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Research Article

Determination of Sulphur Dioxide (SO_2) Air Emission of Refined Petroleum Products by Emission Factor Approach for Air Pollution Control

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Abstract

Air pollution control is a safe method for achieving a sustainable environment and can be accomplished by adequately monitoring pollutants that pose significant environmental risks. The combustion of sulphur-containing petroleum products has been a major concern for several decades. Therefore, this study was aimed at determining sulphur levels in refined petroleum products such as Premium Motor Spirit (PMS), Automotive Gas Oil (AGO), and Dual-Purpose Kerosene (DPK). It also investigated the air quality implications of sulphur levels and estimated the contribution of the refinery's products to sulphur dioxide air emission. Fuel samples were collected from the Warri Refining and Petrochemical Company (WRPC) in Nigeria and analyzed using Ultraviolet-visible spectrophotometer (UV-Vis) and Energy-Dispersive X-ray Fluorescence (EDXRF). Sulphur levels were determined at 425 nm wavelength, and sulphur dioxide air emission were estimated for seven consecutive years from 2010 to 2016 using the emission factor approach. The densities of PMS, AGO, and DPK were 0.77 kg/l, 0.832 kg/l, and 0.82 kg/l respectively. The levels of sulphur in PMS, AGO, and DPK were 2.007 x 10^{-4}%, 6.970 x 10^{-5} wt%, and 4.233 x 10^{-5} wt% respectively from UV-Vis technique and 0.016, 0.087 and 0.029% respectively for EDXRF technique were found below the sulphur limit of 0.015%, 0.005% and 0.015% for PMS, AGO and DPK respectively specified by Standard Organization of Nigeria (SON) specifications of 0.1, 0.5 and 0.15wt% for PMS, AGO and DPK respectively. The annual sulphur dioxide emissions were obtained for seven consecutive years from 2010 to 2016. The results from UV-VIS were observed to have the highest SO_2 emission of 0.1718 tons for PMS in 2011, 0.2593 tons in 2010 for AGO, and 0.0974 tons for DPK in 2010, while the lowest emission was observed to be 0.029 tons for PMS in 2015, 0.0362 tons in 2015 for AGO and 0.0181 tons for DPK also in 2015. The results from EDXRF technique were observed to have the highest SO_2 emission of 13.6939 tons for PMS in 2012, 323.6881 tons for AGO in 2010, and 66.7147 tons for DPK also in 2010, while the lowest emissions for PMS, AGO and DPK were all observed in 2015 to be 2.3122, 45.1872, and 12.4182 tons respectively. The study concluded that the refinery complied with the set requirements.

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Keywords

Sulphur Dioxide, Air Pollution, Gasoline, Diesel, Kerosene, UV-VIS Spectrophotometer, Energy Dispersive X-Ray Fluorescence, Emission Factor

1. Introduction

Air pollution is the introduction of harmful or toxic substances into the atmosphere, causing deleterious effects on human environment. Because of the emission of air pollutants caused by human activity, air pollution is becoming a more serious worldwide issue [1-3]. Any chemical, physical, or biological material that modifies the intrinsic characteristics of the atmosphere is considered an air pollutant [4]. One of the major atmospheric pollutants is sulphur dioxide (SO_2), emitted from the combustion of sulphur-containing fuels [5, 6], and from volcanic activities [7]. Other pollutants that may also be of environmental concern include particulate matter (PM) and volatile organic compounds (VOCs) [8]. Others include nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and particulate matter (PM) [9].

Air pollutants can reach the bloodstream and alveoli through the respiratory tract, whereupon they can lead to acute or chronic systemic illnesses such as circulatory, reproductive, respiratory disorders [10] and skin damage [11-13]. Additionally, air pollutants harmful to health are also produced when cooking with kerosene [14], a major refined petroleum product for domestic activities. In transportation sector, the energy depletion and environmental pollution generated lead to increased strict emission regulations according to investigations on vehicle emissions [15]. Since vehicles and other engines consume refined fuels, adequate monitoring of refined petroleum products is recommended in oil refineries to control the effects of sulphur dioxide emission.

