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IMPACT OF PIG FARMING ON AIR QUALITY IN UMUAHIA.

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ABSTRACT

Impact of pig farming on air quality was investigated in two farms in Umuahia Metropolis using standard microbiological techniques. Settle plate method was used for the air sampling by exposing the plates at different distances and time intervals. Aeroqual AS-R41 large robust carrier was used in estimating the gases and particulate matter (PM_{10} and $PM_{2.5}$) in and around the farms. Ammonia (NH_4), carbon dioxide (CO_2), hydrogen sulphide (H_2S) and nitrous oxide (N_2O) were monitored.CO_2 had the highest concentration of 1200ppm and N2O had the least 0.04ppm in the rainy season and CO_2 was the highest at 700ppm and NH_4 2.4ppm the least in the dry season for farm 1. In farm 2, CO_2 with 1700ppm had the highest concentration while the least was N_2O 0.001ppm in the rainy season and in the dry season CO2 was the highest at 6000ppm and N2O with 1.3ppm the least in the dry season. PM10 ranged from 2.45 to 0.21 µg/m3 in the rainy season and 4.00 to 0.92 µg/m3 for the dry season in farm 1 while in farm 2 it ranged from 1.98 to 0.18 µg/m3 (rainy season) and 3.00 to 0.001 µg/m3 (dry season). PM2.5 ranged from 3.74 to 0.08µg/m3 (rainy season) and 5.19 to 1.92µg/m3 (dry season) in farm 1 and 2.74 to 0.89µg/m3 (rainy season) and 4.78 to 1.52µg/m3 (dry season) in farm 2. Total Heterotrophic Bacteria Count (THBC) had the highest count of 1.0 to 15.9 CFU/plate/exposure time and Total Fecal Coliform Count (TFCC) with range 0.1 to 3.1 CFU/plate/exposure time was the least in the rainy season while in dry season THBC had the highest count with range 1.2 to 12.9 CFU/plate/exposure time, and the least TFCC with range 0.3 to 2.8 CFU/plate/exposure time in farm 1. In farm 2 during the rainy season, THBC had the highest count with range 0.6 to 13.9 CFU/plate/exposure time and the least TPBC with range 0.04 to 3.6 CFU/plate/exposure time and in the dry season THBC had a range of 0.8 to 11.1 CFU/plate/exposure time and Total Fungal Count (TFC) with range of 0.2 to 3.1 CFU/plate/exposure time was the least. A total of 10 species of bacteria like *Klebsiella* species, *Bacillus subtilis, Bacillus cereus* etc and 12 species of fungi like *Aspergillus niger, Penicillium* species, *Microsporum canis*, etc. were isolated in both the rainy and dry season. It was also observed that the microbial load was also higher during the rainy season than in the dry season. Improper handling of waste increased the air pollution in the farms producing delirious gases.

Keywords: Air, microbial load, rainy season, dry season, pig.

INTRODUCTION.

Pigs are housed in a pen in modern pig husbandry. Most frequently a brick home with good ventilation, dwarf walls, and concrete flooring. Animal by-products such as meat, milk, hides, and skin, as well as sources of draught, electricity, and manure are all crucial commodities and services provided by livestock. Additionally, it serves as a capital reserve during difficult times. (Ume *et al., 2018*). Due to the manure and wastes produced, waste management is one of the major issues in pig farming operations.

Manure production and waste treatment have a negative impact on the air. Pig manure has traditionally been handled as "solid," which required that it be collected, kept, and allowed to compost over a few months. (Ume *et al.,* 2018_b). Nowadays, pig dung is frequently kept in open-air "lagoons" or as "liquid manure. This indicates that the gases released from these locations directly enter the air, lowering its quality. To lessen the smell, chemicals are often put to the manure. The manure's organic components and these compounds will enter the atmosphere, harming the environment and perhaps causing acid rain. (Okolo, 2011).

For the welfare of the animals as well as the caregivers, it's critical to maintain adequate air quality surrounding the pig farm. These pig farms produce mytotoxins and endotoxins, and both the animals and farm employees are exposed to significant levels of bacteria and fungi. (Silvana *et al.,* 2014). These microorganisms that are found in the air may cause various negative effects especially allergic and infectious diseases (Duchaine *et al.,* 2000). Factors such as the type of the building, the number of animals, the ventilation type and the microclimate conditions are determinants in the concentration of microorganisms in the indoor air (Yao *et al.,* 2010). Pig production results in environmental degradation which is primarily in form of pollution because it is growing out of balance with the environment. The air quality arises from the excess excretion of dietary phosphorus and other minerals, inappropriate housing conditions that gives rise to unpleasant odour and the waste handling system and operations. Also when considering microbial air pollution in pig farms, improper hygiene conditions are not excluded (Benhazi *et al.,* 2008).

Suspended airborne particles can also absorb toxic and noxious gases as well as bacterial components. High concentrations of airborne particles may contain bacterial toxins and appear to enhance both the prevalence and severity of respiratory diseases in pig farm. Pig farms are important sources of emission of ammonia and the main factor influencing the production of NH_3 are the type of floor, the disposal of manure, conditions inside the building, diet composition and feed efficiency (Benhazi, 2007). These gaseous by products

lead to many environmental problems, affecting the atmosphere, the neighbourhood and health of pig-keepers. Pollutants such as ammonia (NH_3), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are the most abundant gaseous compounds emitted from pig farms (European Union Directive, 2016). NH_3 and N_2O are emitted at all stages of manure management, whereas CO_2 originates from both animal respiration and manure management, and CH_3 comes from both enteric fermentation of animals and manure management. NH_3 released into the atmosphere causes nutrient enrichment and the acidification of soil and water; moreover, it acts as an aerosol precursor in the troposphere (Dumont, 2018). Emission from the manure storage system also put the quality of the air at risk because of the effect of the gases such as hydrogen sulphide, ammonia, methane and volatile organic compounds have on the environment and human health (Andreea *et al.,* 2013). Pigs' odour is usually caused by the complex mixture of odourants that can occur through any of the gaseous, liquid or solid phases. For nearby workers and neighbours who inhale these emissions from the pig farms, the most notable acute health effects are eye, nose and throat irritations, headaches, nausea, diarrhea, sore throat, chest spasm, nasal congestions, palpitations, shortness of breath, stress and sleepiness (Joachim *et al.,* 2010).

MATERIALS AND METHOD.

This was carried out in the two seasons observed in Umuahia; rainy and dry seasons. During the rainy season, sampling will be done between the months of April and September while the dry season sampling will be done between the months of November to March. Also, sampling will be done in the farms at the period when the highest activities are going on in the farms which is between 9am – 12noon and 3pm – 5pm. Air sampling was conducted using hand held devices. It was held up at nose level.

The total heterotrophic bacterial counts (THBC) will be determined using nutrient agar, Total Coliform Counts (TCC) using MacConkey Agar, Total Fungal Count (TFC) using Sabrouad Dextrose Agar supplemented with chloramphenicol (10.05 µg/ml), EMB agar for total fecal coliform and Blood agar for potential pathogenic bacterial counts (Nwaugo *et al*., 2008).

All these will be prepared according to the manufacturer's instructions and autoclaved at 121^{o}C at 15psi for 15minutes. It will be allowed to cool to about 45^{o}C before dispensing into pre-sterilized media.

AIR MICROBIAL ANALYSIS.

The air microbial analyses was carried out using the settle plate technique as described by Napoli *et al.,* (2012). Freshly prepared plates of nutrient agar, MacConkey agar, SDA, EMB

agar, blood agar was properly labelled according to the specified distances and time. It was taken to the various farms and exposed at 1.5m above the ground level away from obstructions. Distances of exposure were 0m, 100m, 200m and 500m at distance the time of exposure was 10mins, 20mins, and 30mins respectively.

SDA plates will be incubated at room temperature (28±2 ^{o}C) for 3-5 days, MacConkey and Nutrient agar will be at 37^{o}C for 24-48 hours while EMB agar will be at 44^{o}C for 24hours.

Isolation of pure bacteria and fungi colonies was done using the streaking method described in Cappuccino & Sherman (2014).

TABLE 1: Microbial load of the air around pig farm 1 in the rainy season measured as CFU/Plate/Minutes at various distances and time.

	THBC			TFC			TPBC			TFCC			TCC		
Minutes	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
Distance															
0 m	3.9	9.4	15.9	0.7	2.2	4.3	0.5	1.6	3.8	0.5	2.0	3.1	1.2	3.2	5.8
100 m	2.2	7.9	13.0	0.6	1.8	3.7	0.4	1.2	2.8	0.4	1.6	2.2	0.9	2.8	4.2
200 m	1.0	4.7	8.1	0.2	1.0	2.1	0.2	0.5	1.2	0.3	1.0	1.0	0.4	1.3	2.2
500 m	0.8	2.5	5.3	0.1	0.9	1.3	0.1	0.3	0.6	0.1	0.7	0.5	0.2	0.9	1.9

TABLE 2: Microbial load of the air around pig farm 1 in the dry season measured as CFU/Plate/Minutes at various distances and time.

