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ASSESSMENT OF HYDROCARBON CONTENTS OF ABATTOIR EFFLUENTS ON GROUNDWATER QUALITY IN PORT HARCOURT METROPOLIS, RIVERS STATE

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Abstract
This study centred on assessing hydrocarbon contents of abattoir effluents on groundwater quality in the Port Harcourt metropolis, Rivers State over 12 months. The study adopted an experimental design. A multi-stage sampling procedure was used to sample 5 abattoirs namely Eagle Island, Elioz, Woji, Iwofe and Control for the study. Forty-nine (49) water samples (comprising 48 groundwater samples and 1 surface water sample) were collected between May 2020 and April 2021 from five (5) sampling stations. Hydrocarbon parameters such as Polycyclic Aromatic Hydrocarbon (PAH) and Total Petroleum Hydrocarbon (TPH) were determined through laboratory analysis and compared with the Control. The study revealed that wet season mean PAH values of 0.86±0.12 mg/l**,** 0.67±0.01 mg/l**,** 0.66±0.02 mg/l**,** and 0.64±0.12 mg/l that were recorded at Eliozu, Woji, Iwofe, and Eagle Island abattoirs respectively were all higher than the wet season mean PAH value of 0.40±0.02 mg/l obtained at the Control. Also, the Control had a higher mean PAH value than the experimental group during the dry season. While the highest mean TPH values of (51.97±0.02 mg/l and 51.00±0.18 mg/l), and (42.01±0.19 mg/l and 41.84±0.14 mg/l) recorded at Eliozu and Woji abattoirs respectively during the wet and dry season was higher than the mean TPH value of 31.09±0.13 mg/l and 33.96±0.15 mg/l for wet and dry season respectively obtained at the Control. The study recommended amongst others that governments (federal, state and local governments) should ban the roasting of meat with tyres which increases the possibility of depositing chemicals (like hydrocarbons) containing carcinogens that are destructive to human health.

Keywords: Abattoir, abattoir effluents, hydrocarbons, groundwater quality, Port Harcourt metropolis

Introduction

Abattoirs are generally known as places registered, approved and planned for the slaughtering of cattle, sheep, and goats, among other animals upon their certification by the veterinary officials that such animal to be slaughtered is healthy and free from any human and environmental health impacting animal diseases. Akange et al. (2016) stated that the activities such as butchering, removal of the hide, intestine management, trimming, cleaning activities, etc. undertaken in abattoirs lead to the generation of waste comprising of substances like blood, oil, mineral and organic solids, salts and chemicals with varying levels of toxicity. Abattoir waste effluents mainly comprise pathogens and bio-degradable organic elements that heighten environmental pollution and health hazard that threaten animal, human and environmental health (Ozdemir et al., 2018).

The activities, productions and processes carried out in abattoirs require a high volume of water which results in an equivalent amount of wastewater or effluents that are directly or indirectly discharged into the streams or rivers that are adjoining most abattoirs in Nigeria (Angelakis et al., 2015). In particular, the discharge of untreated abattoir waste effluents into water bodies through infiltration aggravates poor groundwater quality (Ojekunle & Lateef, 2017). This lead to poor water quality that can accentuate the cycle of waterborne diseases such as cholera and typhoid (Nafanda et al., 2012). In this regard, Behailu et al. (2017) reiterate that groundwater becomes the principal source of pollution from abattoir effluents. The wastes generated during meat processing in abattoirs contain different harmful chemical contents like hydrocarbons (Chukwu & Anuchi, 2016). Hydrocarbons are

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generally colourless and hydrophobic with weak odours (Sephton & Hazen 2013). Equally, hydrocarbons are organic compounds in gaseous, solid and liquid form that consists of hydrogen and carbon (Pawlik, 2017). Thus, the introduction of hydrocarbons into the environment through anthropogenic activities (like the slaughtering of animals) can lead to the generation of waste effluents (Yakimov et al., 2013; Ojekunle & Lateef, 2017). This implies that abattoir wastewater contains complex materials with impurities that can be very harmful to both humans and environmental components (mainly land and water) around the vicinity of the abattoir.

