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Toxicity potential of particulate in the airshed of a university farm

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Abstract. This research work provided information on the particulate in the airshed of a university farm and its toxicity potential. The study area for this research was Landmark University farm. The ambient airborne particulates were monitored at eight different section of the farm using the Aeroset 531S particulate monitor. A control sampling point was also situated in front of the University library some kilometers away from the University farm. 11.42 – 32.40 $\mu\text{g}/\text{m}^3$, 59.32 – 473.52 $\mu\text{g}/\text{m}^3$ and 79.58 – 955.10 $\mu\text{g}/\text{m}^3$ for $\text{PM}_{2.5}$, PM_{10} and TSP respectively. The control point measured averages were of 20.80 $\mu\text{g}/\text{m}^3$, 64.46 $\mu\text{g}/\text{m}^3$ and 80.86 $\mu\text{g}/\text{m}^3$ for $\text{PM}_{2.5}$, PM_{10} and TSP respectively. An assessment of toxicity potential of these particulates shows unhealthy air conditions at some sampling location at the University farm.

1. Introduction

In an agricultural environment, air quality, both indoor and outdoor is a significant phenomenon which needed to be examined with great caution. Air pollution happens to be a standout amongst the most difficult issues the world faces today as the climate is getting dirtied because of vaporous and particulates release from different Man-made sources, for example, modern, residential and human activities do have toxicological effects on human wellbeing and the on atmospheric composition of the earth [1]. Air pollution happens when any kind of contaminant is let-out into the air, in this way altering the chemical structure of air in the environment. Air is surrounding us, scentless, colourless and fundamental to all life on earth as it goes about as a vaporous cover, shielding the earth from perilous infinite radiation from space.

Air pollution cause sicknesses, sensitivities and increment in mortality of people; and furthermore will in general bring harm to the normal or assembled environment. It has dependably been because of civilization. Millions of lives are lost yearly as a result of air pollution. Going by the 2014 World Health Organization report [2], air pollution in 2012 caused the deaths of around 7 million individuals around the globe.



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Air pollution from agricultural activities have serious impact on human, plant and the environment. The emissions from agricultural activities includes: Particulate matter (PM), ammonia (NH_3), oxides of Nitrogen (NO_x) and volatile organic compounds. Other substances released into the atmosphere as a result of agricultural activities are Greenhouse Gases (GHGs) which causes global warming. The most common GHGs are Methane (CH_4), Nitrous oxides (N_2O) and Carbon dioxide (CO_2). These gases as serious implications when emitted into the atmosphere in term of climate change. In this study the toxicity of particulate in an agricultural environment was assessed, this was done in order to determine its impact on the ambient air quality of a farm.

2. Methodology

2.1 Study Area Description

The research was carried out at the Landmark University farms in Omu-Aran, Kwara State, North central part of Nigeria. It is situated on the North western part of the state within the topographical map of Kwara State. The farm has 8 different sections for day-to-day activities. The various sections include the broiler section, layers section, cassava processing plant, fishery, feed mill, grain store, piggery and administrative block. Nineteen sampling points were selected within these 8 sections of the University farm. The control point (C_p) was located in front of the University library. This control point was chosen to allow comparison with the airshed outside the influence of the agricultural activities at the farm.