	THBC			TFC			TPBC			TFCC			TCC		
Minutes	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
Distance															
0 m	2.9	7.2	12.9	0.6	1.7	3.7	0.4	1.3	3.1	0.4	1.8	2.8	1.0	2.7	4.0
100 m	2.0	6.2	10.4	0.5	1.3	3.1	0.3	1.1	2.5	0.3	1.4	1.9	0.8	1.8	3.4
200 m	1.2	5.2	9.4	0.4	1.5	2.5	0.2	0.7	1.9	0.3	1.1	1.3	0.5	1.5	2.8
500 m	0.9	3.6	6.4	0.2	1.3	1.7	NG	0.4	1.0	NG	NG	NG	0.3	1.0	2.0

TABLE 3: Microbial load of the air around pig farm 2 in the rainy season measured as CFU/Plate/Minutes at various distances and time.

	THBC			TFC			TPBC			TFCC			TCC		
Minutes	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
Distance															
0 m	3.2	7.8	13.9	0.5	2.0	3.8	0.5	1.7	3.6	0.9	2.4	4.6	1.5	3.7	6.7
100 m	2.4	6.9	12.5	0.4	1.4	3.0	0.3	1.4	3.0	0.5	1.4	2.2	0.8	2.2	4.7
200 m	1.0	3.0	7.1	0.2	0.5	2.2	0.1	1.6	2.0	0.1	0.6	1.2	0.2	1.0	3.0
500 m	0.6	2.1	5.9	0.1	0.2	1.2	0.04	0.1	1.1	NG	NG	NG	0.02	0.3	1.4

TABLE 4: Microbial load of the air around pig farm 2 in the dry season measured as CFU/Plate/Minutes at various distances and time.

	THBC			TFC			TPBC			TFCC			TCC		
Minutes	10	20	30	10	20	30	10	20	30	10	20	30	10	20	30
Distance															
0 m	2.5	6.6	11.1	0.4	1.8	3.1	0.4	1.5	3.3	0.6	2.0	3.6	1.3	3.4	6.2
100 m	1.6	4.9	9.1	0.4	1.0	2.7	0.2	1.0	2.6	0.4	1.2	2.0	0.7	2.1	4.2
200 m	1.2	3.9	8.3	0.3	0.9	2.4	0.2	0.9	2.2	0.2	0.9	1.5	0.4	1.4	3.4
500 m	0.8	2.8	6.5	0.2	0.3	1.8	0.1	0.3	1.6	NG	NG	NG	NG	NG	1.5

KEYS:

THBC: Total Heterotrophic Bacteria Count. TFC: Total Fungal Count. TPBC: Total Pathogenic Bacteria Count.

TFCC: Total Fecal Coliform Count TCC: Total Coliform Count. NG: No Growth.

TABLE 5: Percentage prevalence of bacterial isolates from the air in pig farms 1 & 2 in the rainy season.

		0 M			100 M			200 M			500 M		
	Minutes	**10**	**20**	**30**	**10**	**20**	**30**	**10**	**20**	**30**	**10**	**20**	**30**
	Isolate												
FARM 1	*Klebsiella* species	6(66.7)	9(100)	9(100)	-	-	-	-	-	-	-	-	-
	Bacillus subtilis	-	5(55.6)	6(66.7)	-	5(55.6)	7(77.8)	-	-	-	-	-	-
	Lactobacillus species	5(55.6)	6(66.7)	6(66.7)	5(55.6)	6(66.7)	6(66.7)	-	-	2(22.2)	5(55.6)	6(66.7)	7(77.8)
	Aeromonas species	-	5(55.6)	6(66.7)	-	-	-	-	-	-	-	-	-
	Bacillus cereus	6(66.7)	6(66.7)	6(66.7)	5(55.6)	6(66.7)	6(66.7)	5(55.6)	6(66.7)	7(77.8)	-	-	-
	Escherichia coli	5(55.6)	6(66.7)	6(66.7)	2(22.2)	2(22.2)	2(22.2)	-	-	-	-	-	-
	Enterobacter species	5(55.6)	9(100)	8(88.9)	5(55.6)	9(100)	10(83.3)	5(55.6)	6(66.7)	9(100)	5(55.6)	7(58.3)	7(77.8)
	Sarcina species	6(66.7)	6(66.7)	9(100)	-	-	-	-	-	-	-	-	-
	Shigella species	2(22.2)	3(33.3)	4(44.4)	-	-	6(66.7)	-	-	-	-	-	-
FARM 2	*Klebsiella* species	5(55.6)	6(66.7)	6(66.7)	-	-	-	-	-	-	-	-	-
	Bacillus subtilis	2(22.2)	3(33.3)	3(33.3)	-	9(100)	8(88.9)	-	-	-	-	-	-
	Lactobacillus species	5(55.6)	6(66.7)	6(66.7)	5(55.6)	6(66.7)	7(77.8)	2(22.2)	4(44.4)	4(44.4)	-	6(66.7)	7(77.8)
	Aeromonas species	-	3(33.3)	5(55.6)	5(55.6)	7(77.8)	6(66.7)	-	-	-	-	-	-
	Bacillus cereus	6(66.7)	6(66.7)	7(77.8)	-	2(22.2)	7(77.8)	2(22.2)	4(44.4)	4(44.4)	2(22.2)	4(44.4)	4(44.4)
	Escherichia coli	5(55.6)	6(66.7)	7(77.8)	2(22.2)	2(22.2)	4(44.4)	-	-	-	-	-	-
	Enterobacter species	-	3(33.3)	6(66.7)	6(66.7)	6(66.7)	7(77.8)	6(66.7)	6(66.7)	7(77.8)	7(77.8)	7(77.8)	7(77.8)
	Sarcina species	-	3(33.3)	4(44.4)	-	-	-	-	-	-	-	-	-
	Shigella species	2(22.2)	3(33.3)	3(33.3)	-	-	-	-	-	-	-	-	-

Keys: N – 9 - Absent

TABLE 6: Percentage prevalence of bacterial isolates from the air in pig farms 1 & 2 in the dry season.

		0 M			100 M			200 M			500 M		
	Minutes	**10**	**20**	**30**	**10**	**20**	**30**	**10**	**20**	**30**	**10**	**20**	**30**
	Isolates												
FARM 1	*Klebsiella* species	6(100)	6(100)	6(100)	-	-	-	-	-	-	-	-	-
	Lactobacillus species	5(83.3)	6(100)	6(100)	5(83.3)	6(100)	6(100)	-	-	6(100)	6(100)	6(100)	6(100)
	Escherichia coli	6(100)	6(100)	6(100)	5(83.3)	6(100)	6(100)	6(100)	5(83.3)	6(100)	-	-	-
	Sarcina species	6(100)	6(100)	6(100)	-	-	-	-	-	-	-	-	-
	Bacillus cereus	6(100)	6(100)	6(100)	5(83.3)	6(100)	6(100)	6(100)	5(83.3)	6(100)	6(100)	6(100)	6(100)
	Staphylococcus aureus	6(100)	6(100)	6(100)	5(83.3)	6(100)	6(100)	-	-	-	-	-	-
FARM 2	*Klebsiella* species	6(100)	6(100)	6(100)	-	-	-	-	-	-	-	-	-
	Lactobacillus species	6(100)	6(100)	6(100)	5(83.3)	6(100)	6(100)	6(100)	6(100)	6(100)	-	6(100)	6(100)
	Escherichia coli	6(100)	6(100)	6(100)	5(83.3)	6(100)	6(100)	6(100)	5(83.3)	6(100)	-	-	-
	Sarcina species	-	6(100)	6(100)	-	-	-	-	-	-	-	-	-
	Bacillus cereus	6(100)	6(100)	6(100)	5(83.3)	6(100)	6(100)	2(33.3)	5(83.3)	6(100)	6(100)	6(100)	6(100)
	Staphylococcus aureus	6(100)	6(100)	6(100)	5(83.3)	6(100)	6(100)	-	-	-	-	-	-

Keys:

N – 6

- Absent

Table 7: Percentage prevalence of fungi isolates from the air in pig farm 1 in the rainy season.

