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Assessment of Inhalable and Respirable Dust for Four Poultry Farms in Dakahlia Governorate, Egypt

Hanaa T. El-Bahnasy[1*], Maie I. El- Gammal[2], Ahmed E. Hagrus[1]
[1] Zoology Department, Faculty of Sciences, Mansoura University, Egypt.
[2] Environmental Sciences Department, Faculty of Sciences, Damietta University, Egypt.

ABSTRACT

The atmosphere of poultry farms usually contains significant levels of agricultural dust and toxic gases, which may cause harm to workers' health. Therefore, this study was conducted to investigate the environmental exposure to dust pollutants; inhalable (PM_{10}) and respirable ($PM_{2.5}$) dust. The study was carried out in 4 commercially operated poultry farms located in Al-Dakahlia Governorate, Egypt. The chosen poultry farms were based on their equipped way. The air samples were collected twice a week during 3 different stages of the rearing period of broiler chicks. The study was done during the period of November 2018 to April 2019. The results of this study showed that inhalable dust varied between 99 - 215 µg/m3 and respirable dust varied from 83-195 µg/m3 in farms C and D, respectively. It can be concluded the accumulation of manure, water, and feed remains lead to several pollutants particulate matters which have hazard health effects on farmworkers. Therefore, personal protective equipment as a face mask and mask filter must be used especially during disinfection process, for reduction of the pollutants exposure.
Keywords: Humidity, Inhalable Dust, Poultry Farms, Temperature, Worker's Health.

INTRODUCTION

Over the past two decades, interest in poultry production has increase due to increase demand for economic efficiency, animal welfare, food safety, reduction in environmental impacts and worker health (Oviedo-Rondón, 2019). Most commercial poultry are now raised entirely indoors, in environmentally controlled or semi controlled buildings. They are managed to maximize production (Karcher and Mench, 2018).

Poultry farming with the high stocking density, which may be implying in small areas and use of reused avian beds, is responsible for the dust particles emission and other pollutants (Rimac *et al*., 2010). The atmosphere of poultry farms usually contains significant levels of agricultural dust and toxic gases, which may cause harm to workers' health. More systematic research is needed to reveal the characteristics of indoor air pollution, characterize human exposure to various air pollutants and related health risks (You *et al.*, 2012). Meanwhile, the poultry sector faces serious multifactorial problems in both intensive and conventional systems, among which are these constraints that could lead to a true epidemic with severe economic loss for poultry farmers (Amine *et al.,* 2020).

Dust is one of the ingredients in poultry production. It arises from poultry waste, feed, manure, litter, mold, feather fragments, and animal skin and is biologically active because it contains microorganisms (bacteria, fungi, and viruses), some of which may be pathogens which negatively affects birds and workers (Millner, 2009). There is epidemiological evidence that the health of farmers working in animal houses may be affected by regular exposure to air pollutants such as dust (El-Gammal, 2005). Providing a safe and healthy work environment for employees is an important goal of any industry - including animal farming (Hartung and Schulz, 2011).

The main objectives of this study were to investigate environmental exposure to; inhalable (PM_{10}) and respirable ($PM_{2.5}$) dust and compare between the four poultry farms and their effects on the poultry workers.

MATERIALS AND METHODS

Poultry Farms Description and Equipment

The measured parameters were carried out in 4 commercially operated poultry farms located in Al-Dakahlia Governorate. One day old broiler chicks were raised from the commercial hybrid "Ross 308" to approximately 40 days old with a down time of 10 days between periods, water and feed were provided ad libitum during the experimental period, and the chicks received balanced formulated commercial diet free from any additives. Chicks were raised from day one till the end of the experiment on deep litter with stocking density of 10 birds / m2, whereas the concrete floor were covered with 3 cm depth wood shavings as bedding material for each subsequent flock with old litter removed between flocks. No additional litter materials or modifications were added to the litter at any time during each raising cycle of the study. All investigated poultry farms were differentiated in how to be equipped as shown in Table (1). The different techniques of disinfection method that applied in four poultry farms are shown in Table (2).

