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Air quality and management in petroleum refining industry: A review

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ABSTRACT

Among the fossil fuels, petroleum is more valuable to several businesses due to the production of extensive assortments of finished products, making it a pivot natural resource in the development of the world's economic system via energy usage which are 32% for Europe and Asia, Middle East (53%), South and Central America (44%), Africa (41%), and North America (40%). The most apparent air pollution impediments of the petroleum industry are concentrated in its refining segment. Various pollutants are discharged from different phases of the petroleum refining process. This article intends at publicising dispersed information and also close the knowledge gap in the area. It offers an update on processes involved in petroleum refining, air pollution sources, impacts, reviews on findings, and highlights from different scientific reports on air quality and management. It is paramount that establishing as well as imposing environmental protocols in the petroleum refining industry are crucial for controlling air pollution to protect flora and fauna including human beings. Moreso, the ambient air quality should be managed methodically in developing countries where increased energy demands, industrialization, and overpopulation is leading to increased emissions and reduced air value.

Contents

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1. Introduction

Environment is referred to as an aggregate of both the non-living and living things as well as their impacts on the living existence of human beings. It is ascribed to be the entirety of both the physical and biotic surroundings in which human life and toils are carried out or a place of abode for plants and animals. It is the surroundings in which human beings, fauna, and flora survive or function. It is generally observed that in recent centuries, anthropogenic influences have distorted the harmony of the ecosystems (air, soil, and water), changed the surface of the earth's crust, and redesigned the standard of living [1]. Anthropogenic activities, most especially the industrial revolutions are altering the ecosystems to some extent at an astronomical measure in this modern era. For instance, industrial pollutions from petroleum refining processes have shattered many wildlife and naturally occurring habitats [2–4].

While industrialization is very crucial in the economic advance of any country, industries have been observed to be the principal donors of ecosystem pollution challenges globally. Contrary to the ideologies of sustainable growth, unrestrained industrial processes in some countries have resulted in elevated quantities of dangerous and noxious messes in the ecosystems. Pollution is the introduction of contaminants or pollutants into the natural environment that results in undesirable modification making an ecosystem unwholesome and intolerable to humans and biomes [5–7].

Petroleum coupled with its refined products performs immense and crucial parts in the global setting. Apart from being a central energy source, refined petroleum products offer feedstock to other numerous industries. Hence, performing a mounting and pertinent part in the life of human beings by generating numerous jobs and a noteworthy size of tax revenues and royalties for the local, state, and national governments including foreign earnings. According to Monteiro [7], the petroleum industry footings a chief latent of threats for the environment, and influences ecosystems and subsequently all living organisms including human beings. Based on the aforementioned issue, the principal prevalent and perilous concern of petroleum industry undertakings is environmental devastation. In the petroleum industry, pollution is practically similar to all processes of oil and gas production, from petroleum exploration to refining, transportation, and marketing. Series of wastes including aerosols, gas emissions, wastewaters, and solid waste is produced during processes of the development of petroleum with accompanied by more than 800 various toxic chemical substances. The environmental effects of this pollution are increasing greenhouse effect; acid rain; biodiversity harm; air, soil, and water-deprived quality [8,9].

According to Sojinu and Ejeromedoghene [10], after mining and transportation of crude oil to the refinery, it will then pass-through refining processes so as to transform it into refined products of high commercial worth. The petroleum refinery is an industrial set up-plant where crude oil is treated and refined into various products (e.g., kerosene, diesel fuel, gasoline, asphalt base, liquefied petroleum gas, and heating oil) of high economic values. Petroleum refining is one of the principal industries globally and a crucial segment of the global economy. Conversely, prospective environmental threats connected to refineries have resulted in great concern for people dwelling in communities nearby [6,11,12].

Damian [13] reported that the petroleum refining industry contributes substantially to the entire aerial system pollution by industrial emissions and impaired atmosphere with hydrocarbons, sulphur dioxide, hydrogen sulphide, carbon monoxide, nitrogen oxides, particulate matters, and other poisonous materials, while the principal pollutants are hydrocarbons and sulphur dioxide.

This review article is restricted to air pollution in petroleum reefing because petroleum refineries are known to be the foremost aerial polluter. Most potential air pollution impacts related to petroleum refining industry activities are already well documented but dispersed in papers or exist in the crania of experts corresponding to undeclared knowledge. It is thus crucial to publicize the information and also close the knowledge gaps in the documented reports. Thus, this article basically gives updates on petroleum composition, operations involved in petroleum refining, air pollution sources, impacts, prevention, and mitigation schemes. This article also offers a review of findings and highlights from different scientific reports on air quality and management in the petroleum refining industry. Furthermore, it sums up a conclusion and submits valued future directions in the subject field.