	0m			100m			200m			500m		
Minutes	**10**	**20**	**30**	**10**	**20**	**30**	**10**	**20**	**30**	**10**	**20**	**30**
Isolates												
Aspergillus niger	6(50)	9(75)	10(83.3)	5(41.7)	8(66.6)	9(75)	-	-	7(58.3)	-	-	6(50)
Penicillium species	4(33.3)	5(41.7)	6(50)	-	5(41.7)	6(50)	-	-	6(50)	-	-	6(50)
Mucor species	-	3(25)	5(41.7)	-	5(41.7)	7(58.3)	-	-	5(41.7)	-	2(16.7)	4(33.3)
Microsporum canis.	-	-	-	-	-	-	4(33.3)	5(41.7)	5(41.7)	8(66.6)	9(75)	10(83.3)
Aspergillus fumigatus	4(33.3)	5(41.7)	5(41.7)	-	4(33.3)	5(41.7)	-	4(33.3)	5(41.7)	5(41.7)	5(41.7)	6(50)
Candida albicans	10(83.3)	11(91.7)	12(100)	-	3(25)	4(33.3)	-	-	-	-	-	-
Trichophyton species	5(41.7)	7(58.3)	8(66.6)	3(25)	3(25)	5(41.7)	-	3(25)	3(25)	3(25)	3(25)	3(25)
Trichoderma species	7(58.3)	7(58.3)	8(66.6)	-	6(50)	6(50)	-	6(50)	6(50)	-	6(50)	7(58.3)
Cladosporium species	5(41.7)	5(41.7)	5(41.7)	5(41.7)	6(50)	6(50)	4(33.3)	5(41.7)	5(41.7)	4(33.3)	5(41.7)	5(41.7)
Fusarium oxysporium	2(16.7)	3(25)	3(25)	3(25)	5(41.7)	6(50)	5(41.7)	6(50)	6(50)	6(50)	6(50)	6(50)
Alternaria species	6(50)	6(50)	6(50)	4(33.3)	6(50)	6(50)	4(33.3)	6(50)	6(50)	7(58.3)	7(58.3)	7(58.3)
Phialophora richardsiae	-	3(25)	3(25)	3(25)	6(50)	6(50)	3(25)	6(50)	7(58.3)	4(33.3)	7(58.3)	7(58.3)

Keys: N – 12 - absent

Table 8: Percentage prevalence of fungal isolates from the air in pig farm 2 in the rainy season.

	0m			100m			200m			500m		
Minutes	**10**	**20**	**30**	**10**	**20**	**30**	**10**	**20**	**30**	**10**	**20**	**30**
Isolates												
Aspergillus niger	6(50)	8(66.6)	9(75)	5(41.7)	7(58.3)	8(66.6)	-	-	4(33.3)	-	-	4(33.3)
Penicillium species	5(41.7)	5(41.7)	5(41.7)	-	4(33.3)	4(33.3)	-	-	4(33.3)	-	-	4(33.3)
Mucor species		3(25)	4(33.3)	-	5(41.7)	5(41.7)	-	-	5(41.7)	-	3(25)	5(41.7)
Microsporum canis.	-	-	-	-	-	-	5(41.7)	5(41.7)	5(41.7)	8(66.6)	8(66.6)	8(66.6)
Aspergillus fumigatus	5(41.7)	5(41.7)	5(41.7)	-	4(33.3)	4(33.3)	-	4(33.3)	4(33.3)	5(41.7)	5(41.7)	5(41.7)
Candida albicans	9(75)	10(83.3)	10(83.3)	-	3(25)	4(33.3)	-	-	-	-	-	-
Trichophyton species	9(75)	10(83.3)	10(83.3)	3(25)	3(25)	4(33.3)	-	3(25)	3(25)	3(25)	3(25)	3(25)
Trichoderma species	6(50)	6(50)	7(58.3)	-	5(41.7)	5(41.7)	-	5(41.7)	5(41.7)	-	5(41.7)	5(41.7)
Cladosporium species	6(50)	6(50)	6(50)	6(50)	7(58.3)	7(58.3)	7(58.3)	8(66.6)	7(58.3)	8(66.6)	8(66.6)	9(75)
Fusarium oxysporium	3(25)	3(25)	3(25)	2(16.7)	3(25)	3(25)	5(41.7)	5(41.7)	6(50)	5(41.7)	5(41.7)	6(50)
Alternaria species	8(66.6)	9(75)	9(75)	3(25)	4(33.3)	4(33.3)	3(25)	5(41.7)	5(41.7)	5(41.7)	6(50)	7(58.3)
Phialophora richardsiae	-	2(16.7)	2(16.7)	2(16.7)	4(33.3)	4(33.3)	2(16.7)	5(41.7)	5(41.7)	6(50)	6(50)	6(50)

Keys:

N – 12

- Absent

Table 9: Percentage prevalence of fungal isolates from the air in pig farms 1 & 2 in the dry season.

		0m			100m			200m			500m	
	Minutes	10	20	30	10	20	30	10	20	30	10	20	30
	Isolates												
Farm 1	*Aspergillus niger*	9(100)	9(100)	9(100)	6(66.7)	6(66.7)	9(100)	3(33.3)	6(66.7)	6(66.7)	3(33.3)	6(66.7)	6(33.3)
	Aspergillus fumigatus	8(88.9)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)
	Trichophyton species	-	5(55.6)	5(55.6)	6(66.7)	9(100)	9(100)	6(66.7)	9(100)	9(100)	9(100)	9(100)	9(100)
	Cladosporium species	3(33.3)	5(55.6)	5(55.6)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)
	Trichoderma species	9(100)	9(100)	9(100)	6(66.7)	6(66.7)	7(77.8)	7(77.8)	8(88.9)	8(88.9)	6(66.7)	6(66.7)	7(77.8)
	Candida albicans	3(33.3)	3(33.3)	3(33.3)	2(22.2)	3(33.3)	3(33.3)	2(22.2)	3(33.3)	3(33.3)	3(33.3)	3(33.3)	3(33.3)
	Mucor species	3(33.3)	3(33.3)	3(33.3)	2(22.2)	2(22.2)	3(33.3)	3(33.3)	3(33.3)	3(33.3)	2(22.2)	3(22.2)	3(33.3)
	Microsporium canis	-	-	-	-	-	-	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)
	Phialophora richardsiae	2(22.2)	3(33.3)	3(33.3)	2(22.2)	3(33.3)	3(33.3)	2(22.2)	3(33.3)	3(33.3)	2(22.2)	3(33.3)	3(33.3)
Farm 2	*Aspergillus niger*	9(100)	9(100)	9(100)	6(66.7)	6(66.7)	9(100)	3(33.3)	6(66.7)	6(66.7)	3(33.3)	6(66.7)	6(66.7)
	Aspergillus fumigatus	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)
	Trichophyton species	-	6(66.7)	6(66.7)	6(66.7)	9(100)	9(100)	6(66.7)	9(100)	9(100)	9(100)	9(100)	9(100)
	Cladosporium species	3(33.3)	33.3)	3(33.3)	5(55.6)	5(55.6)	6(66.7)	5(55.6)	6(66.7)	6(66.7)	5(55.6)	6(66.7)	6(66.7)

Trichoderma species	5(55.6)	5(55.6)	6(66.7)	5(55.6)	6(66.7)	6(66.7)	5(55.6)	5(55.6)	5(55.6)	5(55.6)	5(55.6)	5(55.6)
Candida albicans	2(22.2)	2(22.2)	2(22.2)	2(22.2)	2(22.2)	3(33.3)	2(22.2)	2(22.2)	3(33.3)	2(22.2)	3(33.3)	3(33.3)
Mucor species	3(33.3)	3(33.3)	3(33.3)	3(33.3)	4(44.4)	4(44.4)	4(44.4)	4(44.4)	5(55.6)	5(55.6)	6(66.7)	6(66.7)
Microsporium canis	-	-	-	-	-	-	9(100)	9(100)	9(100)	9(100)	9(100)	9(100)
Phialophora richardsiae	3(33.3)	3(33.3)	3(33.3)	2(22.2)	2(22.2)	2(22.2)	2(22.2)	2(22.2)	2(22.2)	2(22.2)	2(22.2)	2(22.2)

Keys:

N – 9

- Absent.

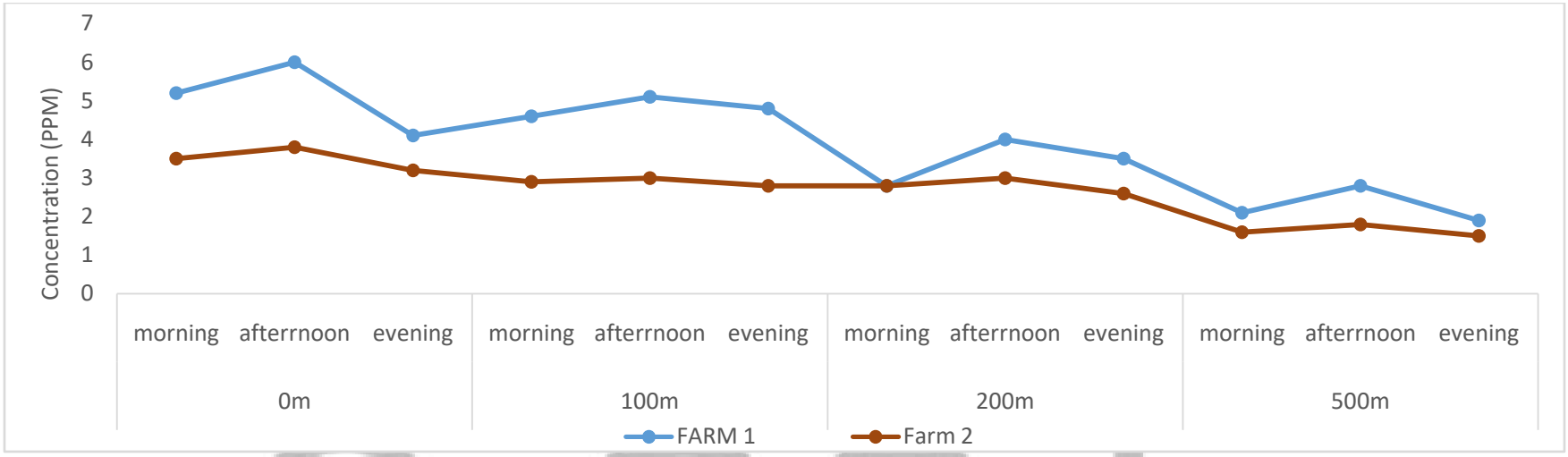

Fig. 1: Concentration of ammonia (NH_3) in the air in farm 1 and farm 2 in the rainy season.