Sampling point S1 is an indoor section of the broiler pen house 3 which contained four weeks old birds. Sampling point S2 is an indoor section of the broiler pen house 4 which contained six weeks old birds. Sampling point S3 is an indoor section of the broiler house 5. It contained 1,000 ten weeks old birds; each weighing about 2.5 kg. Sampling point S4 is an indoor section of broiler house 6 which also contained 1,000 ten weeks old birds; each weighing about 2.5 kg. Sampling point S5 is an outdoor region of the entire broiler pen house. The area has no other activities besides the poultry. Sampling points S6, S7, S8 covered the indoor section of the auto-pen house 1 (front, middle and back section respectively) of the layers section. The auto-pen house 1 has a population of 10,000 layers producing an average of 500 crates of eggs per day. The area is properly ventilated using an industrial fan (ventilator). Sampling points S9, S10, S11 covered the indoor section of the auto-pen house 2 (front, middle and back section respectively) of the layers section. The auto-pen house 2 has a population of 20,000 layers producing an average of 1,000 crates of eggs per day. The area is also properly ventilated using an industrial fan (ventilator). Sampling point S12 covered the outdoor section of the layers auto-pen house. Sampling points S13 and S14 covered the indoor and outdoor respectively of the administrative block. This section located very close to the feed mill and grain store section of the farm where administrative works are done. Sampling point S15 covered the feed mill section of the farm while Sampling point S16 covered the grain store of the farm. Sampling point S17 covered the fishery section; an open air fish pond with a lot of vegetation surrounding the area. Sampling point S18 is the cassava processing plant where garri, fufu flour are produced. For the production of garri, the frying aspect is done locally using wood as a source of fuel in the open air. Sampling point S19 covered the piggery section operated on a semi-intensive scale with a total population of 20 pigs.

2.2 Particulate Sampling

Sampling was carried out both indoor and outdoor of the University farm. Particulate Matter Measurements at 15 minutes sampling time were conducted for five consecutive days at each of the nineteen sampling points and at the control point.

In the course of study, all measurements were taken using the MetOne Aerocet air particulate mass monitor (Model 531S). The gadget is a handheld, rechargeable and totally versatile unit estimating six range of particulates PM_1 , $\text{PM}_{2.5}$, PM_4 , PM_7 , PM_{10} and TSP. The device utilizes light dispersing principle to estimate each particle that goes through the laser optical framework.

During the sampling protocol the particulate mass monitor was placed one meter above ground level to avoid measurement of unwanted residue assembled by tides. For this study three range of particulate PM_{2.5}, PM₁₀ and TSP were reported. The 24-h averaging period concentrations of the measured pollutant were extrapolated using an atmospheric stability formula [3] given in Equation (1) as:

$$C_0 = C_1 F \quad 1$$

Where C_0 is the concentration at the averaging period t_0 ; C_1 is the concentration at the averaging period t_1 ; F is the factor to convert from the averaging period t_1 to the averaging period t_0 ,

$$F = \left(\frac{t_1}{t_0}\right)^n$$

Where $n = 0.28$, the stability-dependent exponent.

2.3 Toxicity Potential

Toxicity potential (TP) is a quantitative toxic equivalency which expresses the potential harm of a unit of pollutant discharged into the environment. It is expressed as the ratio of measured ambient PM concentration to the statutory limit of ambient concentration [4].

It is vital in assessing the harmful effects of the University farm on human health. It was computed using Equation (2) taking into consideration the air quality standard of the various sizes of particulates by the World Health Organization and the Federal Ministry of Environment (FMEnv) Air quality Standards (Table 1).

$$\text{Toxicity potential} = \frac{M_p}{S_p} \quad 2$$

Where M_p is the measured pollutant concentration and S_p is the statutory limit set for such pollutant using World Health Organization (WHO) standard.

Table 1. Ambient Air quality Standard for Particulates

Air pollutants	Concentrations [5]	FMEnv [6]
PM _{2.5}	25 µg/m ³ (24-h)	
PM ₁₀	50 µg/m ³ (24-h)	100 µg/m ³ (24-h)
TSP		250 µg/m ³ (24-h)

3. Results

Summarized in Tables 2 – 4 are the measured particulate concentrations from the various sampling points for PM_{2.5}, PM₁₀ and TSP while Table 5 contains the measured particulate at the control point.

Average Measured particulate from the sampling locations were of the range, 11.42 – 32.40 µg/m³, 59.32 – 473.52 µg/m³ and 79.58 – 955.10 µg/m³ for PM_{2.5}, PM₁₀ and TSP respectively. The control point measured averages were of 20.80 µg/m³, 64.46 µg/m³ and 80.86 µg/m³ for PM_{2.5}, PM₁₀ and TSP respectively.