An oil refinery is an industrial process plant that processes and refines crude oil into more useful petroleum products such as gasoline, diesel fuel, asphalt base, heating oil, kerosene, and liquefied petroleum gas. Adequate monitoring of fuel products in oil and gas sector is critical for addressing local air quality and public health concerns [16]. Economically, the sulphur level in crude oil or hydrocarbon also affects both its price and processing cost [17] and hence calls for adequate determination to meet the requirement to control sulphur dioxide emission. Sulphur determination in petroleum products, feedstock, and crude oil is being done using analytical methods [18]. Alternative methods for removing sulphur have become increasingly popular among crude oil transporters and processors due to regulations governing sulphur content, restricted crude oil choices, and downgrading of refined products owing to elevated sulphur levels [17]. Even after petroleum refining, sulphur removal from fuel oil has been a complex operation, and the issue remains critical to the petrochemical industry [19]. The International Energy Agency has indicated that although the world's energy needs have increased more slowly than in the past, they are still predicted to expand by 30% [20]. The world's approach to supplying its expanding energy needs is evolving, with natural gas, renewable energy sources, and energy efficiency now taking the lead [21].

However, the oil era is far from ending, and the new policy scenario’s oil demand growth is still strong partly because of the increased use of shipping, aviation, and land transportation causing the emission of sulphur dioxide. Additionally, acid rain is produced when sulphur combines with water vapor in various atmospheric oxide forms [22]. Maintaining economic development while causing less environmental damage has piqued the interest of regulators and researchers [23]. Enforcing legislation will only slow the rate at which sulphur dioxide and acid rain pollution are increasing due to the presence of sulphur in fuels [24]. With a range of 0.03% to 7.89% (w/w), sulphur and its compounds rank among the top three most commonly occurring chemicals in crude oil in the petroleum industry [25]. Besides the harm that sulphur dioxides cause to car catalytic converters, burning sulphur-containing oil directly releases a significant amount of sulphur dioxide into the atmosphere, which can seriously contaminate the environment and endanger human and animal health [26].

To establish a sustainable environment, it is necessary to monitor the sulphur contents from three major crude oil fractions to ascertain the expected sulphur dioxide air emission when these fuel products are consumed. This can be achieved by employing the use of Ultra-violet visible spectrophotometry and Energy Dispersive X-ray Fluorescence analytical techniques. On the other hand, emission factor can be used to estimate the expected sulphur dioxide emission. The emission factor approach is a representative metric to establish a connection between the number of pollutants emitted into the atmosphere and the activity involved in releasing those pollutants [27]. By using this approach, a broad estimate of emission from the refined fuel products. Emission factors calculate the rate at which a pollutant is released into the atmosphere because of a process activity and are often employed in point source inventories [28]. Table 1 presents the emission factors of SO_2 in fuel products.

Table 1. *Emission factor for SO_2 [28].*

Fuels	Power Output		Fuel Input	
	(g/hp-hr)[a]	(g/L)[b]	(lb/MMBtu)	g/L
PMS	0.268	1.27	0.084	1.26
AGO	0.931	4.82	0.29	4.72
DPK	0.931	4.82	0.29	4.67

The basic emission equation when using a controlled emission factor is as given in equation 1.

$$E = A \text{ x } EF \left[1 - \frac{CE}{100}\right] \quad (1)$$

Where, E = Emission estimates for the process
A = Activity rate (liter/year)
EF = Controlled emission factor (g/l)
CE = % control efficiency

As a result of the pollution caused by the presence of sulphur in refined petroleum products in Nigeria, it has led to strict environmental protocols established by the Standard Organization of Nigeria (SON). Table 2 presents the SON requirements of sulphur in refined petroleum products to control sulphur dioxide air pollution.