Ethical approval

All applicable international, national and/ or institutional guidelines for bird care have been followed to avoid any infection and microbial transmission like wearing special suit, face mask, gloves, clean our shoes with disinfectant or wearing over shoes before entering the poultry farm.

* *Corresponding author e-mail:* hanaa_tawfik_2012@mans.edu.eg

Sampling and Analysis

Air samples were collected twice a week at 3 different stages of the production period, inside the four investigated poultry farms. The time period of sample collection was carried out from November 2018 to April 2019. The different stages have been classified as follows: first sample was taken at the initial sampling stage (S1) during which the air samples were collected at the entrance of the chicks, after cleaning and disinfecting process of the farm. The second sample was taken during the rearing period, in which the samples were collected twice a week and designated S2. Meanwhile, the third collected samples (S3) it was performed before the old litter removal, recognizing that the chicks were kept on a deep litter.

All stationary measurements were carried out at breath simulation region 1.5 m aspirate height above ground.

Table (1): Characteristics of Studied Poultry Farms.

Working area	No. of chicks	Area (m^3)	Openings	Heating	Ventilation methods
Farm A	5000	1474.7	1 door	Automatic heater adjust at 32^{o}C + 3 flame gas stove	3 cooling cells 3 big electric exhaust fans (Tunnel Ventilation)
Farm B	5100	1541.01	1 door 20 windows	5 flame gas stove	2 big electric exhaust fans
Farm C	500	62.53	1 door 2 windows	2 flame gas stove	1 small exhaust fan
Farm D	65	25.25	1 door 1 window	1 flame gas stove	lack of ventilation

Table (2): Sterilization techniques used in poultry farms that selected for the study.

Working area	Sterilization techniques
Farm A	Phase 1: Chlorine, Fennec and insecticide Malso /Courmendel were used 57% (glutinous insect comes after cleaning) Phase 2: TH4 antiviral, bacterial and fungal antiseptic was sprayed (free of phenol and formalin)
Farm B	Spraying: Insecticide, Liquid Soap, Water, Chlorine, Formalin, Caustic soda, TH4 antiviral
Farm C	Insecticide, Liquid Soap, Water, Formalin, Finike, Dettol, Hot sauce
Farm D	Insecticide, Liquid Soap, Water, Formalin

Temperature and Humidity

In the studied farms both the temperature and humidity were measured as a function of dust pollutants. Temperature was recorded by using AR8500 air temperature detector and air humidity was measured by DZ-8600 6IN1 Portable air quality detector. However, humidity (RH) was calculated following the method of Alduchov and Eskridge (1996).

Evaluation of Inhalable and Respirable Dust

PM_{10} and $PM_{2.5}$ samples were evaluated using DZ-8600 6IN1 Portable air quality detector.

Potential Health Impacts

Population Characteristics

This investigation was carried on 50 individuals; 25 unexposed groups (control group) and 25 poultry workers residing 24h in poultry farms with recently 40-year history of at least one year and ongoing exposure to pollutants in the poultry farms.

Personal questionnaire

A self-structured questionnaire, to get information about the personal data including age, body mass index, BMI, kg/m^2, years of employment, smoking history, histology of liver, kidney, blood diseases, the duration of the work of the poultry house, and the use of protective equipment, were recorded. In meantime, 25 poultry workers were subjected to the required questionnaire; all of them are non-smoking males aged 26 to 56 years. Twenty healthy subjects, with age ranging from 29 to 57 years old, were also randomly selected for the questionnaires that were far from poultry farms.