On extrapolation to 24-hour concentrations the measured PM_{2.5} became 4.75 - 13.46 µg/m³ while PM₁₀ and TSP were 24.71 - 197.29 µg/m³ and 33.17 - 397.96 µg/m³ respectively (Table

6). At the control points the 24-hour extrapolation were $8.29 \mu\text{g}/\text{m}^3$, $26.50 \mu\text{g}/\text{m}^3$ and $33.50 \mu\text{g}/\text{m}^3$ for $\text{PM}_{2.5}$, PM_{10} and TSP respectively.

Summarized in Table 7 are the calculated toxicity potential (TP) of the 24-hr particulates from the various sampling points. TP calculated for the observed sampling point were ranged 0.13 – 0.36, 0.33 – 2.64, for $\text{PM}_{2.5}$ and PM_{10} , respectively using the 24-hrs WHO, 2005 air quality standard for particulate while the TP for PM_{10} and TSP using FEPA, 1991 were 0.17 – 1.32 and 0.09 – 1.06, respectively. The control point recorded toxicity potential of 0.23 and 0.36 for $\text{PM}_{2.5}$ and PM_{10} using WHO standards while FEPA, 1991 at the control were 0.18 and 0.09 for PM_{10} and TSP respectively.

The mean peak for $\text{PM}_{2.5}$, was recorded at S_{19} next to this is the sampling point S_2 , which could be attributed to the population of birds in the pen house and their feeding pattern. Also $\text{PM}_{2.5}$, having low concentration in the sampling point could be attributed to the fact that the sampling exercise were carried out during wet season of the study area. During wet season there will be wash down of fine particles during this period. For PM_{10} and TSP the highest concentrations were recorded at S_2 . Sampling point S_2 is an indoor environment without proper ventilation system, this could contribute to the level of particulate in its air quality. Also the population density of the birds, the feeding pattern of the birds, the deep litter system used in rearing the birds and also poor management could contribute to its poor air quality in terms of PM_{10} and TSP.

Table 2. Measure of particulate for $\text{PM}_{2.5}$

Designated sampling point	Day 1 ($\mu\text{g}/\text{m}^3$)	Day 2 ($\mu\text{g}/\text{m}^3$)	Day 3 ($\mu\text{g}/\text{m}^3$)	Day 4 ($\mu\text{g}/\text{m}^3$)	Day 5 ($\mu\text{g}/\text{m}^3$)	Average ($\mu\text{g}/\text{m}^3$)
S1	15.50	14.60	16.50	29.20	30.50	21.26±7.88
S2	13.80	40.30	18.30	28.20	27.20	25.56±10.22
S3	12.50	34.70	13.90	15.40	20.70	19.44±9.09
S4	11.90	12.30	13.60	12.40	22.40	14.52±4.45
S5	9.50	19.50	13.70	20.60	20.70	16.80±5.00
S6	14.00	24.70	29.80	32.40	13.60	22.90±8.76
S7	24.70	14.00	30.20	25.40	14.20	21.70±7.25
S8	18.00	18.20	24.80	27.50	15.90	20.88±4.99
S9	13.40	14.20	15.40	13.90	31.90	17.76±7.94
S10	12.30	13.40	14.40	13.40	26.20	15.94±5.78
S11	14.10	13.90	15.00	15.10	29.00	17.42±6.50
S12	10.50	10.80	11.20	12.20	12.40	11.42±0.84
S13	10.90	11.80	15.40	18.70	17.80	14.92±3.49
S14	9.50	11.90	13.30	19.30	15.00	13.80±3.68
S15	10.40	15.30	13.50	20.10	17.80	15.42±3.76
S16	11.60	16.10	12.60	22.30	16.00	15.72±4.19
S17	21.50	20.10	22.40	21.40	22.20	21.52±0.90
S18	25.40	23.50	16.50	26.90	30.10	24.48±5.07
S19	30.30	31.10	32.40	33.00	35.20	32.40±1.89