An environment polluted by hydrocarbons could have a significant impact on the microbiological, chemical and physical properties of that environment (Mason et al., 2010). Given this, Pawlik (2017) stated that hydrocarbon contamination of an environment (like a water body) is a serious global issue due to its negative impact on human health and environmental sustainability. Consequently, the use, production and movement of hydrocarbons accounts for the daily and increasing release of dangerous toxic chemicals or contaminants such as polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbon (TPH) and polychlorinated biphenyls (PCBs) that are recalcitrant and most xenobiotic into the soil and water systems in both natural and cultured environment around the vicinity of abattoirs. Abattoir activities could increase hydrocarbon contents in underground waters, rivers and streams which in turn could be a source of pollution to both man and animals. Corroborating this view, Edori and Iyama (2017) asserted that abattoir activities led to the generation of effluents with hydrocarbon contents (TPH and PAH) in the environment in Port Harcourt. In addition, Pawlik (2017) posited that the continuous deposition of hydrocarbon content in either soil or water would over time inevitably lead to bi-accumulation with its attendant pollution of the inherent natural resources, plants, fishes and crabs. Similarly, Ojekunle and Lateef (2017) reported that marine lives that breed in hydrocarbon-polluted waters alongside, animals which graze on plants and drink from waters contaminated with hydrocarbons may accumulate such hydrocarbons in their tissues and milk if lactating respectively. When such fish species and animals are killed and consumed by humans; they can trigger nutritional diseases like cardiovascular and cancer.

The unethical release of waste containing hydrocarbons into the soil and wells afterwards infiltrates into nearby streams or water bodies and even groundwater adjoining abattoirs thereby resulting in severe ecological and human health effects (Abdel-Shafy & Mansour, 2016). In addition, Elemile et al. (2019) found that the hydrocarbons generated from abattoir effluents percolate into the soil and nearby water bodies causing pollution to the groundwater quality as well as making it unsuitable for the plant, animal and human intake. Against this backdrop, Adeniji et al. (2019) reiterated that the continued generation and unethical discharge of untreated effluents would overtime accumulate to stir the level of groundwater pollution, especially in aquatic and terrestrial ecosystems that may likely surpass recognized national and global standards. In reality, the ubiquitous nature and toxic levels of hydrocarbons that are found in aquatic and terrestrial ecosystems accentuate groundwater contamination that may result in the drinking water crisis, drought, and pandemics like Escherichia coli infection, cholera, and typhoid among other health risks suffered by the human population in that environment. Based on this premise, Nkansah et al. (2019) advocated the need for regular surveillance, pre-treatment and treatment of wastewater before their discharge into water bodies to prevent the generation of chemicals (like hydrocarbons) that pollute the environment, harm human health, and biodiversity, thereby impeding the realization of sustainable development. Thus, the crux of this study stems from the fact that cautiously adopting sustainable abattoir effluents disposal and management practices would avail as a better way to address the risks from groundwater pollution that are steadily befalling mankind with its likely social, health and economic impacts in Port Harcourt metropolis.

Statement of the Problem

The slaughtering of animals for the production of meat and other by-products in abattoirs without veterinary and other regulatory officials could lead to the improper disposal of effluents (like blood, oil, mineral and organic solids and salts) with their chemical constitutes into a shallow hand dug wells, streams, rivers and other groundwater sources around the vicinity of abattoirs. Thus, the continuous discharge of the varying gaseous, liquid and solid abattoir effluents could indicate the presence of toxic hydrocarbons such as PAHs and TPHs into the soils, wells, streams, rivers and other groundwater sources can stir pollution around abattoirs. Accordingly, groundwater pollution could trigger waterborne diseases, and pollution, with devastating effects on the life, and well-being of man and the environment.