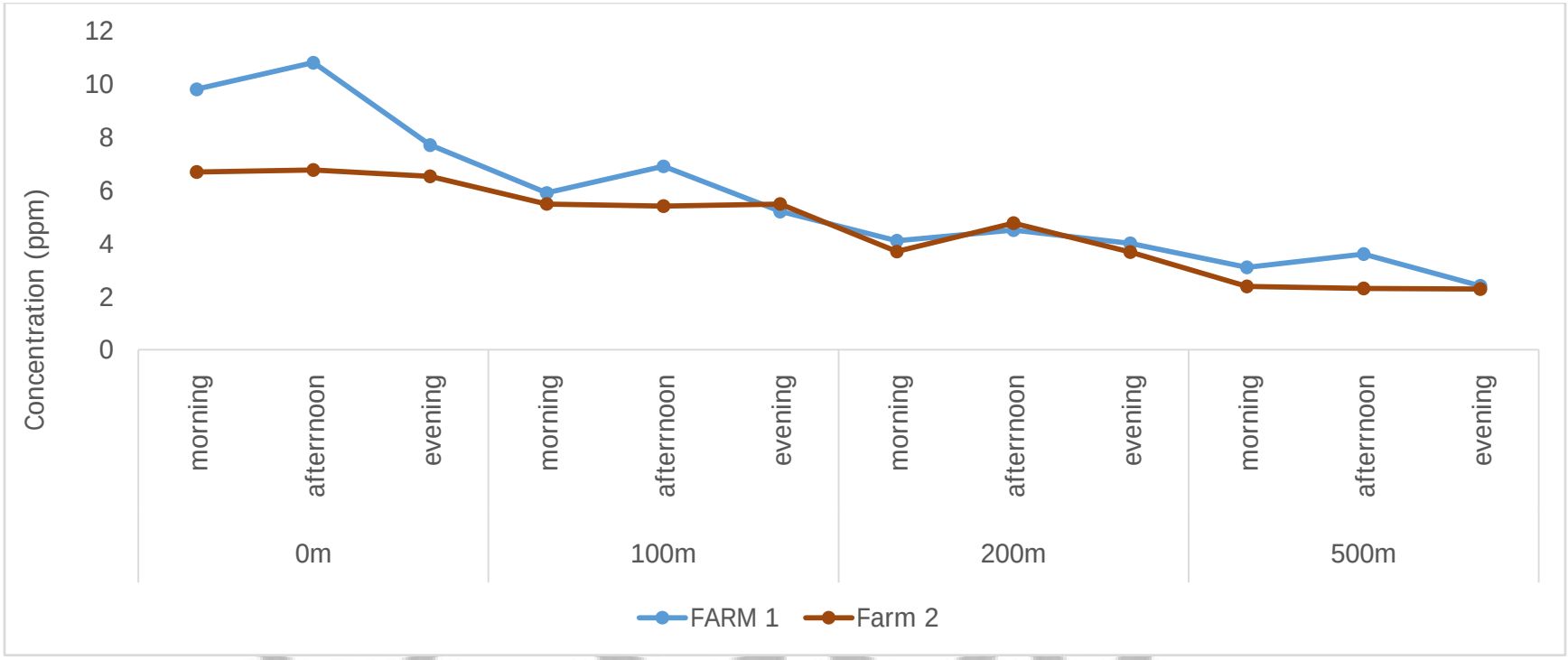

Fig. 2: Concentration of ammonia (NH_3) in the air in farm 1 and farm 2 in the dry season.

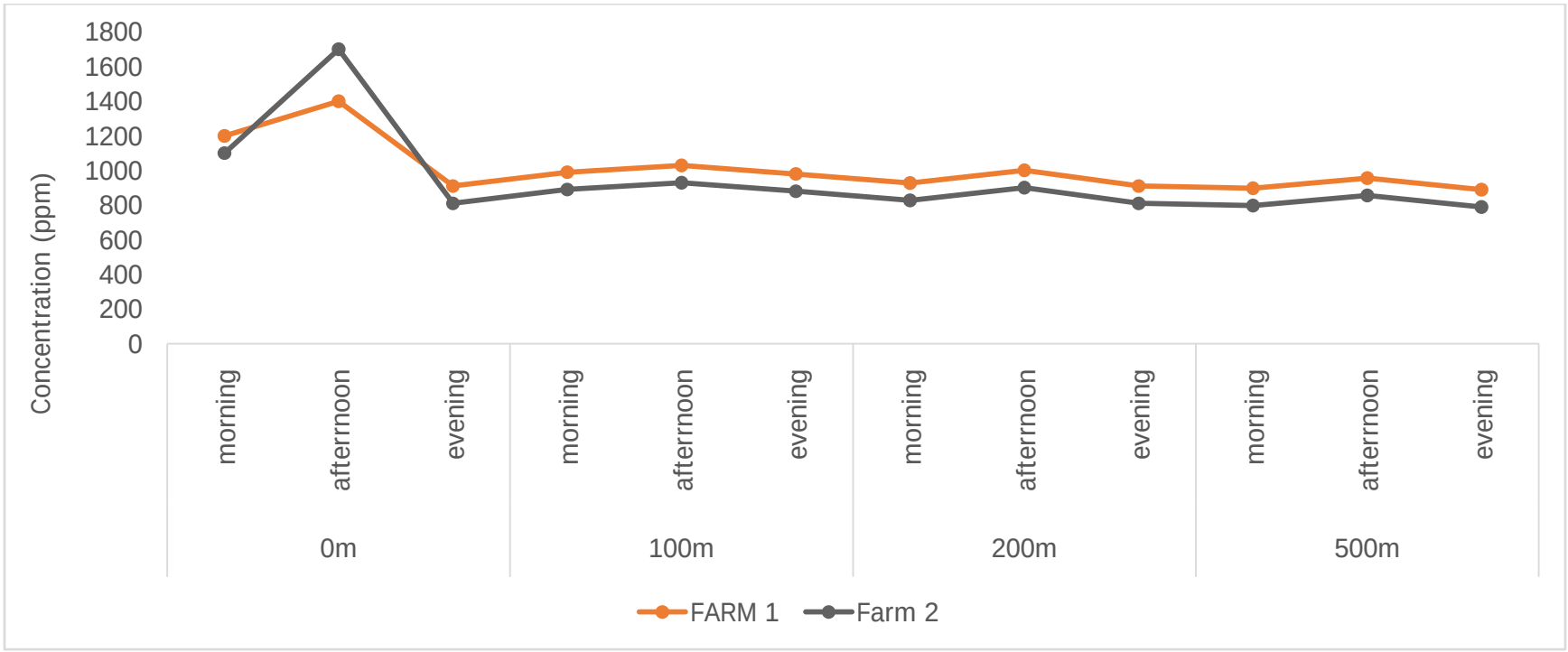

Fig. 3: Concentration of carbon dioxide (CO_2) in the air in farm 1 and farm 2 in the rainy season.