Table 2. *SON Requirements for PMS, AGO and DPK [29].*

Fuels	Requirements (wt%)
PMS	0.015
AGO	0.005
DPK	0.015

In this study, three refined petroleum products have been selected. These are Premium Motor Spirit, PMS (Gasoline), Automotive Gas Oil, AGO (Diesel) and Dual-Purpose Kerosene, DPK (Kerosene). There are several methods to determine sulphur levels in different petroleum products [30]. Energy-dispersive X-ray fluorescence (EDXRF) and UV/vis spectrophotometer are more efficient when compared with the typical analysis time of about 10 –12 h of measurement, cost implication and low accuracy associated with gravimetric method. Therefore, these two analytical techniques were selected for the study to determine the sulphur levels in the refined fuel products due to high accuracy and efficiency. These techniques are Ultraviolet Visible Spectrophotometer (UV-Vis) and Energy Dispersive X-Ray Fluorescence (EDXRF). The emission factor of the PMS, AGO and DPK are presented in Table 2 while Equation 2 can be used to estimate the emission rate of uncontrolled combustible emission factor [3, 31, 32]

$$E = A * EF \quad (2)$$

E = emission estimates for the process
A = activity rate with throughput
EF = Emission factor assuming no control

The sulphur dioxide air emission was estimated using the yearly production rate of WRPC's from 2010 to 2016 shown in Figure 1 and Figure 2 [33].

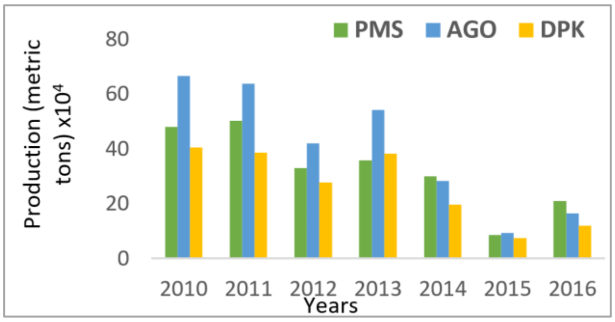


Figure 1. *Yearly production rate of WRPC.*

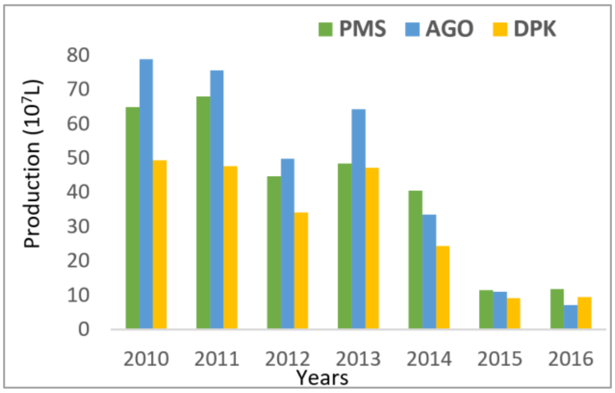


Figure 2. *Yearly production rate of WRPC.*

2. Experimental Section

2.1. Description of the Study Area

The Warri metropolis, one of Nigeria's largest oil cities and located in Delta state in the Niger Delta, is the study's sampling region [34]. Warri is home to the Warri Refinery and Petrochemical Company (WRPC), the Nigerian Gas Company (NGC), as well as other indigenous and international oil companies and oil service providers [35]. It is the most populous metropolis in Delta, with a population of approximately 987,000 inhabitants [36]. Warri (Figure 2) is located at latitude 5 33'44.52"N and longitude 5 46'48.09"E. It has a humid (Relative Humidity, 50% - 70%) equatorial climate with a dry season that lasts from about November to February and a wet season that starts in March and peaks in July and October. The state borders Edo State in the North, Ondo State in the Northwest, Anambra and Imo States in the East, and Bayelsa State in the South. It has approximately 122 kilometers of coastline bound by the Atlantic Ocean in the South and Southwest.

2.2. Materials

Premium Motor Spirit (PMS), Automotive Gas Oil (AGO), Dual-Purpose Kerosene (DPK) shown in Figure 3 were obtained from Warri Refinery and Petrochemical Company in Nigeria. Other materials include hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3), acetic acid, distilled water, glycerol, ethanol, barium chloride crystal, anhydrous sodium sulphate (Na_2SO_4), isooctane, sodium chloride (NaCl), ultraviolet visible spectrophotometer (UV-Vis), conical flask, measuring spoon, measuring cylinder, weighing balance, syringe, water bath, Energy Dispersive X-ray Fluorescence spectrometer Shimadzu (DXRF-702HS).

