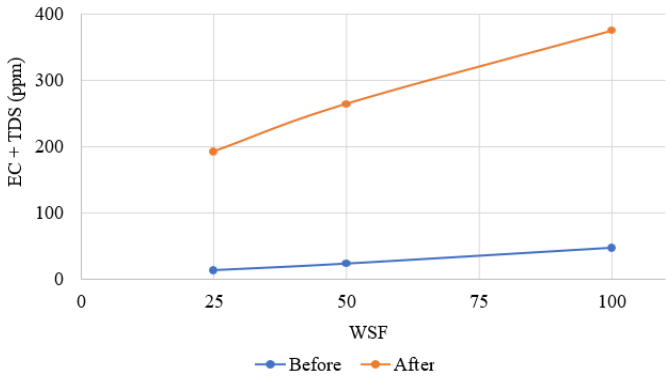

Figure 4. Sum of (EC + TDS)

6.1 Notable water pollution incidents

Water pollution incidents include examples of spills of petroleum products, waste oil, and chemical discharges onto land, rivers, lakes, and coastal waters. Notable incidents in the petroleum industry include tanker accidents and refinery chemical discharges. Similar incidents also occur in ports and in other petrochemical industries such as those dealing with the production of bulk chemicals, such as the production of hydrochloric or transport of chemicals and bulk goods storage in ports. In terms of public perception, the largest notable incidents in the petroleum industry include the Piper Alpha (1988), the Torrey Canyon (1977), the Amoco Cadiz (1978), the Braer (1993), the Erika (1999), and the Prestige (2002).

An investigation report of an oil pollution incident in 2016 specifies that the crude oil venting operation was performed by the barge's own crew, some of whom were not familiar with oil handling due to crew changes, which could lead to the fact that they were unaware that they need to wear disposable protective equipment such as gloves during the operation. The venting hose pump was used to transfer the crude oil to the 2-inch nozzle and hose, which were connected to the ballast water tanks. Upon completion of the cargo tank cleaning, oil residues were discharged to the sea. The disposal hose was later connected directly to the venting nozzle. However, during the disposal operation, the crew found out from the thin

and see-through hose that the ballast tank was almost filled. The crew decided to turn the valve to dry the hose with oil, and when the ballast tank was completely filled, they stopped the disposal operation. After the disposal operation, when the crew handed over their respective watches, they immediately informed the other crew and the master of the quantity of the discharged crude oil. The barge was then anchored at Heron Island, where the crude oil venting operation was reported to the CCG. The friction caused by the crude oil flowing from a 2-inch hose into the empty ballast tanks was believed to have created small amounts of static electricity in the hose, which were discharged when the hose was dropped and came into contact with the water, igniting a fire at the sea surface. The rising pressure caused by the accumulation of oil then expelled the end plug of the hose, forcing the oil to spill and burn.

7. FUTURE TRENDS AND INNOVATIONS

In terms of water pollution during the petroleum industry process, increasingly more stringent regulations and citizen environmental awareness are going to reduce the environmental impact derived from those activities. The need for cleaner technologies is going to promote research in advanced wastewater treatment and impelling the use of alternative secondary energy sources (such as biogas) for integration into the processing facilities.

Increases in the complexity and diversity of crude oil have encouraged the lifelong development of spectroscopic analytical techniques to track these changes and improve oil recovery with lesser environmental impacts in the petroleum industry. Regarding oil and gas production, these techniques are able to detect operational problems, therefore speeding up decision-making and oil recovery and reducing the environmental footprint of oil and gas activities. Some of the most promising innovative analytical techniques are penetration or online, remote detection, and desktop hyperspectral imaging and range scanning devices for faster decision-making in terms of emergencies such as oil spills or treatment of hazardous wastes.

7.1 Advancements in pollution control technologies

There have been a number of advances in recent years, particularly in pollution control technologies adopted by the petrochemical industry and increasing imperatives associated with achieving specific pollution objectives. Increasingly, environmental issues are a mainstream subject, directed at broad public awareness rather than confronting particular technical areas. At the same time, public awareness and concerns are on a steeply rising trend, interacting with politics and public policies. To a large extent, those service sectors aimed at meeting public needs - governments; public and private businesses - along with regulatory institutions, have both highlighted and formalized the public demands related to critical environmental issues.

The withdrawal of natural resources is not an inexhaustible process; energy and matter resources are endowments from nature. A widening gap has been discernible in recent years, particularly in petroleum resources, which must be compensated for through some combination of improved efficiency, greater diversity in energy sources, and technological advancements - both to minimize pollution and to develop renewable resources. Water represents one of our main resources. For environmental policymakers, environmental pollution has indeed become the most important issue as industry develops. The knowledge gap is compounded by the problems in the relative newness of the expansion process and in the pace of technology and industry advancements.

8. CONCLUSION

We conclude that the sources of the greatest impacts associated with the exploration and production of petroleum are the various sources of discharge to the water column. This high impact is related to the quantity of discharges generated at their points of origin. It should be noted that most of these discharges are launched into the environment without undergoing even basic treatment, thus directly affecting the water bodies and, in many cases, those living near the exploitation fields. One of the biggest problems in the field of water pollution is the release of crude both in trench storage and superficial storage caused by corrosion in the installations, as well as a product of the deposition of components of the water associated with the crude. This problem has been reduced with the construction of walls encrusted with waterproof material, as well as with the installation of dikes to retain crude spills in the superficial storage of the product, which is treated directly towards the equipment of physical-chemical treatment, and from there it is sent to the networks of first sector sanitation. For salvoconducto, it is approved and sent to treatment plants, or directly to the outside environment. The environmental impacts associated with all phases so intensely involve the environment. Among those greater deteriorations are the production of effluents with a high content of organic chemicals that may be toxic, the formation of oil spills causing clogging of the stream bed, and the deterioration of plants and animals. The wasteful consumption of wetland resources, infrastructural impacts, and damage to native vegetation leads to loss of site integrity and loss of fauna. This, together with the activity of the industry that undermines its sustainability, generates disordered development in the region. The problem of the environmental impact of the petroleum industry activity and the need for environmental conservation and rehabilitation that involves one of the most threatened environments on the planet, wetlands, requires discussion and substantial change in approach. The escape of these situations not only has to be dealt with by the oil industry and the victims of its negative consequences but this complex problem must be dealt with by the state as a whole and with the cooperation of broader sectors of society.

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