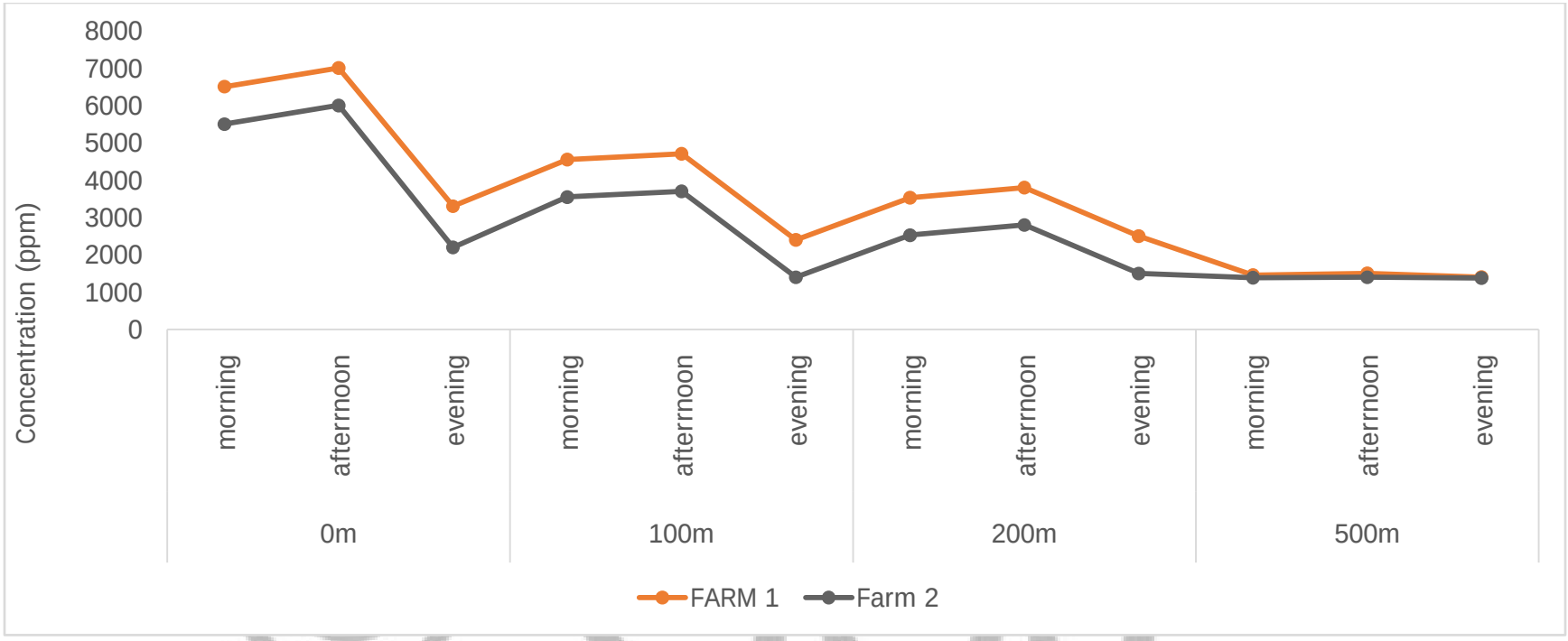

Fig. 4: Concentration of carbon dioxide (CO_2) in the air in farm 1 and farm 2 in the dry season.

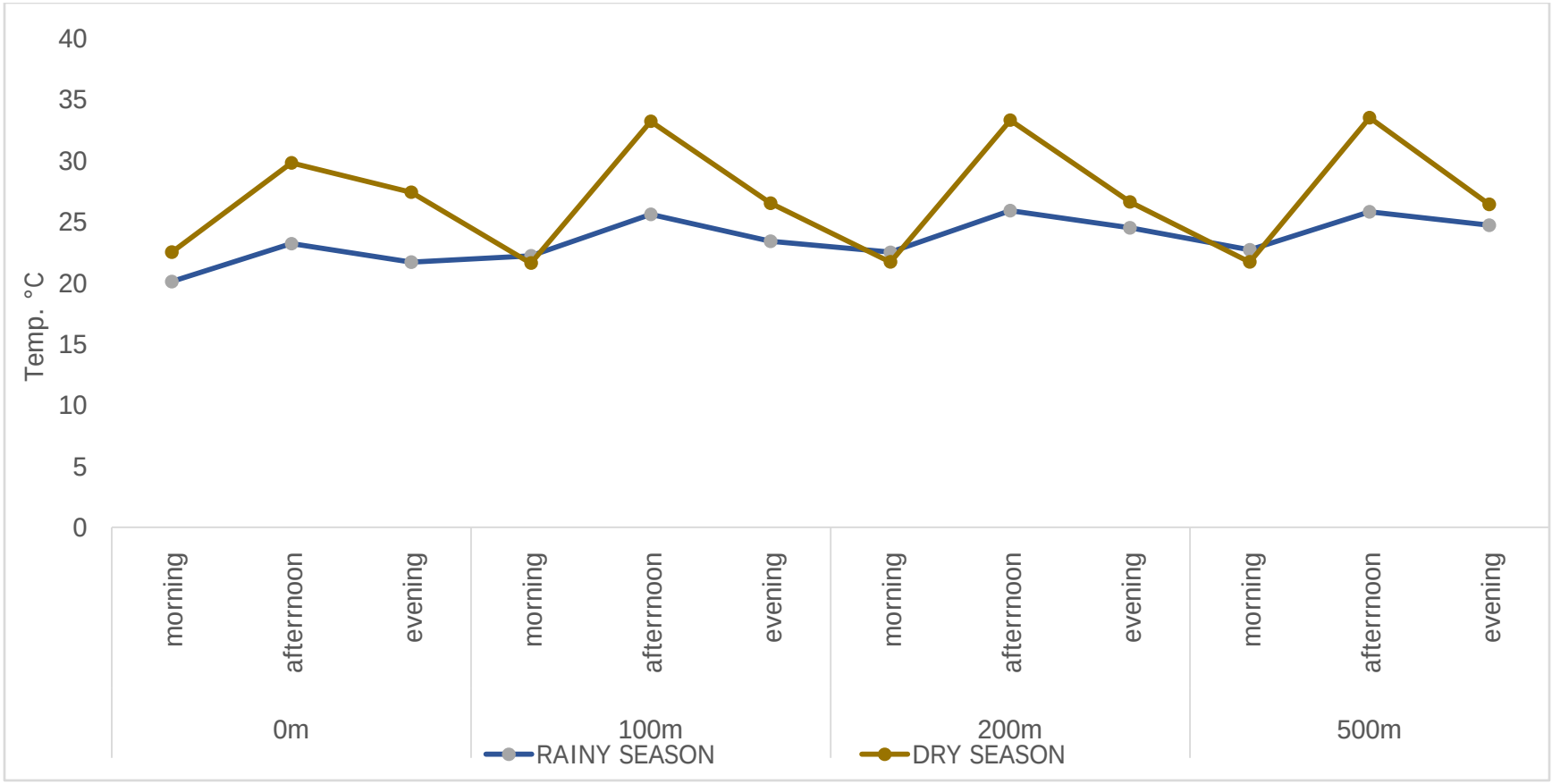

Fig. 5: Temperature during the rainy and dry season in farm 1 & farm 2.

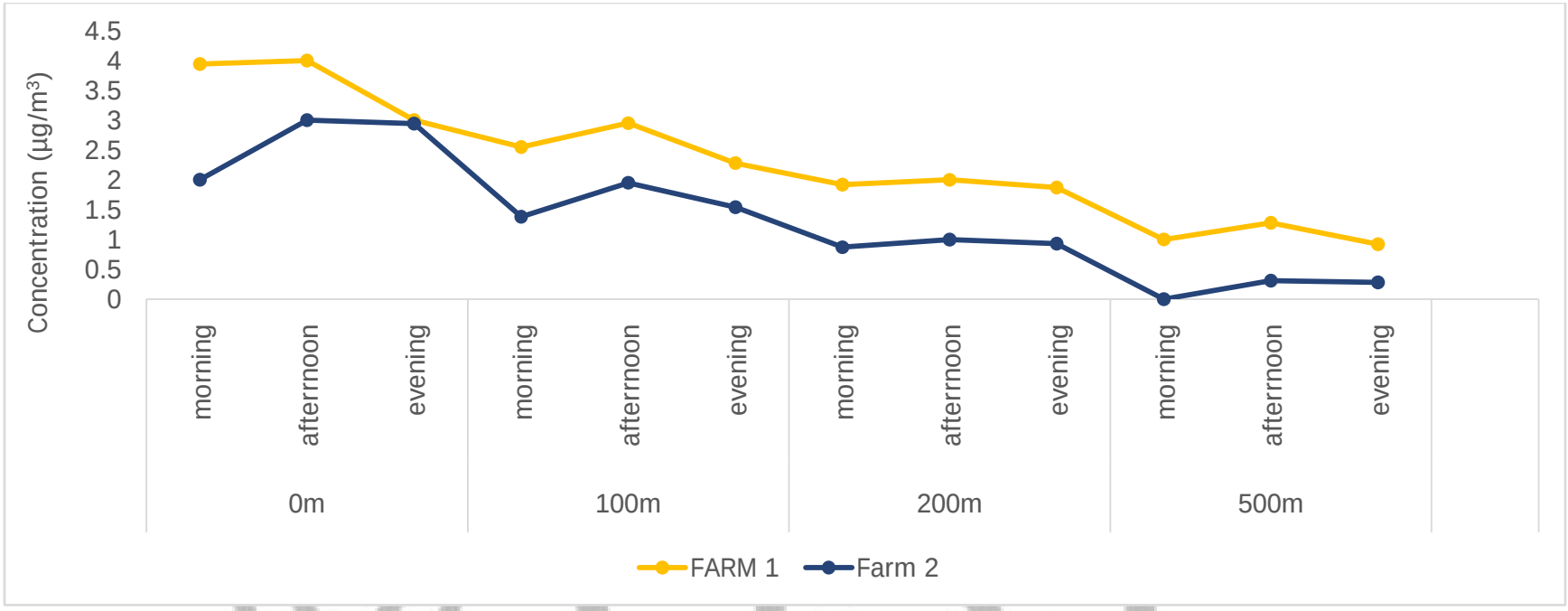

Fig. 6: Concentration of Particulate Matter 10 (PM_{10}) in the air in farm 1 and farm 2 in the rainy season.