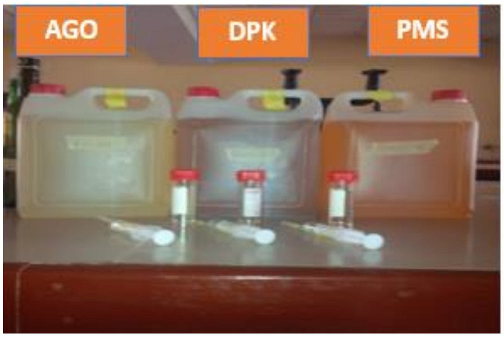


Figure 3. *Refined petroleum products from WRPC.*

2.3. Methods

2.3.1. Preparation of Blank

Blank samples were prepared by measuring 20 ml solution of HNO_3 and HCl in the ratio of 2:1. The resulting mixture was rigorously shaken to ensure a homogenous mixture.

2.3.2. Digestion of Refined Fuel Products

The refined petroleum products were digested with blank. The reaction was carried out by mixing 1.5 g of each fuel sample with 20 ml of blank. The fuel samples were measured using a 20 ml syringe followed by rigorous stirring. The obtained mixture was heated at 80 ℃ for 4 hours to ensure total digestion and analyzed by UV-Vis spectrometer at 425 nm.

The method for EDXRF analysis involves the reaction of 10 ml of fuel samples with a mixture of 20 ml HNO3 and H2SO4 (ratio 4:1). The solution was heated 4 hours slightly in a water bath at a temperature of 80 ℃ to ensure complete digestion of fuel samples in the acids. This method was adopted to avoid inflammation due to the volatility of fuel samples. The digested samples were then analyzed for sulphur using Energy Dispersive X-ray Fluorescence (EDXRF) spectrometer Shimadzu DXRF-702HS.

2.3.3. Preparation of Conditioning Reagents

The reagents used include conditioning reagents prepared by mixing 50 ml of glycerol with a solution containing 30 ml concentrated HCl, 300 ml distilled water, 100 ml of 95% ethanol and 75 g NaCl, barium chloride crystal solution prepared by diluting 0.2- 0.3liter capacity of $BaCl_2$ crystal in 2 ml of distilled water.

2.3.4. Sulphur Analysis Using Ultraviolet Visible Spectrophotometer, UV-Vis

The standard solution was prepared by dissolving 0.1479 g of anhydrous sodium sulphate, Na_2SO_4 in distilled water and the solution was diluted to 1L. The standard solution was then measured at 5 mg/l increments in 0 to 40 mg/l sulphate range using anhydrous Na_2SO_4. 10 ml of each of these solutions was measured into a 250 ml Erlenmeyer flask. Conditioning reagent of 5 ml was added to the solution in the flask and mixed with the aid of a magnetic stirrer. While stirring the solution at a constant speed, a spoonful of barium chloride solution was added. Some of the solution was poured into the cuvette and the absorbance was read at 425 nm in the UV-Vis. The readings for all the various sulphate concentrations were obtained in triplicates. The sulphate and sulphur concentrations were determined using the curve equation and the sulphur levels were estimated using equations 3 and 4. [30]

$$SO_4^{2-}\left(\frac{\text{mg}}{\text{L}}\right) = \frac{\text{Mass of } SO_4^{2-} \text{ calculated from curve } \left(\frac{\text{mg}}{\text{l}}\right)}{\text{Sample (ml)}} * 1000\ (\text{ml}) \quad (3)$$

$$\text{S}\left(\frac{\text{mg}}{\text{L}}\right) = \frac{\text{Molar mass of S}}{\text{Molar mass of } \text{SO}_4^{2-}} * [\text{SO}_4^{2-}] \quad (4)$$

2.3.5. Sulphur Analysis by Energy Dispersive X-Ray Fluorescence, Edxrf

Acetic acid was reacted with isooctane in the ratio 30:1. A drop of the mixture was mixed with digested samples to form a jelly like sample. 0.5 g of each of the fuel jelly samples was measured into a slide and the three fuel samples were inserted in the trays of the EDXRF. The collimator was set to 10 mm for 100 s. This procedure was repeated ten times, and the average concentration was estimated.