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Hydrocarbon contents from abattoir effluents could aggravate a series of contamination that readily occur at very extraordinary levels of concentrations where their hazardous nature could impact serious threats to the health of humans, plants and aquatic organisms. Since, effluents seem inevitable in virtually all activities (like butchering, trimming, cleaning activities, etc.) in the abattoir. However, the problem rests on the inability of the regulators, authorities and management in these abattoirs to integrate proper treatment of abattoir effluents before their being discharged into water bodies that are characteristically nearby of most abattoirs in Nigeria. Hence, forestalling the increasing loss of groundwater quality and its attendant epidemics calls for the proper regulation and sustainable management of abattoir effluents that can lead to the generation of toxic hydrocarbons. It is based on the foregoing that this study attempted to assess the hydrocarbon contents of abattoir effluents on groundwater quality in the Port Harcourt metropolis, Rivers State.

Objectives of the Study

Specifically, the objectives of the study are to:

1. determine the concentration of Polycyclic Aromatic Hydrocarbons (PAH) in abattoir effluents in groundwater during the wet season in selected abattoirs in the study area.
2. ascertain the concentration of Polycyclic Aromatic Hydrocarbons (PAH) in abattoir effluents in groundwater during the dry season in selected abattoirs in the study area.
3. find out the concentration of Total Petroleum Hydrocarbon (TPH) in abattoir effluents in groundwater during the wet season in selected abattoirs in the study area.
4. ascertain the concentration of Total Petroleum Hydrocarbon (TPH) in abattoir effluents in groundwater during the dry season in selected abattoirs in the study area.

Materials and Methods

This study adopted the experimental design. The experimental design is applied to a study where the manipulation and control of one or more intervening variables may depend on the subjects, experimenter, tools of experiment and other paramount environmental factors (Nwankwo, 2016). Furthermore, the study also adopted the completely randomized block design (CRBD). The CRBD is applied in a work where the experimental points are similar. This study was conducted in the Port Harcourt metropolis, which spans two local government areas (LGAs) namely; Port Harcourt and Obio/Akpor. Port Harcourt metropolis is located between Latitude 4°45'N and Latitude 4°55'N, and Longitude 6°55'E and Longitude 7°05'E in Rivers State. Also, the study area lies at an average altitude of about 12 m above mean sea level as well as located about 25 km from the Atlantic Ocean and is situated between the Dockyard creek/Bonny River and the Amadi creek (ChiadikobI et al., 2011). Furthermore, the Port Harcourt metropolis is bounded by Emohua, Ikwerre, Eleme, Oyigbo, and Okrika LGAs including the Atlantic Ocean. Similarly, Port Harcourt metropolis experiences two seasons, that is, dry and rainy seasons. Temperatures over the Port Harcourt metropolis are constantly high with a mean maximum of about 34°C and a mean minimum of about 21°C. Forty-nine (49) water samples (comprising 48 groundwater samples and 1 surface water sample) were collected over 12 months (i.e. between May 2020 to April 2021) from 4 abattoirs (i.e. 4 sampling points or stations) and the Control which constituted the sampling points that were used in this study. The sampling was in four phases. Firstly, a cluster sampling technique was used to delineate the study area (i.e. Port Harcourt metropolis) into 12 clusters for the collection of groundwater samples. The 12 cluster classification include: (1) May, (2) June, (3) July, (4) August, (5) September, (6) October, (7) November, (8) December, (9) January, (10) February, (11) March, and (12) April.

Secondly, a random sampling technique (using a blind) was used to select five (5) out of the 20 abattoirs in the Port Harcourt metropolis. Thus, the consecutive pick of 5 numbers (from a pot of 20 numbers) led to the picking or selection of Eagle Island, Eliozu, Iwofe, and Woji abattoirs in the study area and the control (Iwofe). In the third phase, purposive sampling was used to select 1 groundwater from each of the 4 selected abattoirs monthly. In the fourth and final phase, purposive sampling was used in the selection of 1 surface water around the vicinity (say a distance of 1500 m) of one purposively selected abattoir (like Iwofe abattoir), which served as the control. The This constituted a sample of forty-eight (48) (via four (4) groundwater samples from the four selected abattoirs. In specificity, 12 groundwater samples were selected from each of the four selected abattoirs (that served as the experimental) while 1 surface water sample (i.e. control) totalled 49 water samples that were collected from 5 different locations in the study area.