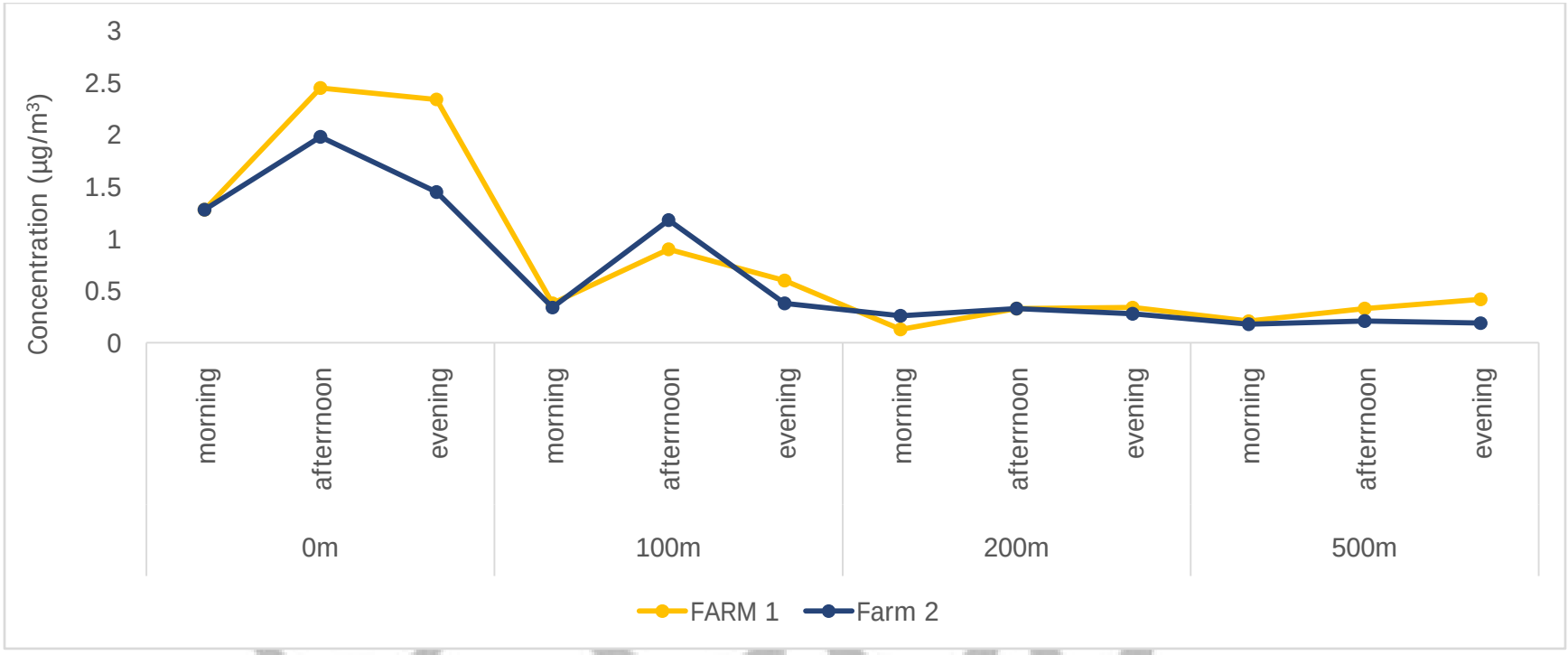

Fig. 7: Concentration of Particulate Matter 10 (PM_{10}) in the air in farm 1 and farm 2 in the dry season.

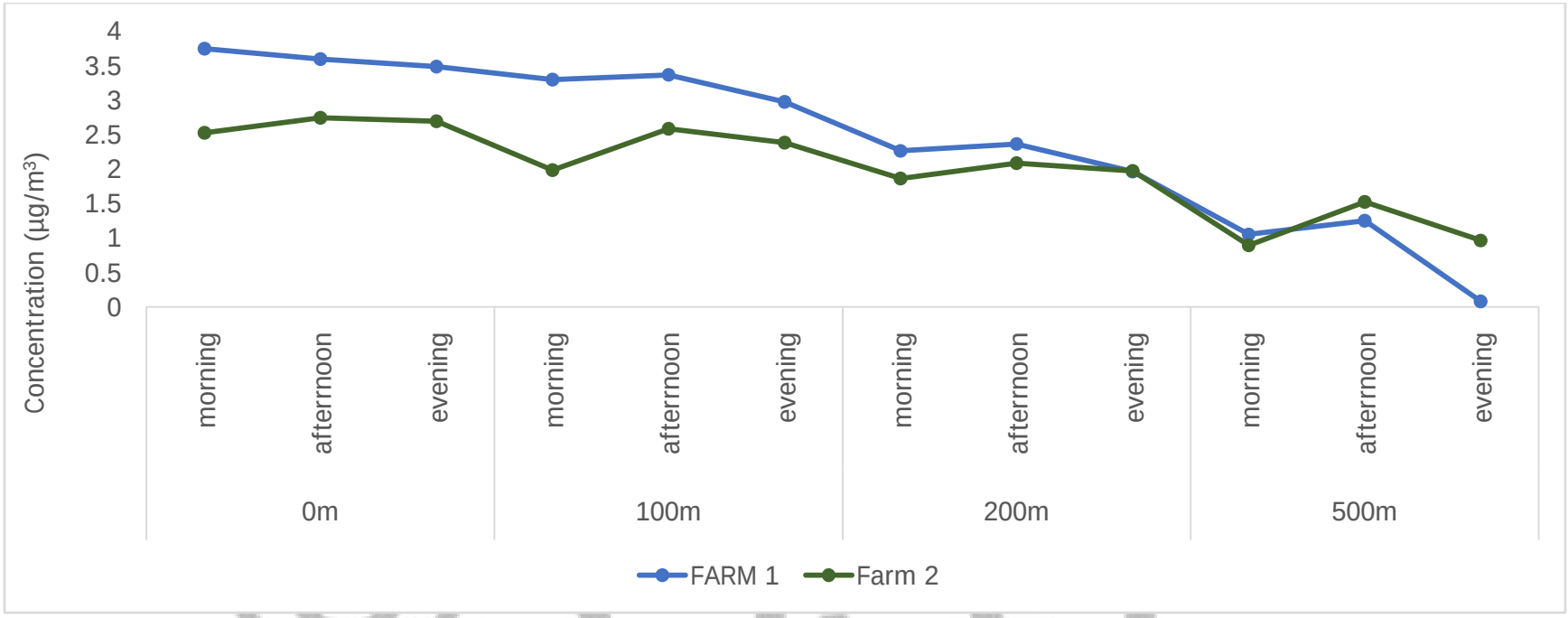

Fig. 8: Concentration of Particulate Matter 2.5 ($PM_{2.5}$) in the air in farm 1 and farm 2 in the rainy season.