2.4. Estimation of Sulphur Dioxide Emission

The annual SO_2 emission from consumption of refined petroleum products was estimated using a combination of annual domestic consumption of refined petroleum products from the refinery using the emission factor approach. Equation 5 was used to estimate the annual emission of SO_2 from gasoline, diesel, and kerosene consumption.

$$Annual\ SO_2\ Emission = Production\ rate * EF * Sulphur\ wt\% \quad (5)$$

3. Results and Discussion

3.1. Fuel Characteristics

The PMS sample is a yellow liquid with a strong odor. Its boiling point ranges between 70 ℃ and 200 ℃. The densities of PMS, AGO and DPK are 0.739, 0.844 [30] and 0.820 [37] kg/l. The higher heating value (HHV) or gross calorific value (GCV) of PMS, AGO and DPK for combustion with air are 46.4, 45.6 and 46.2 MJ/kg, respectively [38]. The PMS maximum adiabatic combustion temperature is 2200 ℃. The AGO is a thick brown liquid with boiling points ranging from 150 ℃ to 380 ℃. It has a theoretical air/fuel ratio of 15 kg/kg, with a higher flash point and auto-ignition temperatures of 330 ℃ and 550 ℃, respectively. The DPK sample is a clear liquid formed from hydrocarbons obtained from fractional distillation of crude oil between 150 ℃ and 275 ℃. Its theoretical air/fuel ratio is 15 kg/kg. The maximum adiabatic combustion temperature is 2300 ℃, while its flash point and auto-ignition temperature are 330 ℃ and 500 ℃, respectively.

The average concentrations of the three fuel samples and the values obtained were used to obtain sulphur dioxide air emission for seven consecutive years (2010 to 2016) using Equation 6.

The curve equation (dependency: 0.99) is given as:

$$A = 0.0273 * [C] \quad (6)$$

[A] = Absorbance of the sample detected by the spectrophotometer

[C] = Concentration of the sulphate

3.2. Concentrations of Sulphur in the Fuel Products

Figures 4a and 4b describe the concentrations of sulphur in PMS, AGO and DPK using UV-Vis and EDXRF, respectively. The average concentrations of sulphur in refined PMS, AGO and DPK are 2.007 x 10^{-4} wt.%, 6.967 x 10^{-5} wt.%, 4.233 x 10^{-5} wt.% respectively (Figure 4a) with UV-Vis analytical technique and 0.016, 0.087 and 0.029% respectively for EDXRF technique (Figure 4b). The results indicated that the total sulphur levels were below the limit specified by the Standard Organization of Nigeria. The accuracy of the use of UV-Vis for sulphur determination is in consonance with what was reported by Adetunji et al. [30]. The percentage by weight of sulphur in the fuel samples were found to be in consonance with those reported in previous studies within the range of 0.05-0.30 wt.% in Nigerian refined petroleum products [36, 39]. It was also observed that sulphur levels in the diesel samples were below the 0.05 wt.% (500 ppm) limit specified by the United States Environmental Protection Agency (USEPA).

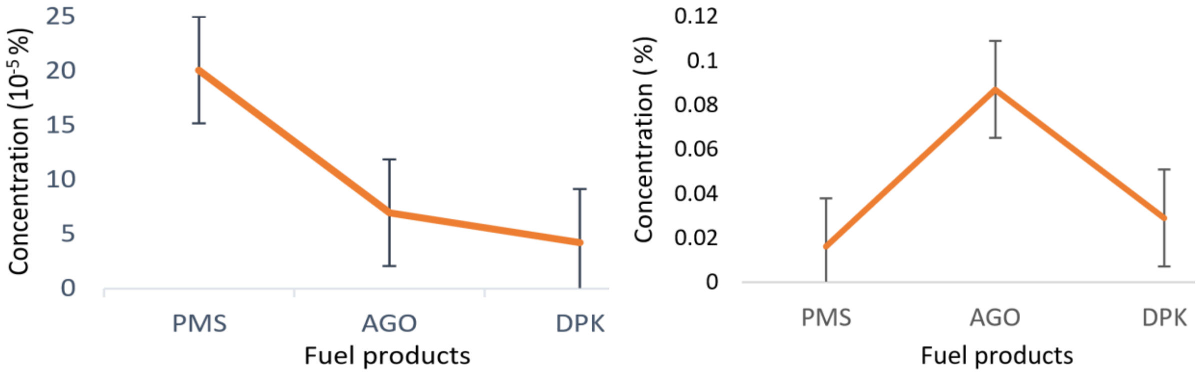
3.3. Estimation of Sulphur Dioxide Emission