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The GPS, sterilized scrap-tap container, plastic bottle and cooler were instruments that were used for the collection of groundwater samples over 12 months from May-October 2020 (representing wet season) and November 2020-April 2021 (representing dry season) for the determination of the hydrocarbons in abattoir effluents. Once the approval for the monthly sample collection was obtained from the management of the five selected abattoirs then the sample collection commences. This began with the opening of the tap to allow water to flow for five (5) minutes before the collection of the water sample using sterilized scrap-tap containers and plastic bottles. In addition, the geographical coordinates of each of the selected abattoirs were determined using the Automated GPS before the collection of the wastewater using sterilized scrap-tap containers and plastic bottles. The samples were put into the iced cooler in the course of their movement to the laboratory for the determination of the hydrocarbons (TPH and PAH) in each of the selected abattoirs in the study area. Relevant Statistical Analytical tools like to mean, standard deviation and line graph were utilized or deplored to determine the objectives stated in this study.

Results

Table 1: Concentration of Polycyclic Aromatic Hydrocarbon (PAH) in abattoir effluents in groundwater during the wet season in selected abattoirs in the study area

Month	Woji	Iwofe	Eliozu	Eagle Island	Control	NSDWQ (2008)
May	0.53±.01	0.72±.02	0.65±.02	0.35 ±.01	0.32±. 01	
June	0.76±.00	0.23±.00	0.94±.01	0.74±.00	0.31±.01	
July	0.93±.02	1.12±.03	0.81±.03	0.65 ±.03	0.74±.03	
August	0.41±.01	0.48 ±.02	0.83±.02	0.83±.01	0.60±.01	0.55
September	0.68±.00	0.67±.01	0.57±.01	0.93±.02	0.35±.03	
October	0.69±.01	0.75±.01	1.33±.02	0.36±.00	0.07±.02	
Wet Season Mean Value	**0.67±.01**	**0.66±.02**	**0.86±.12**	**0.64±.12**	**0.40±.02**	

Table 1 shows the concentration of PAH (mg/l) in groundwater across the selected abattoirs in the Port Harcourt metropolis during the wet season (May-October 2020) using mean and standard deviation. The result indicated that PAH concentration was highest at Eliozu (1.33±0.02 mg/l) and lowest at the Control (0.07±0.02 mg/l) during October. It further shows that the values of PAH ranged from 0.23±0.00 to 1.33±0.02 mg/l obtained at the experimental group (Woji, Iwofe, Eliozu and Eagle Island) was higher than the range of PAH values (0.07±0.02 to 0.74±0.03) from the Control during the wet season. Specifically, the highest PAH value of 1.33±0.02 mg/l and lowest PAH value of 0.07±0.02 mg/l were recorded at Eliozu and Control respectively during October. Furthermore, spatial variation was highest in the Eliozu abattoir (ranging from 0.65±0.02 to 1.33±0.02 mg/l) and minimal at the Woji abattoir (ranging from 0.53±0.01 to 0.93±0.02 mg/l). Temporal variations were at their peak in July 2020 (0.65 ±0.03 to 1.12±0.03 mg/l) and lowest in August 2020 where they fluctuated from (0.83±0.02 to 0.41±0.01 mg/l). Furthermore, the wet season mean PAH values of 0.86±0.12 mg/l**,** 0.67±0.01 mg/l**,** 0.66±0.02 mg/l**,** and 0.64±0.12 mg/l that were recorded at Eliozu, Woji, Iwofe, and Eagle Island abattoirs respectively were all higher than the average PAH value of 0.40±0.02 mg/l obtained in the Control during the wet season.