2. Literature review

2.1. Petroleum and its composition

Ollivier and Magot [14] reported that the term petroleum is a two compound Latin word viz., petra and oleum meaning *rock* and *oil* respectively. Petroleum is a general term that classifies collectively as a group of organic liquids, gases, and or asphaltic solids that was produced after kerogen was heated and compacted through high pressure over lengthy periods of time. Petroleum is naturally occurring and originates in geological formations beneath the Earth's surface. It can be refined into fractions such as kerosene, natural gas, gasoline, naphtha, paraffin wax, lubricating oils, and asphalt of higher economic values [14]. It is also employed as a source of raw material for the broad diversity of derived products. It is a fossil fuel, indicating that it was produced via the microbial degradation of organic material principally zooplankton and algae below the sedimentary rock that have been exposed to high levels of heat and pressure for millions of years. Petroleum is fairly multifaceted; the principal constituent gas of petroleum is natural gas, which is mainly methane (CH_4), while the key liquid constituent is crude oil. Refined petroleum products such as diesel, kerosene, gasoline, and heating oil also partake in the designation of *petroleum*. The petroleum sector categorizes crude based on the place of its source and relative density or viscosity i.e. heavy, intermediate, or light. The comparative level of sulphur, which is in form of elemental sulphur or in compounds such as hydrogen sulphide (H_2S) in the crude, makes it to be referred to as either *sweet* or *sour*, i.e. crude of low and high sulphur contents respectively [15,16].

Speight [16] reported that the composition of petroleum varies broadly subject to where and how it was formed. This variation in petroleum composition accounts for the differences in colour and viscosity between crude oil wells and geographical zones. Actually, chemical investigation is usually employed to fingerprint the origin of petroleum because crudes of different origins possess divergent compositions and properties. Crude oil consists of numerous chemical compounds and the utmost productive among them are the hydrocarbons which offer the **crude oil composition** its explosive nature. According to Baker [17], crude oil comprises of four hydrocarbon groups, which include alkanes **(**paraffin, 15–60%**)**, cycloalkanes **(**naphthenes, 30–60%**)**, aromatics **(**3–30%**)**, and asphalts (resins and asphaltenes, NSOs heteroatomic compounds which also hold trace quantities of metals such as vanadium, nickel, iron, and copper).

Nonetheless, the hydrocarbons primarily are alkanes, cycloalkanes, and aromatics. Paraffins are the primary hydrocarbons in petroleum; gasoline (petrol) constitutes mostly definite liquid paraffins making them of high economic value. Naphthenes are a significant fragment of the liquid refinery products, nevertheless, they are also constituted by various heavy asphalt-like residues of refinery practices. Largely, aromatics form a low percentage of many crudes [16]. Resins and asphaltenes constitute the dark coloured constituent of petroleum and they are comparatively polar, high-molecular-weight, aromatic, polycyclic ring compound components of crude oils. Even though there is significant disparity concerning the ratios of organic molecules, the elemental composition of petroleum is distinct viz., carbon (83–87%), hydrogen (10–14%), nitrogen (0.1–2%), oxygen (0.05–1.5%), sulphur (0.05–6.0%) and trace metals (<0.1%) mostly vanadium, nickel, copper, and iron. Generally, the heavier the crude oil, the higher the sulphur level of the crude oil. Thus, the sulphur content needed to be gotten rid of or reduced in the refining process because sulphur dioxide which is the product of the combustion of S in the crude oil is a principal criterion air pollutant [18,19].

2.2. Petroleum industry

Speight [20] reported that the petroleum industry, also referred to as the oil and gas industry or the oil patch, comprises the broad practices of exploration, extraction, refining, transportation, and marketing of crude oils, natural gases, and petroleum products such as petrol, kerosene, diesel e.t.c. Petroleum is also the raw material feedstock for verities of chemical products, such as solvent, pesticides, fertilizer, pharmaceuticals, plastics, and synthetic fragrances. Petroleum is referred to as black gold because of its high economic value including its refined products. The petroleum industry is typically subdivided into three principal segments viz., upstream, midstream, and downstream. The upstream deals with exploration and mining of crude oil, midstream includes conveyance and storage of crude, while downstream embraces the refining of crude oil into several finished products. Petroleum is an important raw material for numerous industries and also significantly enhances the economy of a producing nation if well managed [20–22]. The petroleum industry is massive, its operations touch almost every region globally, while the sector in totality signifies the global biggest industry. Petroleum is responsible for a huge proportion of global energy usage. For instance, 32% for Europe and Asia, 53% for the Middle East, South and Central America (44%), Africa (41%), and North America (40%). Annually, the global consumption of petroleum is 36 billion barrels, while the civilized countries are the principal users. Generally, petroleum processes comprise oil- and gas-field processes, gas plant processing operations, refining and refinery operations, and refining technologies. Oil and gas are goods generated, bought, sold, shipped, and used globally [22,23].