The total annual sulphur dioxide emission of refined PMS, AGO and DPK from Warri Refining and Petrochemical Company (WRPC) for seven consecutive years obtained using UV-VIS (Figure 5) and EDXRF (Figure 6) techniques are presented in this section.

The annual SO_2 emission from PMS were 0.16392 tons/yr in 2010, 0.17177 tons/yr in 2011, 0.1130 tons/yr in 2012, 0.1224 tons/yr in 2013, 0.1023 tons/yr in 2014, 0.0290 tons/yr in 2015 and 0.07174 tons/yr in 2016 while the results obtained using EDXRF technique for the selected years were 13.0679 tons/yr in 2010, 13.6939 tons/yr in 2011, 9.0082 tons/yr in 2012, 9.7587 tons/yr in 2013, 8.1538 tons/yr in 2014, 2.3122 tons/yr in 2015 and 5.7189 tons/yr in 2016.

The UV-Vis analytical technique results gave respective annual SO_2 emission levels from AGO as 0.2593 tons/yr in 2010, 0.2484 tons/yr in 2011, 0.1638 tons/yr in 2012, 0.2114 tons/yr in 2013, 0.1103 tons/yr in 2014, 0.0362 tons/yr in 2015 and 0.0640 tons/yr in 2016 while the results obtained from EDXRF technique for the seven selected years are 323.6881 tons/yr in 2010, 310.0657 tons/yr in 2011, 204.4043 tons/yr in 2012, 263.9133 tons/yr in 2013, 137.7216 tons/yr in 2014, 45.1872 tons/yr in 2015 and 79.9126 tons/yr in 2016.

Annual SO_2 emission levels from DPK obtained using the UV-Vis analytical technique were 0.0974 tons/yr in 2010, 0.0941 tons/yr in 2011, 0.0674 tons/yr in 2012, 0.0931 tons/yr in 2013, 0.0480 x 10-5 tons/yr in 2014, 0.01813 tons/yr in 2015 and 0.0290 tons/yr in 2016 while the results obtained from EDXRF technique for the seven selected years are 66.7147 tons/yr in 2010, 64.4800 tons/yr in 2011, 46.1684 tons/yr in 2012, 63.7604 tons/yr in 2013, 32.8910 tons/yr in 2014, 12.4182 tons/yr in 2015 and the result obtained in 2016 was 19.8980 tons/yr.



a b

Figure 4. *a: Average sulphur concentrations of the samples (UV-VIS), b: Average sulphur concentrations of the samples (EDXRF).*

Figures 5 and 6 depict the estimated annual sulphur dioxide emission for seven consecutive years using UV-Vis and EDXRF analytical techniques. From the emission factor approach from UV-VIS analytical technique, the maximum and minimum sulphur dioxide air emission in PMS were observed in years 2011 and 2015 with emission rates of 0.1718 tons and 0.0290 tons respectively, while the maximum and minimum sulphur dioxide air emission in AGO were observed in the years 2010 and 2015 with emission rates of 0.2593 and 0.0362 tons respectively and the maximum and minimum sulphur dioxide air emission in DPK were observed in years 2010 and 2015 with emission rates of 0.0974 and 0.0181 tons respectively.