Table 2: Concentration of Polycyclic Aromatic Hydrocarbon (PAH) in abattoir effluents in groundwater during the dry season in selected abattoirs in the study area

Month	Woji	Iwofe	Eliozu	Eagle Island	Control	NSDWQ (2008)
November	0.62±.01	0.69±.01	0.53±.00	0.99±.02	1.16±.02	
December	0.91±.13	0.62±.02	1.03±.02	1.00±.03	0.81±.02	
January	0.52±.01	0.83±.01	0.55±.01	0.39±.00	1.13±.03	
February	0.87±.02	0.93±.01	0.79±.02	0.92±.03	0.67±.02	0.55
March	0.38±.00	1.04±.02	0.71±.01	0.35±.01	0.65±.02	
April	0.88±.03	0.75±.02	0.48±.01	1.14±.02	0.43±.01	
Dry Season Mean Value	**0.70±.03**	**0.81±.02**	**0.68±.01**	**0.80±.02**	**0.81±.02**	

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Table 2 shows the concentration of PAH (mg/l) in groundwater across the selected abattoirs in the Port Harcourt metropolis during the dry season (November 2020-April 2021). It further shows that the values of PAH ranged from 0.35±0.01 to 1.16±0.02 mg/l obtained in the Eagle Island abattoir and Control in March 2021 and November 2020 respectively. Specifically, the highest values of PAH were recorded at the Control and Eagle Island abattoir with 1.16±0.02 and 1.14±0.02 mg/l during November 2020 and April 2021 respectively. This means that across sampling stations the highest (1.16±0.02 mg/l) and lowest (0.35±0.01 mg/l) values were recorded at the Control and Eagle Island abattoir respectively. Also, spatial variation was highest in the Control (ranging from 0.43±0.01 to 1.16±0.02 mg/l) and minimal at the Woji abattoir (ranging from 0.38±0.00 to 0.91±0.13 mg/l). Temporal variations were at their peak in November 2020 (0.53 ±0.00 to 1.16±0.02 mg/l) and lowest in February 2021 where they fluctuated from (0.93±0.01 to 0.67±0.02 mg/l). Furthermore, the dry season average PAH value of 0.81±0.02 mg/l obtained at the Control and Iwofe abattoir was higher than the mean PAH values of 0.80±0.02 mg/l**,** 0.70±0.03 mg/l**,** and 0.68±0.01 mg/l that were recorded at Eagle Island, Woji and Eliozu abattoirs respectively.

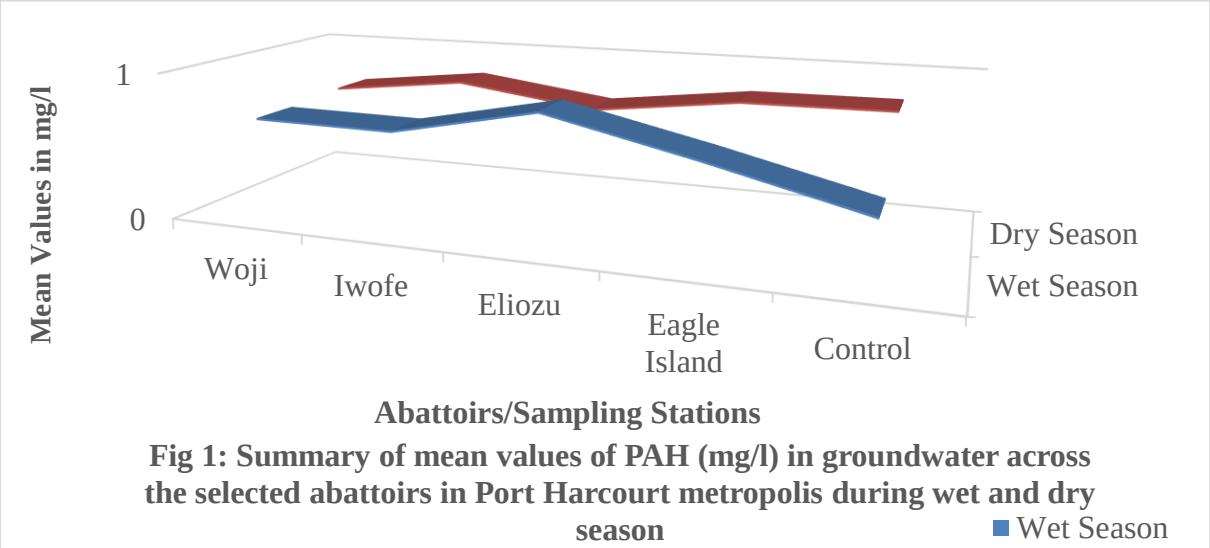

Fig 1: Summary of mean values of PAH (mg/l) in groundwater across the selected abattoirs in Port Harcourt metropolis during wet and dry season