2.3. Refinery units and basic refining processes

According to Aitani [24], petroleum refining is referred to as the processing of crude into various hydrocarbon products of higher economic value. Petroleum processing makes use of catalysts, pressure, heat, and chemicals to isolate and put together the rudimentary categories of molecules of hydrocarbon naturally existing in crude oil into assemblies of alike molecules. During the petroleum refining procedure, structures and bonding configurations are also reorganized into various classes of hydrocarbon molecules and/or compounds. Thus, it is the classes of hydrocarbon (paraffinic, aromatic, or naphthenic) and its request that constitute the refining industry. The refining of crude oil has developed unceasingly due to increasing demands for improved and diverse petroleum products. Drift in the demand for these products has also been attended by incessant enhancement in the quality of petroleum products; for example, cetane number for diesel and octane number for petrol [24,25].

Initially, the goal of the petroleum refinery is to generate kerosene as lamp oil for domestic consumption. This was followed by the advancement of the internal combustion engine and the manufacturing of transportation petroleum products (fuels) viz.; gasoline, diesel, and engine oils. Early petroleum refining involved a basic fractional distillation of crude, then followed by the advancement during the 1920s of the thermal cracking procedures, like coking and visbreaking. The processes that break down heavy oils into further valuable and desired refined products using controlled heat and pressure [24,26].

Aitani [24] reported that the catalytic procedures were established during the early 1940s in order to accommodate the surging request for premium motor spirit (petrol) and higher-octane number petrol. Furthermore, in the 1960s, to improve the production of petrol and advance antiknock features, processes including catalytic alkylation, cracking, hydrocracking, reforming, and isomerization were established. Petroleum refineries now generate a diversity of refined products; many of which are vital as feedstocks for modern-day petrochemical production. In the current century, petroleum refinery employs different sorts of catalytic and non-catalytic practices to accomplish novel product stipulations and to alter less or non-desired components into better-prized fuels, electricity, and petrochemical feedstocks. In fact, the petroleum refinery has moved from only physical separations by distillation to rather near to a chemical plant [24,27].

Modern-day petroleum refineries include processes such as conversion, fractionation, blending, and treatment as well as the processing of petrochemical. The less-dense distillates are additionally transformed into better valuable petroleum products by altering the structure and magnitude of the hydrocarbon molecules using reforming, cracking, and other conversion procedures (Fig. 1). Different petroleum streams are exposed to a variety of separation practices, like extraction, sweetening, and hydrotreating to get rid of unwanted components and enhance the quality of refined products. On the whole, refinery processes are categorized into the following sections viz.;

i) Fractional distillation: This involves the separation of crude inside the vacuum distillation and atmospheric towers into categories of hydrocarbon compounds of divergent boiling-point ranges, known as cuts or fractions.
ii) Light oil handling makes light distillates via reordering of hydrocarbon molecules by processes including catalytic reforming and isomerization or mixed processes polymerization and alkylation.
iii) Treatment and environmental protection procedures comprise physical or chemical separations such as precipitation, absorption, or dissolving using diversity and blend of practices such as solvent refining sweetening and drying.
iv) Heavy oil handling modifies the configuration and/or magnitude of hydrocarbon molecules via catalytic or thermal cracking procedures [24,28,29].

2.4. Air pollution and pollutant source in the petroleum refinery

Aitami [24] reported that among all the divisions of the petroleum industry, the refining division usually has huge air pollution challenges, unlike the other three divisions viz.; production, transportation, and marketing. Refiners usually enchanter various operational, economic, and environmental concerns. Environmental legislation is becoming a mounting worry, pushing modifications in product stipulations, product markets, and refinery functioning processes. Stringent product quality stipulations and stark emission and discharge limits put economic influence on a typical refiner. The structures of a lot of refineries have been modified considerably, as a result of the diminishing petroleum quality supply and environmental guidelines. The refinery modifications as a result of the differences in petroleum supply and composition are evolutionary, conversely, environmental guidelines are revolutionary [24,25,30].