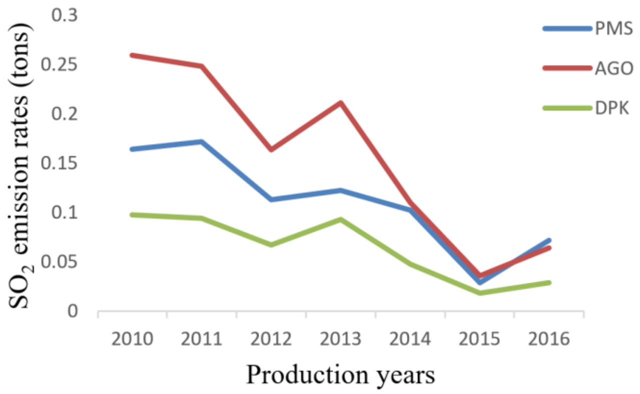


Figure 5. *Estimated annual sulphur dioxide emission (UV-VIS).*

From the EDXRF (Figure 6) analytical technique, the maximum and minimum sulphur dioxide air emission in PMS were observed in the years 2012 and 2015 with emission rates of 13.6939 and 2.3122 tons respectively while the maximum and minimum sulphur dioxide air emission in AGO were observed in years 2010 and 2015 with emission rates of 323.6881 and 45.1872 tons respectively and the maximum and minimum sulphur dioxide air emission in DPK were observed in the years 2010 and 2015 with emission rates of 66.7147 and 12.4182 tons respectively.

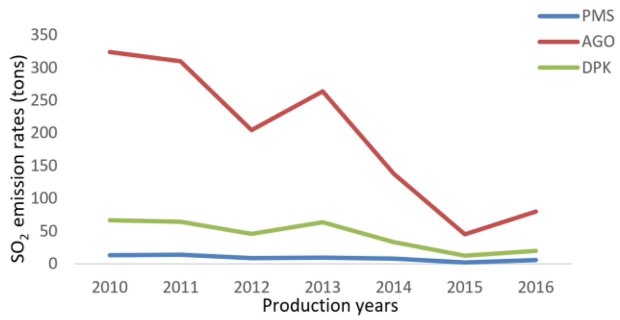


Figure 6. *Estimated annual sulphur dioxide emission (EDXRF).*

The results obtained agree with the work reported in the literature [40]. It implies that the health effects of the combustion of the refined PMS, AGO and DPK of the refinery are at the minimum and within the appreciable limit specified by the regulating agencies.

4. Conclusion

In this work, the levels of sulphur in refined PMS, AGO, and DPK from Warri Refinery and Petrochemical Company, WRPC, were determined using two analytically techniques, and their respective sulphur dioxide air emissions were estimated using the emission factor approach. Sulphur levels were determined by Ultraviolet-visible spectrophotometer, Energy Dispersive X-ray Fluorescence, and EDXRF analytical techniques. These two analytical techniques have demonstrated a high accuracy for sulphur determination in refined petroleum products. The sulphur levels in refined fuels are equivalent to the sulphur dioxide air emission generated because of the combustion of the fuels in the human environment. The contribution of sulphur dioxide emission from the refined fuels of the refinery to national emission levels was established. Therefore, from the results obtained, the emission from the refinery's fuel product does not negatively impact human health and the environment, which confirms the refinery's compliance with the set standard limits.

Abbreviations

PMS: Premium Motor Spirit
AGO: Automotive Gas Oil
DPK: Dual Purpose Kerosene
WRPC: Warri Refining and Petrochemical Company
UV-VIS: Ultra-Violet Visible Spectrophotometer
EDXRF: Energy Dispersive X-Ray Fluorescence
SON: Standard Organization of Nigeria
DPR: Department of Petroleum Resources
EF: Emission Factor
ER: Emission Reduction efficiency
USEPA: United States Environmental Protection Agency

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Author Contributions

Olufemi Oni: Conceptualization, Formal Analysis, Methodology
Jacob Sonibare: Conceptualization, Supervision, Investigation
Bamidele Fakinle: Validation, Investigation
Daniel Oke: Resources, Validation, Writing - original draft
Odunola Odofin: Data Curation
Motunrayo Oladele: Formal Analysis
Michael Ikeh: Data Curation

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Conflicts of Interest

The authors declare no conflicts of interest.