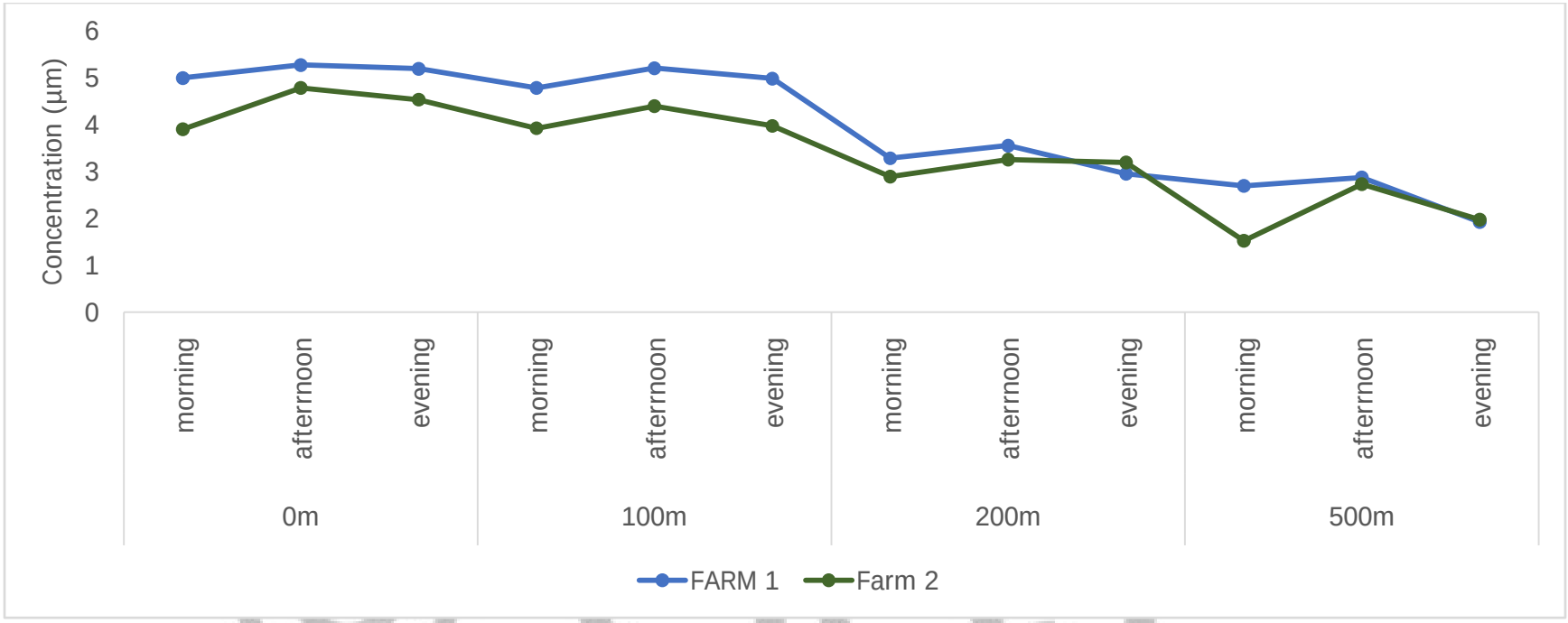

Fig. 9: Concentration of Particulate Matter 2.5 ($PM_{2.5}$) in the air in farm 1 and farm 2 in the dry season.

Fig. 10: Concentration of hydrogen sulphide (H_2S) in the air in farm 1 and farm 2 in the rainy season.

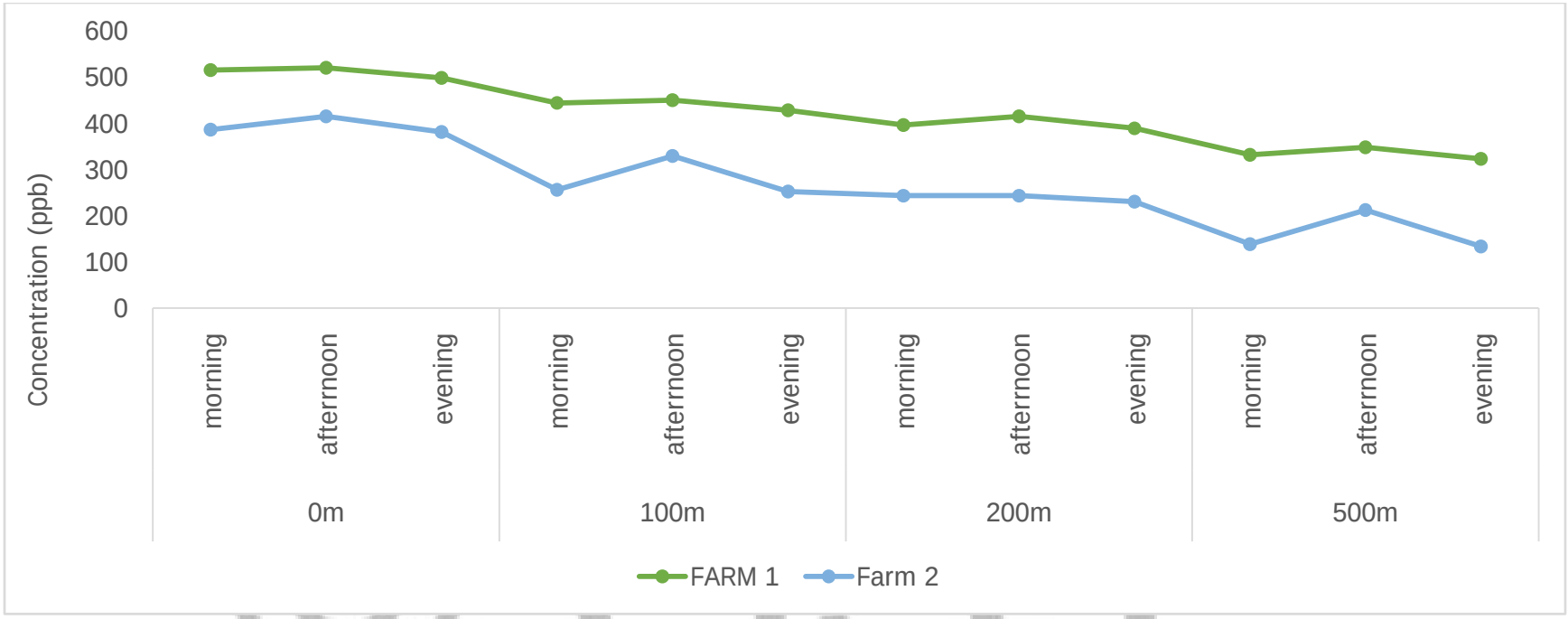

Fig. 11: Concentration of hydrogen sulphide (H_2S) in the air in farm 1 and farm 2 in the dry season.

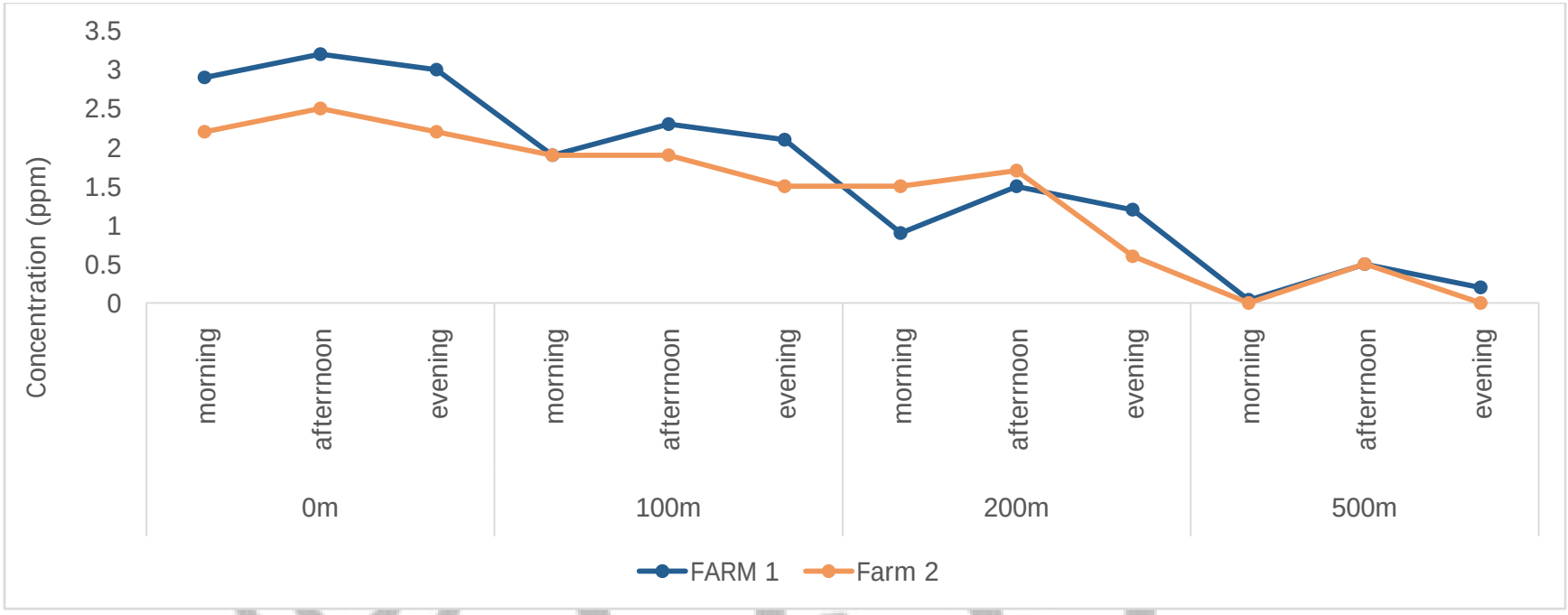

Fig. 12: Concentration of nitrous oxide (N_2O) in the air in farm 1 and farm 2 in the rainy season.