Based on the report of Liu et al. [31], as a result of the refinery undertakings, pollutants are generated particularly in the form of toxic emissions and hazardous wastes that are discharged into the ecosystems. Many environmental factors hinge principally on the settings and operations of the facilities in particular. Pollution caused by this refining industry count on design and operating processes; regularity of upkeep and check; kind, oldness, and equipment quality; functioning circumstances; equipment for processing and treatment as well as appropriate environmental and conservation guidelines [24,32].

Furthermore, a number of accident and equipment let-downs will promote environmental degradation; potentials are well or tanker mishaps, pipeline breaks tank eruptions and blowouts.

If refinery operations are not well managed, the public will be faced with risks from both chronic and acute contacts of numerous toxic chemicals, including substantial quantities of carcinogenic aromatic species

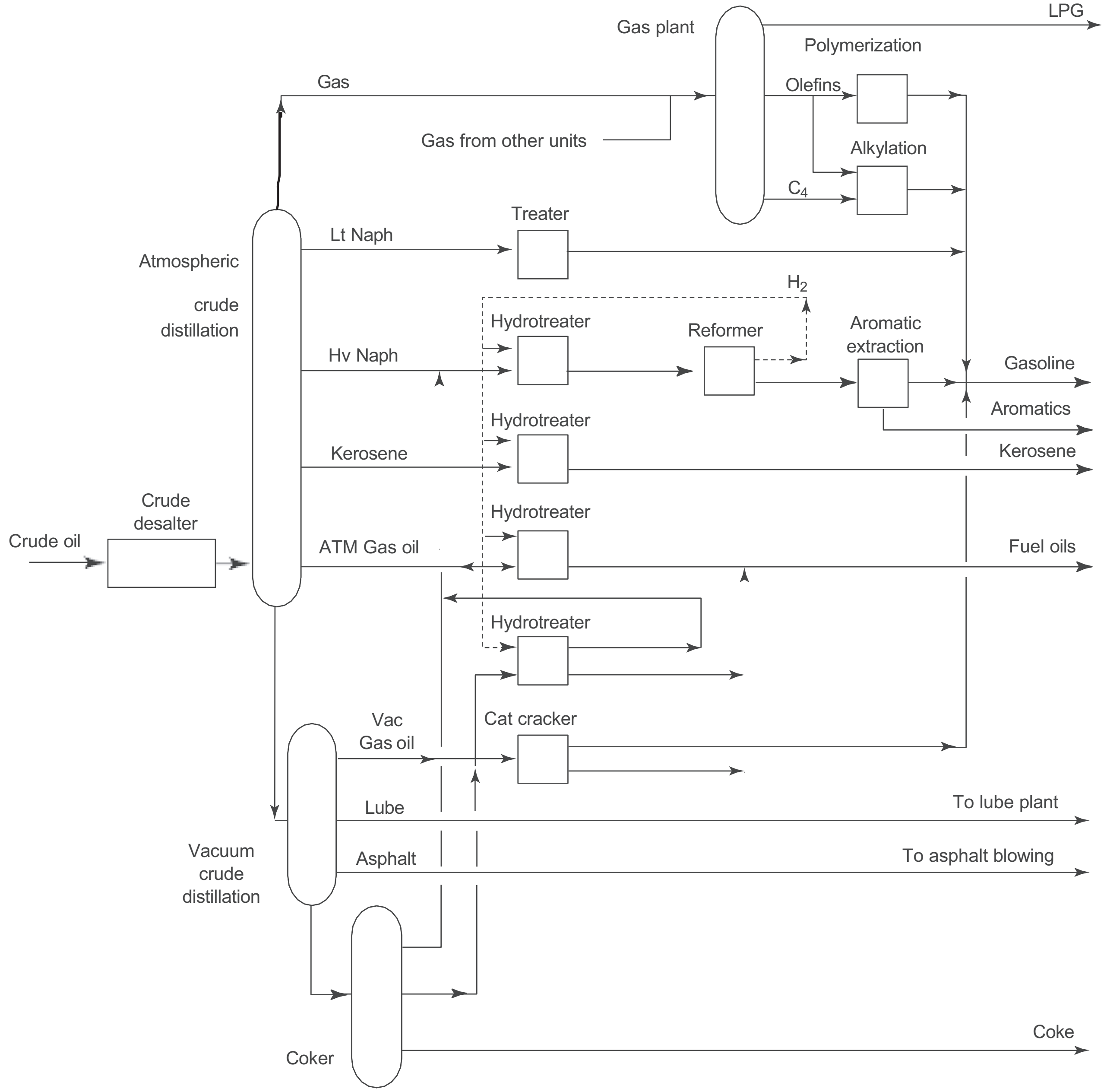

Fig. 1. A chart of a high-conversion refinery indicating air pollutant sources [24]. ATM gas oil = atmospheric gas oil; Cat cracker, catalytic cracker; Lt Naph = light naphtha; Vac gas oil = vacuum gas oil; LPG = liquefied petroleum gas; Hv Naph, heavy naphtha.