Table 3. Measure of particulate for PM_{10}

Designated sampling point	Day 1 ($\mu\text{g}/\text{m}^3$)	Day 2 ($\mu\text{g}/\text{m}^3$)	Day 3 ($\mu\text{g}/\text{m}^3$)	Day 4 ($\mu\text{g}/\text{m}^3$)	Day 5 ($\mu\text{g}/\text{m}^3$)	Average ($\mu\text{g}/\text{m}^3$)
S1	311.50	179.60	172.90	465.80	470.90	320.14±146.16
S2	259.80	1166.10	213.30	368.00	360.40	473.52±392.74

S3	227.10	939.20	225.90	229.90	196.10	363.64±322.04
S4	204.70	205.10	210.60	201.90	200.90	204.64±3.78
S5	64.40	88.40	496.80	137.30	80.20	173.42±182.81
S6	279.20	332.40	170.40	242.90	242.00	253.38±59.23
S7	336.10	280.60	162.40	225.60	224.90	245.92±65.51
S8	206.50	210.20	158.70	238.00	238.40	210.36±32.53
S9	223.80	229.40	240.20	230.90	240.60	232.98±7.28
S10	279.50	223.80	228.40	280.20	294.60	261.30±32.73
S11	270.00	274.00	230.40	272.60	269.60	263.32±18.49
S12	67.90	70.40	75.40	74.10	72.90	72.14±3.00
S13	67.50	55.40	80.70	72.60	60.20	67.28±10.00
S14	44.80	66.50	62.20	71.20	51.90	59.32±10.8
S15	68.60	167.50	100.00	83.00	66.80	97.18±41.51
S16	173.50	229.90	74.90	130.00	61.30	133.92±69.91
S17	69.20	67.60	69.80	69.50	70.10	69.24±0.98
S18	92.73	94.93	108.90	84.30	88.30	93.83±9.37
S19	150.76	166.76	158.73	109.60	207.90	158.75±35.21

Table 4. Measure of particulate for TSP

Designated sampling point	Day 1 (µg/m ³)	Day 2 (µg/m ³)	Day 3 (µg/m ³)	Day 4 (µg/m ³)	Day 5 (µg/m ³)	Average (µg/m ³)
S1	687.6	343.3	314.9	945.6	899.2	638.12±298.56
S2	547.1	2457.5	396.4	693.6	680.9	955.10±848.44
S3	466.7	1693.7	462.8	471.1	406.8	700.22±555.99
S4	393.3	400.1	400.4	400.1	500.4	418.86±45.68
S5	101.0	115.0	149.5	219.4	120.0	140.98±47.26
S6	628.6	539.2	295.4	400.2	395.4	451.76±131.53
S7	535.8	614.2	210.5	320.1	320.8	400.28±168.00
S8	334.5	339.8	233.6	338.4	340.2	317.30±46.84
S9	436.8	440.1	450.2	440.8	439.2	441.42±5.14
S10	706.1	439.2	439.1	306.4	309.2	440.00±162.61
S11	582.3	580.2	445.5	580.4	582.6	554.20±60.77
S12	127.2	132.4	140.5	150.2	160.9	142.24±13.58
S13	118.5	112.0	126.7	98.2	85.1	108.10±16.56
S14	55.3	87.0	93.8	86.1	75.7	79.58±15.04
S15	111.3	349.4	223.4	100.7	100.1	176.98±109.46
S16	373.7	496.8	132.4	216.0	109.5	265.68±165.61
S17	81.45	80.20	82.0	81.7	82.4	81.55±0.83
S18	136.52	144.62-	176.1	120.3	125.3	140.57±25.29
S19	247.00	240.00	252.00-	151.8	342.2	246.60±77.81

Table 5. Measure of particulate at Control Point

Particulate Sizes	Day 1 (µg)	Day 2 (µg)	Day 3 (µg)	Day 4 (µg)	Day 5 (µg)	Average (µg)
PM _{2.5}	20.7	18.9	22.5	22.0	19.9	20.80±1.48
PM ₁₀	69.1	58.9	66.9	63.0	64.4	64.46±3.89
TSP	83.0	79.5	78.0	70.8	93.0	80.86±8.11