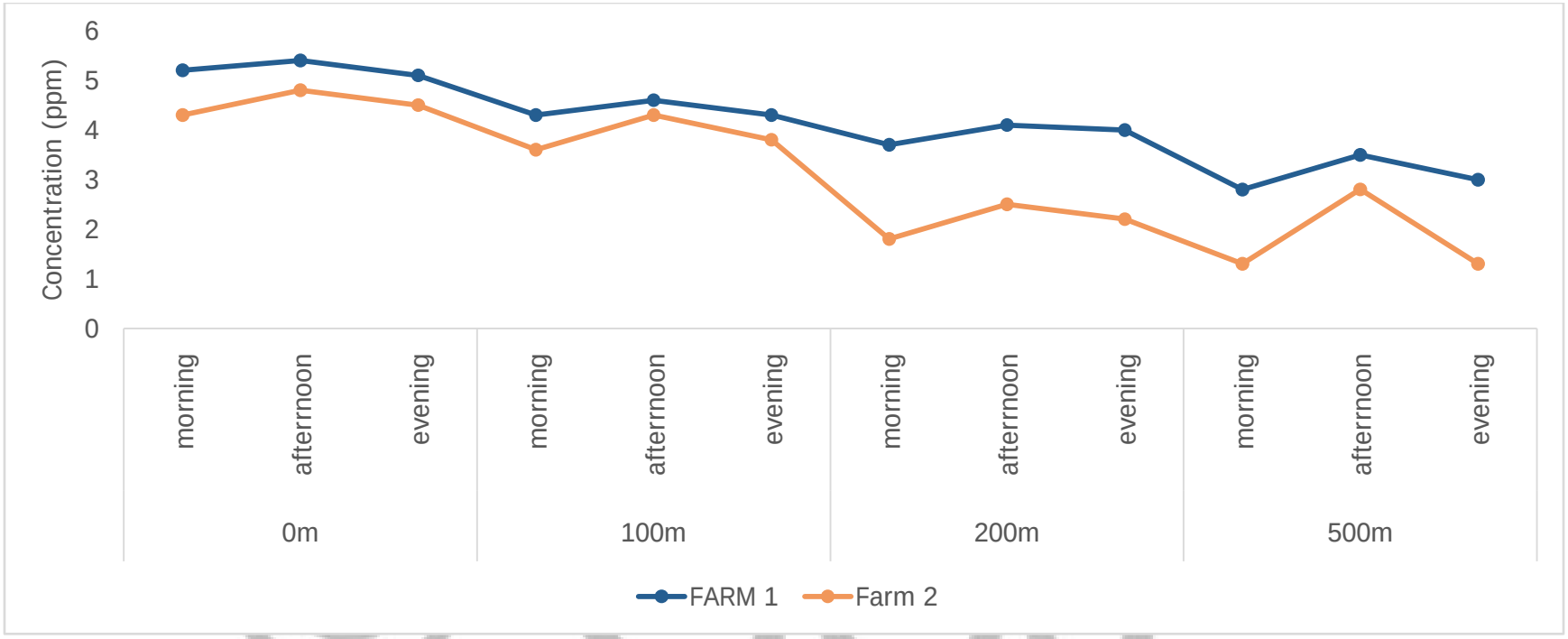

Fig. 13: Concentration of nitrous oxide (N_2O) in the air in farm 1 and farm 2 in the dry season.

DISCUSSION.

Results for the microbiological load of the air at various times and distances were displayed in Tables 1 and 2. The results showed that the maximum microbial load in both farms was reported at 0 m, followed by 100 m, 200 m, and finally the control (500m). Rooji et al. (2019) did not take time into account but found that the microbial exposure from livestock emission occurred at a very detectable level in the air at greater distances from the animal farms. However, Popescu et al. (2014) found that the number of bacteria was significantly higher in the cold season than in the warm season in their study of microbial air contamination in indoor and outdoor environments of pig farms, and they attributed this to increased ventilation to lower high temperatures as the primary cause.

Humid air increases the moisture content of the settle dust so that less dust becomes airborne. Seasonality affected the microbial counts which was observed in this study as higher counts were seen in the rainy season at 200m and 500m. This is so because according to Popescu *et al.* (2014) the higher count in the dry season could be due to wet and humid conditions which induced decomposition of raw organic materials in theses farms hence providing a comfortable growth condition for the bacteria and fungi increasing the airborne load. The presences of these microbes in large number could represent a significant immunological challenge to the human respiratory system (Lonc & Plewa, 2010).

The various count of airborne bacteria and fungi reported by different researchers could be as a result of different types of sampling methods adopted and device used. Different climate conditions also play a vital role in this disparity (Popescu *et al.*, 2014). The determined number of organism in the air indicates the need for setting standards on air quality in animal dwellings and the occupational environment and for developing reliable systems for monitoring the above factors (Duquenne *et al.*, 2013).

This study is in agreement with the findings of Popescu *et al.* (2014) whose study showed that the most frequent bacterial isolates were Gram positive with up to 90% occurrence whereas Gram negative bacteria occurrence was between 0.02% and 5.2%. This may be because the Gram negative bacteria have lower survival rate in the air. Kim & Ko (2019) reported that the main predominant specie of the airborne bacteria was *Enterobacter* species. Makut *et al.* (2014) reported same isolates as were seen in this study. They noted that bioaerosols may contain Gram

negative bacteria such as *E. coli, Shigella* species and *Pseudomonas* species and Gram positive bacteria such as *Staphylococcus aureus, Streptococcus* species, *and Micrococcus* species.

The microbial flora of the air in pig houses depends on the environmental parameters and the reason for the high levels of air contamination in pig houses are malfunctioning ventilation systems, high humidity of the feed and the climatic conditions. Improper hygiene can also cause considerable microbial pollution (Popescus *et al.,* 2014).

Mould and yeast can live practically anywhere and have particularly favourable conditions inside the animal house (Lonc & Plewa, 2010). According to Soliman *et al.* (2009) fungi like *Candida albican, Aspergillus niger, Penicillium* species, and *Mucor* species were predominant in broiler farm in Egypt. Also Agranovski *et al.* (2007) isolated and identified from a poultry many fungal strains including *Cladosporium. Aspergillus, Penicillium, Fusarium, Mucor, Trichophyton.* Some microbial specie and serotype such as *Trichophyton* species and *Aspergillus fumigatus* are pathogenic for animals and humans. Many of these organisms are opportunists which are particularly dangerous for animals with compromised immunity.

It was observed that the NH_4 concentration before cleaning the floors were 2ppm to 12ppm while it dropped to 1ppm to 5ppm after cleaning the floor. It can be inferred that animal activity and events such as manure removal exert an effect in the daily concentration of gases (Huaitalla *et al.,* 2013). Wathes *et al,* (2003) also observed mean values of NH_4 emission. The mean values are 5.1ppm, 11.1ppm for England with the maximum of 14.3ppm and 41.1ppm for the sow litters and sow slat respectively and in Germany it was observed to be 12.5ppm and 10.2ppm for the mean value and maximum 27.3ppm and 43.7ppm respectively. These values are so high as compared with what we obtained and this so because of their high protein content feed which increases the nitrogen input.

Huh & Kim (2013) also reported that in the air going through the composting process, the range of concentration of the generated CO_2 was 1086ppm – 2621ppm whereas that of the concentration of the generated CO_2 in the air outside the swine farm was 305ppm – 661ppm suggesting a major difference in distribution. Huaitalla *et al.* (2013) suggested that during the summer season, the CO_2 concentration was in the range of 300ppm -1500ppm and the daily mean concentration was 588ppm, which met the Chinese Standard NY/T 388-1999 ‘Environmental quality standard for livestock and poultry farms’, which indicated an average

CO_2 concentration of 819ppm for pig farms from China. During the winter, the range was from 1400ppm – 8000ppm which surpassed the Chinese threshold (819ppm).

Ni *et al.* (2018) reported that over a 63 day period in two naturally ventilated pig buildings, the H_2S concentration was about 280ppb and in a pig building between pig cycles with manure stored in under-floor pit, the measured H_2S ranged from 221 to 1492 ppb. This is very high compared with the result obtained from this study. Blunden *et al.* (2008) measured the seasonal variation in H_2S concentration in a finishing swine confinement house with 673, 429, 47, and 304 ppb in winter, spring, summer and fall respectively. Ni *et al.* (2018) also observed that the concentration of H_2S rises as the manure accumulates under the floor. Liu & Powers (2013) also reported that the average H_2S concentration at the edge of the emission source (0m) was 40 ± 48 ppb which is less than the acute Maximum Residual Level (MRL) (1000 ppb) but higher than the intermediate MRL (20 ppb) for H_2S. They also stated that the ambient H_2S concentrations in the vicinity of swine facilities decreases quickly to be less than 20 ppb as distances from emission source increases.

The study of the microbiological implication of pig farms on environment have been studied in this work and it has been observed that there was:

1. An increase in microbial load in and around the farm. This was seen in the study as the distance and time increased, the microbial load increased
2. An increase in the Particulate Matter whose constituent maybe delirious to both human and animal.
3. Presence of potentially pathogenic species of both bacteria and fungi.
4. A production of many gases some of which maybe toxic when in large concentration.
5. An increase in air pollution due to the improper handling and disposal of the waste. This was observed more in farm 1 which is a twelve years old and do surface disposal of the waste, the pollution was more than in farm 2 that is four year and their waste is collected in septic tank.

Therefore, proper sanitary measures are to be put in place to avoid their increase and these farms should be located far from residential areas.

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