such as benzene, toluene, ethylbenzene, and xylene (BTEX). Other associated complications are the issues with several harms linked to sulphur-containing compounds in petroleum and its refined products. These associated threats are catalyst poisoning, product odour, and storage constancy, pollution generated through usage, and operational equipment corrosion [31,32].

The refining industry is known to be the principal industrial source of emissions of volatile organic compounds (VOCs). The VOCs are a category of chemicals that account for the production of ground-level ozone referred to as smog. The burning of fossil fuels produces greenhouse gases and other various air pollutants as by-products including sulphur dioxide, nitrogen oxides, trace metals, and VOCs [33]. When these oxides of sulphur and nitrogen are released into the air, they can move to high levels in the atmosphere, where they combine and react with water vapour, oxygen, and other chemicals to produce added acidic pollutants, known as acid rain. Sulphur dioxide and nitrogen oxides are easily dissolved in water and move very far away by the wind to where they assume a share of the fog, rain, snow, and hail that we are frequently familiar with. It has been observed that greenhouse gases resulting from fossil fuels motivate climate change like temperature rise since the mid of the 21st century. Due to climate change alarms, various alternative energy supporters have resulted in applying varieties of procedures to source energy like solar, biofuel, and wind, among others. The raw material input in petroleum refineries is predominantly crude oil. Conversely, petroleum refineries also make use of and produce a huge volume of chemicals, several of them get out of the plants in form of discharges of solid waste, air emissions, or effluent waters. Air pollutants usually produced are sulphur oxides (SO_X), nitrogen oxides (NO_X), particulate matters, VOCs, NH_3, CO, H_2S, trace metals, etc. [24,31,34].

Aitani [24] reported that there are two key sources of emissions from the refining industry.

i) Emissions which are precise to functions or units of the refinery viz.; catalytic cracking units, sulphur removal units, storage, and loading operations, and coke plants. Sour gas or operation off-gas streams emanated from the hydroprocessing units, catalytic cracking unit, hydrotreating units, and coker comprise elevated levels of H_2S blended with light refinery fuel gases from which sulphur is recovered to generate commercial sulphur elements. Those air emissions emanated from catalytic cracking operations are the fugitive emissions, operation heater flue gas emissions, and emissions produced in the process of rejuvenation of the catalyst comprise of CO and fine catalyst dust generated in the fluidized-bed catalytic cracking units (FCCUs). The coking process generated air emissions comprise of the fugitive emissions, process heat flue gas emissions, and emissions that are produced from the separation of the coke out of the coke drum. Effluent water is produced from the coke separation and cooling processes as well as the steam injection. Furthermore, the separation of coke out of the drum may discharge particulate matter emissions and remnant hydrocarbon pollutants to the airshed. In the tank firm, storage tanks are employed during the refining operations to stock crude oil and intermediate process products to cool and for advance handling. Storage tanks justify substantial VOC emissions at petroleum refineries even if they are furnished with floating roofs [24,35].

ii) The second source embraces emissions not definite to specific fittings and can be ascribed to inter-functional features such as emissions emanated from rejuvenations of catalysts, diffuse emissions, and combustion emissions [24,35].

According to Bartzokas and Yarime [36], the scheme and administration of the fuel coordination as well as the fuel constituents of a refinery pose a vital influence on the environmental pollution effects of the refinery. In a modern refinery, 90% of SO_2 emissions as well as the highest quantity of the NO_X emissions and particulate matters of the refinery hinge on or directly associated with the kind of fuels consumed and the particular portion in the entire fuel intake of the refinery. In case combustion processes are not well controlled and there is incomplete combustion, CO emissions are also generated. Also, incessant or periodical renewal of used catalyst through the combustion of the coke, the catalyst at elevated temperatures will generate particulate matters, NO_X, and SO_X emissions. Fugitive emissions arise during the refinery operations and they evolve from numerous probable fugitive emission sources such as pumps, valves, tanks, flanges, pressure relief valves, etc. Though discrete leaks are usually minor, the total volume of fugitive leaks at a refinery is a major emission source [36,37].