Fig 1 showed that the mean values of Polycyclic Aromatic Hydrocarbon (PAH) were generally and comparatively higher during the wet season than during the dry season. Specifically, the highest mean value of 0.86±0.12 mg/l for Polycyclic Aromatic Hydrocarbon (PAH) was recorded at Eliozu abattoir during the wet season while the dry season's highest mean value of recorded 0.81±0.02 mg/l for Polycyclic Aromatic Hydrocarbon (PAH) was recorded at Iwofe abattoir and Control during the dry season.

Table 3: Concentration of Total Petroleum Hydrocarbon (TPH) in abattoir effluents in groundwater during the wet season in selected abattoirs in the study area

Month	Woji	Iwofe	Eliozu	Eagle Island	Control	NSDWQ (2008)
May	41.86±.17	23.51±.15	49.12±.20	40.06 ±.15	32.96±. 13	
June	42.07±.18	25.86 ±.14	48.75±.19	38.55 ±.13	33.57±.15	
July	40.66±.21	26.28±.16	53.63±.18	39.97±.14	30.47±.08	
August	43.68±.18	25.94±.18	52.61±.15	41.03±.10	26.43±.14	52.00
September	44.35±.20	23.16±.09	54.38±.20	39.12±.13	27.21±.12	
October	39.42±.17	26.75±.13	53.37±.14	37.96±.16	35.87±.15	
Wet Season Mean Value	**42.01±.19**	**25.25±.14**	**51.97±.16**	**39.45±.14**	**31.09±.13**	

The concentration of TPH (mg/l) in groundwater across the selected abattoirs in the Port Harcourt metropolis during the wet season (May-October 2020). Spatial variation was highest in the Eliozu abattoir (ranging from

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48.75±0.19 to 54.38±0.20 mg/l) and minimal at the Iwofe abattoir (ranging from 23.16±0.09 to 26.75±0.13 mg/l). Temporal variations were at their peak in July 2020 (26.28 ±0.16 to 53.63±0.18 mg/l) and lowest in June 2020 where they fluctuated from (48.75±0.19 to 25.86±0.18 mg/l). Furthermore, apart from Iwofe abattoir with wet season mean TPH value of 25.25±0.14 mg/l, all other wet season mean TPH values of 51.97±0.02 mg/l, 42.01±0.19 mg/l, and 39.45±0.14 mg/l that were obtained at Eliozu, Woji and Eagle Island abattoirs respectively were higher than the wet season average TPH value of 31.09±0.13 mg/l that was obtained at the Control.

Table 4: Concentration of Total Petroleum Hydrocarbon (TPH) in abattoir effluents in groundwater during the dry season in selected abattoirs in the study area

Month	Woji	Iwofe	Eliozu	Eagle Island	Control	NSDWQ (2008)
November	42.15±.15	22.82±.14	44.28±.16	28.73±.14	35.19±.17	
December	44.36±.17	19.86±.12	49.98±.15	33.94±.18	36.45±.18	
January	38.49±.14	26.61±.12	50.26±.21	14.96±.10	30.47±.10	
February	37.03±.12	25.50±.13	52.77±.19	36.24±.18	32.60±.11	52.00
March	45.73±.13	23.36 ±.15	56.41±.22	37.14±.17	34.23±.16	
April	43.27±.11	25.73±.16	52.10±.16	45.19±.15	35.09±.19	
Dry Season Mean Value	**41.84±.14**	**20.65±.12**	**51.00±.18**	**32.70±.15**	**33.96±.15**	