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Biography

Olufemi Oni is a PhD student in the Department of Chemical Engineering at the University of North Dakota, USA. He obtained is Bachelor of Science degree in Chemical Engineering from Obafemi Awolowo University, Nigeria and his Master of Science in Chemical Engineering with distinction from the same institution. He was awarded the 2023 Judges Choice Presentation Award by the Red-River Valley, American Chemical Society (RRV-ACS) annual conference in Minnesota, USA, and 2024 North Dakota Academy of Science (NDAS) annual conference in Grand Forks, USA. In addition, he is a member of The American Institute of Chemical Engineers (AIChE) and The American Chemical Society (ACS). He has served as a Judge for poster presentation at the 2024 North Dakota Academy of Science Annual meeting. He currently serves as the Speaker Head of the American Institute of Chemical Engineers at the University of North Dakota, United States.

Jacob Sonibare is a Professor of Chemical Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria. He is a consultant in Air quality and Life Cycle Analysis (LCA). Additionally, he has conducted multiple environmental Impact Assessment Projects and has published his works in reputable journals.

Bamidele Fakinle is an Associate Professor in the Department of Chemical Engineering at Landmark University, Omu Aran, Otta in Nigeria. Bamidele does research in Chemical Engineering and Environmental Engineering. His focuses on Air Quality and Life Cycle Analysis (LCA). Currently he is an Ag. Head of Department, Chemical Engineering. He has conducted and supervised multiple Research projects published a lot of works in reputable journals.

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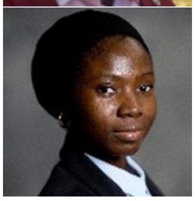

Odunola Odofin is a PhD student in the Chemical Engineering Department at the University of North Dakota, United States. She earned her B.Tech in Chemical Engineering from Ladoke Akintola University of Technology, Nigeria. She has actively participated in various research collaboration projects in recent years. Additionally, she served as a poster judge at the North Dakota Academy of Science Annual Conference held in March 2024.

Motunrayo Oladele is PhD student at Chemistry at the University of Kentucky. She obtained her Bachelor of Science degree in Chemistry from Olabisi Onabanjo University in Nigeria with a First Class. She was awarded at the GradTeach Live event in February 2024 and the UK Sustainability poster competition in October 2023. She is the Principal Investigator alongside peers for an NSF-funded project on soil remediation, and she actively contributes as a reviewer for academic journals. She is a member of esteemed organizations such as the American Chemical Society and the Kentucky Academy of Science. She holds leadership roles as the Diversity and Inclusion Officer for the Chemistry Graduate Student Association and the Volunteer Coordinator for the American Chemical Society, University of Kentucky chapter.

Michael Ikeh is a seasoned environmental scientist specializing in natural climate solutions, particularly in habitat restoration, REDD+ methodologies, and natural resource management. He obtained his Bachelor of Science degree in Geology and Mineral Sciences from the University of Ilorin in 2018, followed by the completion of a Professional master's degree in environmental sciences at Oregon State University in 2023. He has been actively engaged in various research endeavors, notably contributing to projects focused on the restoration of riparian forest ecosystems in the coastal region of the Pacific Northwest. He currently serves as the head of operations and consultant at an electronic recycling firm, where he applies his academic knowledge to address contemporary environmental challenges.

Research Field

Olufemi Oni: Air Quality, Bioprocess, Renewable Energy, Wastewater Management, polymers, Air Pollution Control, Corrosion control
Jacob Sonibare: Air Quality, Life Cycle Analysis, Air Pollution Control and Modelling, Natural Gas
Bamidele Fakinle: Air Quality, Life Cycle Analysis, Air Pollution Control and Modelling
Daniel Oke: Air Quality, Life Cycle Analysis, Air Pollution Control, Life Cycle Analysis

Odunola Odofin: Air Quality, Renewable Energy, Bioprocess, Air Pollution Control, Wastewater treatment
Motunrayo Oladele: Environmental Chemistry, Analytical chemistry, Separation
Michael Ikeh: Environmental Science, Environmental Remediation, restoration of riparian forest ecosystems in the coastal region