2.5. Health consequences of the principal air pollutants from the refinery

2.5.1. Volatile Organic Compounds (VOCs)

Cheng et al. [38], USEPA [39], and Lewis et al. [40] reported that the volatile organic compounds can initiate throat, nose, and eye irritation, headaches, breath shortness, skin problems, fatigue, dizziness, and nausea. Elevated levels or long-time exposures may result in lung irritation, kidney impairment, liver impairment, cancer as well as central nervous system damage. The ill-health defects triggered by VOCs are subject to the level and exposure extent to the pollutants. The majority of people are not affected by temporary contact to the low concentrations of VOCs establish in homes, but asthmatic people are more sensitive [1,38,40].

2.5.2. Ozone (O_3)

According to Wigle et al. [41], unlike the stratospheric O_3 layer that shields the earth planet from dangerous wavelengths of solar ultraviolet radiation, ground-level ozone can cause ill-health in human beings. It has been observed that short-term contact with ground-level ozone may result in a diversity of respiratory ill-health such as lung damage, irritation of the lung coating, and other respiratory signs including chest burning, cough, wheezing, breath shortness, and chest pain. Exposure to ground-level ozone is capable of reducing the ability to do physical exercise. Long-term contact to elevated levels of O_3 can worsen ill-health such as emphysema, bronchitis, asthma and completely destroy lung muscle leading to untimely death [42]. Studies have also found that long-term ozone exposure may contribute to the development of asthma, especially among children with certain genetic susceptibilities and children who frequently exercise outdoors [43,44].

2.5.3. Nitrogen Dioxide (NO_2)

Exposure to nitrogen dioxide has been associated with a variety of ill-health complications, such as respiratory symptoms, particularly among people with asthmatic and respiratory-related complications [44,45].

2.5.4. Sulphur Dioxide (SO_2)

Short-term exposures to high concentrations of SO_2 cause breathing complications, attended by ill-health signs like breath shortness or chest tightness, or wheezing, Short-term exposures to SO_2 have also been associated with respiratory-related complications predominantly for children and old people [44,45].

2.5.5. Lead (Pb)

Lead amasses in soft tissues, bones, liver, and blood of the body system. Thus, exposure to lead can negatively impair the growth of the central nervous system in young children, causing neurodevelopmental defects like reduced intelligence quotient (IQ) and some behavioral complications [46,47].

2.5.6. Air Particulate Matters (PM)

Based on the report of Bråbäck et al. [48], even though scientific confirmations associate human ill-health with exposures to both fine and coarse particles, the confirmation is for fine PM than for coarse PM. Nonetheless, the ill-health effects linked with exposures to both groups of PM are an aggravation of the respiratory, cardiovascular disease, and untimely death as well as alterations in sub-clinical pointers of respiratory and cardiac functions [49]. Exposures to PM have been linked with lung stunted function and worsened allergic signs generally. People with previous heart and lung diseases or lower socioeconomic status are part of the categories most at threat for impacts linked with PM regular contacts. It can also increase low birth weight and infant death as a result of respiratory defects [48,50].

2.5.7. Hydrogen Sulphide (H_2S)

Almeida and Guidotti [51] described H_2S as an irritant and a chemical asphyxiant having impacts on oxygen consumption and the central nervous system. The health effects of H_2S vary subject to its concentrations and exposure period. Frequent exposure can cause health defects magnified at concentrations that were formerly allowed without adverse effects. Low levels of H_2S irritate the throat, eyes, nose, and respiratory system. For instance, cough, shortness of breath, and eyes burning. Breathing difficulties may be experienced by asthmatic patients. Recurrent or extended contacts usually result in eye fatigue, swelling, irritability, headache, digestive disturbances, weight loss, and insomnia. Moderate levels of H_2S can result in further austere eye and respiratory irritation, staggering, nausea, excitability, headache, vomiting, dizziness, unconsciousness, and death [51–53].