The concentration of TPH (mg/l) in groundwater across the selected abattoirs in the Port Harcourt metropolis during the dry season (November 2020-April 2021). Spatial variation was highest in the Eliozu abattoir (ranging from 44.28±0.16 to 56.41±0.22 mg/l) and minimal at the Iwofe abattoir (ranging from 19.86±0.12 to 26.61±0.12 mg/l). Temporal variations were at their peak in April 2021 (25.73 ±0.16 to 52.10±0.16 mg/l) and lowest in January 2021 where they fluctuated from (50.26±0.21 to 14.96±0.10 mg/l). Furthermore, Eliozu and Woji abattoirs had dry season mean TPH values of 51.00±0.18 mg/l and 41.84±0.14 mg/l which was higher than the dry season mean TPH value of 33.96±0.15 mg/l that was recorded at the Control. While Eagle Island and Iwofe abattoirs recorded dry season mean TPH values of 32.70±0.15 mg/l and 20.65±0.12 mg/l which was lower that the Control value.

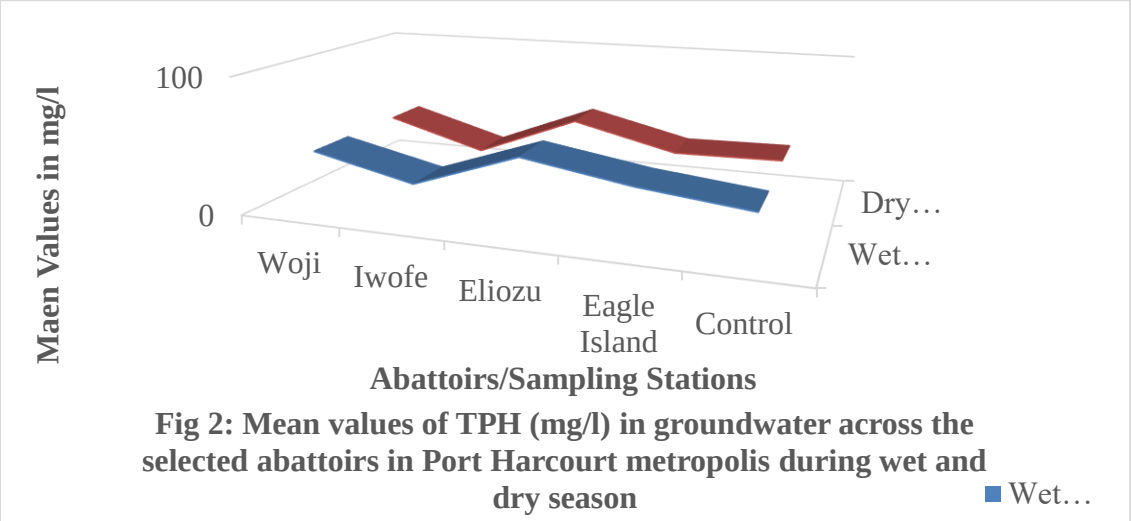

Fig 2: Mean values of TPH (mg/l) in groundwater across the selected abattoirs in Port Harcourt metropolis during wet and dry season

Fig 2 showed that the mean values of Total Petroleum Hydrocarbon (TPH) were generally and comparatively higher at Eliozu abattoir both during the wet and dry seasons. Specifically, the highest mean values of 51.97±0.16 mg/l and 51.00±0.18 mg/l for Total Petroleum Hydrocarbon (TPH) were recorded at the Eliozu abattoir during the wet and dry seasons.

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Discussion of Findings

The study in terms of spatial variations revealed that abattoir effluents contained a concentration of Polycyclic Aromatic Hydrocarbon (PAH) which is peak at the Eliozu abattoir and minimal at the Woji abattoir during the wet season. Also, in terms of temporal variations, the month of July 2020 was found to record the peak concentration of PAH with August 2020 recording the lowest concentration of PAH in the Port Harcourt metropolis. This implies that the spatiotemporal analysis of activities across the sampled abattoirs and months during the wet season led to the generation of effluents containing PAH as pollutants that could be harmful to the environment. This finding is consistent with Khan et al. (2016) that revealed the wastewater or effluents discharged in abattoirs contain polycyclic aromatic hydrocarbons with varying levels of pollution with the propensity to contaminate the groundwater quality in the environment.