Table 6. Extrapolated 24-h averaging period's pollutants' concentration

Sampling points	Concentration ($\mu\text{g}/\text{m}^3$)		
	PM _{2.5}	PM ₁₀	TSP
S1	5.92	89.19	177.77
S2	7.12	131.92	266.08
S3	5.42	101.31	195.07
S4	4.05	57.01	116.69
S5	4.68	48.31	39.275
S6	6.38	70.59	125.86
S7	6.05	68.511	111.51
S8	5.82	58.60	88.40
S9	4.95	64.91	122.97
S10	4.44	72.80	122.58
S11	4.85	73.36	154.39
S12	3.18	20.10	39.627
S13	4.16	18.74	30.12
S14	3.84	16.53	22.17
S15	4.30	27.07	49.30
S16	4.38	37.31	74.02
S17	6.00	19.29	22.72
S18	6.82	26.14	39.16
S19	9.03	44.23	68.70
CP	5.79	17.96	22.53

Table 7. Toxicity potential from measured concentration

Sampling points	PM _{2.5} (WHO)	PM ₁₀ (WHO)	PM ₁₀ (FEPA)	TSP (FEPA)
S1	0.24	1.78	0.89	0.71
S2	0.28	2.64	1.32	1.06
S3	0.22	2.03	1.01	0.78
S4	0.16	1.14	0.57	0.47
S5	0.19	0.97	0.48	0.15
S6	0.26	1.41	0.71	0.50
S7	0.24	1.37	0.69	0.44
S8	0.23	1.17	0.59	0.35
S9	0.20	1.30	0.65	0.49
S10	0.18	1.46	0.73	0.49
S11	0.19	1.47	0.73	0.62
S12	0.13	0.40	0.20	0.16
S13	0.17	0.37	0.19	0.12
S14	0.16	0.33	0.17	0.09
S15	0.17	0.54	0.27	0.20
S16	0.18	0.75	0.37	0.30
S17	0.24	0.39	0.19	0.09
S18	0.27	0.52	0.26	0.16
S19	0.36	0.88	0.44	0.27

CP	0.23	0.36	0.18	0.09
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Over the years, there has been extensive international body of literatures on the health impacts of air pollution, reporting a wide range of adverse health outcomes, including exacerbation of chronic respiratory and cardiovascular diseases and premature mortality. Air pollution worsens asthma and chronic obstructive pulmonary disease and can increase the risk of cardiac arrhythmia, heart attack, stroke, and lung cancer, which hinders lung development. This translates to increases in health issues of the workers [7, 8, 9].

As mentioned earlier, toxicity potential values above unity pose great treat to the health conditions of the farm workers where detected. The highest toxicity potential was at S_2 (broiler pen house) for PM_{10} and TSP using FEPA 1991, this is of major concern for the workers in the environment. Using the recommended WHO air quality standard, the TP at Sampling $S_1, S_2, S_3, S_4, S_6, S_7, S_8, S_9, S_{10}$ and S_{11} were above unity, this toxicity is of concern because of the deleterious impact this will have on humans, animals, plants and materials.

4. Conclusion

The study provides a valuable data on impact of various activities in a farm environment on ambient air quality in terms of particulate matter. The Aerocet 531S particulate monitor was used to determine the concentration of the various particulate size fractions considered in this study. Result indicated that the 24-h PM_{10} concentrations at $S_1, S_2, S_3, S_4, S_6, S_7, S_8, S_9, S_{10}$ and S_{11} breached Air quality standards of the World Health Organization standards, while S_2 and S_3 breached National Air Quality Standards (NAQS) of the FMEnv standard, Nigeria. Similarly TSP at sampling S_2 breached the FMEnv standard with 16.08%. The toxicity potential exceeding unity at some designated sampling points call for attention, particularly for workers with susceptible health conditions. It is therefore necessary that control measures should be put in place in order to abate the deleterious effect of particulate on the farm works, the animals, plants and the environment.

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