2.5.8. Carbon Monoxide (CO)

According to Clark et al. (2010), exposure to carbon monoxide decreases the ability of the blood to carry oxygen, thereby decreasing the supply of oxygen to tissues and organs such as the heart. The hemoglobin, the oxygen species of the blood has a high affinity for CO than O_2 thereby forming carboxy-hemoglobin instead of beneficial oxy-hemoglobin. Those people with severe heart disease already have a decreased ability to pump oxygenated blood to the heart and other parts of the body including the brain. This can cause such individuals to have e myocardial ischemia, frequently attended by chest pain known as angina, particularly if the person is doing physical exercise or under intense stress. Other individuals under threat as a result of CO exposure are those having anemia, diabetes, chronic obstructive pulmonary disease, and the old [44,46,54]. Table 1 presents the air quality standard guidelines for exposure to air pollutants.

Table 1
Ambient air quality standards for combustion pollutants in various nations.

	Country/organization	Concentration	Time
NO_x (as NO_2)	Germany	0.05 ppm	2–12 mo
	Japan	0.04–0.06 ppm	24 h
	United States	0.05 ppm	Annual arithmetic mean
	Former USSR	0.05	24 h
SO_2	Germany	0.06 ppm	24 h
	United States	0.03 ppm	Annual arithmetic mean
		0.14 ppm	24 h
		0.5 ppm	3 h
	Former USSR	0.02 ppm	24 h
	World Health Organization	38–37 ppb	24 h
		15–23 ppb	Annual arithmetic mean
CO	Canada	13 ppm	8 h
	Germany	26 ppm	0.5 h
	Japan	20 ppm	8 h
	World Health Organization	25 ppm	24 h
	United States	9.0 ppm	8 h
		35 ppm	1 h
	Former USSR	1.3 ppm	24 h
Nonmethane hydrocarbons	Canada	0.24 ppm	–
	United States	0.24 ppm	Average from 6 to 9 A.M.
Particulate matters	Japan	200 $\mu g\ m^{-3}$	1 h
	United States	150 $\mu g\ m^{-3}$	24 h
		50 $\mu g\ m^{-3}$	Annual arithmetic mean
	World Health Organization	60–90 $\mu g\ m^{-3}$	Annual arithmetic mean
O_3	Australia	0.10 ppm	1 h/1 day/year or
		0.08 ppm	4 h/1 day/year
Pb		0.50 $\mu g/m^3$	None
		<30 $\mu g/m^3$	None

Source: Smoot and Baxter [63] and ASE [64].

2.6. Air quality management

According to Gero and Arthur [54], there should be a possibility of applying sound technologies as safety stratagems to prevent and or alleviate safety and health threats posed by the refining industry air pollution. These processes are to decrease oil spillages, false floors to prevent gasoline drips as well as effective and economical technologies such as bio-filtration that can manage air pollution threats [54].

Damian [13] and Alnahdi et al. [55] reported that air quality management aims at lessening aerial degradation as a result of elevated levels of VOCs, CO, H_2S, SO_2, PM, and other criteria air pollutants discharged into the mid-air. These proposed management stratagems for mitigating air pollution will offer a significant drop in the whole air pollution.