The spatial variations of the abattoir effluents revealed levels of concentration of Polycyclic Aromatic Hydrocarbon (PAH) which was peak at the Control and minimal at Woji abattoir during the dry season. While in terms of temporal variations, the month of November 2020 recorded the peak concentration of PAH with February 2021 recording the lowest concentration of PAH in the Port Harcourt metropolis. This implies that the spatiotemporal analysis of activities across the sampled abattoirs and months during the dry season led to the generation of effluents containing PAH as pollutants that could be harmful to both humans and the environment. This finding is in agreement with the study of Edori and Iyama (2017) which observed that abattoir activities lead to the generation of effluents containing Polycyclic Aromatic Hydrocarbon (PAH) that increased the environmental pollution in Port Harcourt.

The spatial variations of the abattoir effluents revealed levels of concentration of Total Petroleum Hydrocarbon (TPH) which was peak at the Eliozu abattoir during the wet season (July and September 2020) and minimal at the Iwofe abattoir. While in terms of temporal variations, the month of July 2020 recorded the peak concentration of TPH with June 2020 recording the lowest concentration of TPH in the Port Harcourt metropolis. This implies that the spatiotemporal analysis of activities across the sampled abattoirs and months during the wet season led to the generation of effluents containing TPH as pollutants that could be harmful to humans and the environment. This finding is consistent with the previous finding by Edori and Iyama (2017) which revealed that abattoir or slaughtering activities resulted in the generation of effluents containing Total Petroleum Hydrocarbon (TPH) that has the propensity to increase the level of pollution in the environment in Port Harcourt.

The spatial variations of the abattoir effluents revealed levels of concentration of Total Petroleum Hydrocarbon (TPH) which was peak at Eliozu abattoir during the dry season (March and February 2021) and minimal at Eagle Island abattoir. While in terms of temporal variations, the month of April 2021 recorded the peak concentration of TPH with January 2021 recording the lowest concentration of TPH in the Port Harcourt metropolis. This implies that the spatiotemporal analysis of activities across the sampled abattoirs and months during the dry season led to the generation of effluents containing TPH as pollutants that could be harmful to humans and the environment. This finding is in agreement with Chukwu and Anuchi (2016) that the effluents from abattoirs contain an unpredictable proportion of Total Petroleum Hydrocarbon (TPH) that can greatly impact both humans and the environment around abattoirs.

Conclusion

The study concludes that effluents from the selected abattoirs (Eagle Island, Eliozu, Iwofe and Woji) in the Port Harcourt metropolis were found to have varying levels of Polycyclic Aromatic Hydrocarbon (PAH) and Total Petroleum Hydrocarbon (TPH). Also, the concentration of PAH and TPH implies the availability of levels of carcinogens and certain chemicals that could be correspondingly disposed towards contaminating the groundwater quality during both wet and dry seasons. Thus, the concentration of noxious hydrocarbons (PAH and TPH) in abattoir effluents as well enhanced the contamination of environmental components (like land, water and air) thereby, increasing disease prevalence and transmission of pollutants that could degrade the environment and heighten biodiversity extinction in Port Harcourt metropolis.

Recommendations

Based on the findings of the study; the following recommendations were proffered.

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1. The Rivers State government are encouraged to set timelines towards the commencement of integrative and sustainable abattoir practices where modern slaughtering and treatment facilities would be installed in abattoirs to reduce the practice of discarding waste effluents containing hydrocarbons and certain chemicals that can be harmful to the environment.
2. Governments (federal, state and local governments) should ban the roasting of meat with tyres which increases the possibility of depositing chemicals (like hydrocarbons) containing carcinogens that are destructive to human health.
3. Biological scrubbers should be used to remove the pollutants, odour, fat, and the chemicals (like hydrocarbons) in abattoir wastewater that hitherto pollutes the environment when they are eventually disposed of without treatment.
4. Government should incorporate green policies and environmentally friendly techniques like sedimentation (separating solid from waste wastewater) and rendering (using heat to breakdown blood, meat pieces and other animal byproducts into useful components) that would be utilized by abattoirs to reduce the issue of discharging waste with hydrocarbon content into the environment.

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