a) Application of bigger refining units as well as distinct components, technology, and structures; building of blend units for numerous processes in a solitary process block. For instance, the building of a sole atmospheric-vacuum pipe immobile unit having a volume of 6 million metric tons per year in the place of two separate units with volumes of 3 million tons each. This can be in conjunction with uniting the big unit by blocks for diesel fuel hydrotreating, hydrocarbon gases fractionation, vacuum gas oil catalytic cracking, reforming of narrow naphtha cuts, naphtha redistillation, and electric desalting. These will offer a decreased usage of cooling water by 26%, process fuel by 20% including non-recoverable losses of crude oil and refined products by 35%. These will eventually lead to a comparative decrease in the release of pollutants into the air [13,56,57].
b) Enhancement in the crude-off pre-treatment quality prior to refining. The pattern for crude-oil pretreatment comprises dewatering of the crude in the oil fields as well as desalting in the refinery. In the practice of the pre-treatment of the crudes in the refineries, huge amounts of effluent water contaminated with salts and petroleum emulsion are released [58,59]. The effluent waters will contaminate the atmosphere with the evaporating volatile organic compounds (VOCs) as they run across the refinery sewers and treating facilities. Thus, it is essential to offer a solitary joint system of pre-treatment of petroleum in the fields and in the refinery in order to provide a better whole elimination of salts from the crude oil prior to its refining, in order to generate the least quantities of contaminated effluent waters. For example, investigations revealed that the quantity of contaminated effluent water drained from electric desalting units in the refining industry can be lessened drastically when a single complex structure of crude oil pre-treatment is employed; compared to the quantity of effluent water generated during a conventional pre-treating system. This is due to the fact that the oil conveyed from the oil field to the refinery must have been pretreated using nonionic demulsifiers reducing the salt constituents to as low as 50–100 mg/l [59,60].
c) Usage of bigger tanks to stock the crude oil and its refined products as well as the fitting of floating roofs and pontoons in the tanks [13,57].
d) Advancement of procedures and monitoring equipment for industrial pollutants management. Thus, it is vital to advance researches that can determine the quantities of industrial release of pollutants which are hinged on equipment, the flow plan of a refinery, and the process units operating environments [57,61].
e) Desulfurization of the engine and boiler fuels generated in the refining industries is vital. It is essential to persevere in the determination to get an economical and better effective catalyst, to advance improved desulfurization procedures, most especially those meant for heavy residual stocks, and also to fit extensive units for hydrogen manufacture. The proposed petroleum products desulfurization units should be made to join with sulphur recovery units of sulphur from the acid gases. This will definitely reduce air pollution by SO_2 and other sulphur containing-compounds [57,60,62].
f) Another vital measure **is** to discover a universal index typifying the ecosystem pollution through refining industries. Arrangement of subsets in the refining industry furnished with distinct procedures and tools for ecosystem safety should be put in place. The task of these refinery subsets should be to detect the cites of ecosystem pollution and also offer processes to remove it. Nonetheless, all the treating units and equipment that are being used in the refinery should be placed under this guideline [55,57,60].
g) It is also good to install automatic meters and computers on the process units. This will give a better distinct accounting of procedural and non-recoverable balance losses of crude oil and its refined products. This will offer basically incessant check-up of the ambient air so that rapid plans can be executed when necessary [13,57,62].
h) Discharge of PM emissions emanated from processes at production and refining plants into the airshed can be controlled by equipment like electrostatic precipitators, cyclones, scrubbers, gent stark and bag filters, etc. A blend of these methods can accomplish more than a 99% reduction of PM. Dust emissions at the courtyards and open-air zones devoid of chemical pollutants can be controlled using water sprigs [13,57,61]. Other logical recommended pollution avoidance and reduction procedures embrace the following: implementation of PM emission lessening systems in coke treatment such as storing coke in bulk in sealed off housings, maintaining coke in continuous wet condition, breaking coke in a crusher, and transporting it to a transitional storage silo (hydrobins). Also drenching the coke using a fine coat of oil so that the fine particles of coke will stick to the coke is a welcome practice. Other suitable practices are the application of aspiration systems to draw and gather coke dust and transport the fines gathered from the cyclones into a silo fixed with exit air filters. Then the gathered coke fines should further be recycled to storage [57,58,61].
i) Nitrogen and **s**ulphur oxides, acid mist, ammonia, and fluorine compounds gas emissions produced from production, and refining plants

processes can be controlled using carbon adsorption or wet scrubber systems. Minimization of SOx emissions by desulfurization of fuels to a possible level, or by controlling the usage of high-sulphur fuels to units furnished with SOx emission control systems; recapture sulphur from tail gases by high proficiency sulphur recapture units such as Claus units; fitting of vapour precipitators such as brink demister and electrostatic precipitators to eliminate H_2SO_4 vapour, and fitting of scrubbers having NaOH solution to deal with flue gases emanated from the alkylation unit and absorption towers [57,60,62].

3. Conclusion and future directions in the field

3.1. Conclusion

The petroleum industry is associated with environmental degradation with virtually all it operations. Chains of effluents emanate in the processes of drilling, production, refining as well as transportation, while the refining process accounts for the greatest environmental degradation. Oil and gas firms may even be economically viable by accepting active environmental policies. Nonetheless, several companies in the oil commerce are not in compliance with pollution prevention systems. Their environmental guidelines are focused on obedience to the rules put in place by certified environmental establishments. Recognizing ecosystem variables in production practices has been a severe and vital predicament for the oil and gas industry. In this new era, the obligation by any firm to help in community sustainable enhancement is more than just moral, ethical and financial commitments, due to the fact that people and governments may be predisposed by the undesirable reputation accompanying firms that degrade the environment.

3.2. Future directions in the field

Efforts needed to be strengthened on researches that can offer information on prevention and minimizing environmental degradation associated with petroleum refining processes. The proposal to establish a petroleum refining plant should also accommodate operation wastes recapture, eradication of effluent releases, and degradation of the ecosystem with toxic materials to the barest minimum levels. Refiners of all categories and the company authority must conform with the environmental guidelines to avert or minimize pollutant discharges into the ecosystems.

Declaration of Competing Interest

Conflict of interest is not applicable in this manuscript.

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