Blood sampling and analysis

Blood samples were collected from each participant at two different time period during the working day; one sample was collected at 7 am before the work shift and second at 9 pm at the end of work shift. Three millilitres of antecubital vein blood were drawn and collected in dipotassium salt of Ethylenediamine tetra acetic acid (EDTA) vacutainers. These samples were transported to the laboratory within half hour then centrifuged for 30 minutes before analysis for various hematological parameters to determine complete blood picture (CBC) according to Dacie and Lewis (1995) including: red blood cell count (RBC), hemoglobin concentration (Hb), Hematocrit % (HCT%), blood cell indices like mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corp-uscular haemoglobin concentration (MCHC), total leukocyte count (TLC), differential leukocyte count (DLC), platelets (PLT) by using celtak alpha MEK-6400 haematology analyser.

Statistical analysis

A statistical analysis was performed using SPSS (25 editions) for the descriptive statistic. The "t" student test was used to compare mean and statistically significant differences were calculated at a probability of 0.05 or less ($p \leq 0.05$). Correlation coefficients and the derived relationship equations were also calculated between the related parameters. Temperature and humidity in each farm were also compared using variance analysis (one-way ANOVA test) and Post Hoc tests (Tukey HSD) were also used. Correlation analysis methods of the data collected were carried out in order to determine the relationship between the effect of temperature and humidity in farms on the haematological parameters of poultry workers using the MVSP (Multi-Variate-Statistical Package, version 2 program).

RESULTS AND DISCUSSION

Evaluation of Atmospheric parameters

The mean temperature and relative humidity during the rearing period in the four poultry farms was presented in Table (3). The results showed that the highest mean temperature of the four poultry farms was 24.1 °C for poultry farm A. Meanwhile, the mean temperature of poultry farms B and C and D recorded 21.9°C, 22.3 °C, and 21.6°C, respectively. A significant difference in temperature among the four poultry farms during the whole rearing period was recorded. The temperature in farm A recorded a highly significant difference compared to other studied farms. There was also a highly significant difference ($p \leq 0.001$) between poultry farms C and D and ($p \leq 0.01$) between poultry farms B and D.

Based on obtained results, the temperature in the four poultry farms was in high value in the 1st day of fattening period (FP). The main reason can mostly be attributed due to apply thermal comfort for the initial period of growth of broilers to establish more productive performance. Therefore, the high value recorded for the outdoor temperature may be functional of the raised indoor temperature.

For humidity, as second measured atmospheric parameter, the results showed that the highest mean relative humidity of the four poultry farms was 68 %, recorded at poultry farm D. However, the mean relative humidity of poultry farms A, B and C were 57 %; 54 and 56 %, respectively (Table 3).

According to statistically analysis, a very highly significant difference between the four poultry farms of the relative humidity during the whole fattening cycle ($p \leq 0.001$), was recorded. As shown in Fig. (1), the mean percentage value of relative humidity, recorded during the FP in the four poultry farms, revealed the following succession: farm poultry D, 28.8%> A, 25.3% > B, 23.8%> D 22.1%. However, the recent outstanding results using artificial intelligence techniques

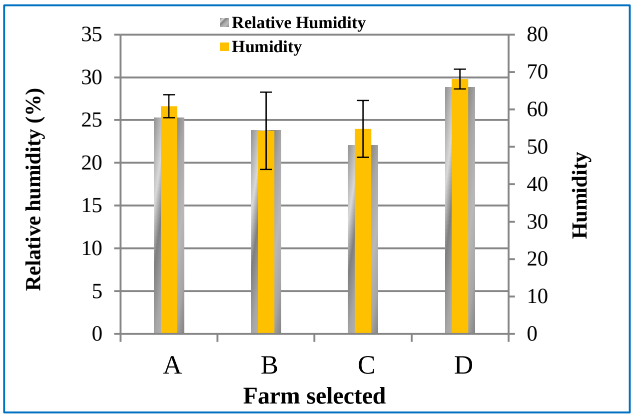

Figure 1: Humidity and relative humidity (%) during rearing period in four studied poultry farms

in building and equipping facilities have become required to reduce damage to the environment in general and humans in particular (Atiaa and Abdul-Qadir, 2012). Pereira *et al.,* (2017) also proved that the outdoor temperature was related to the high relative humidity indoor values that associated with the heating system used, whereas lowing temperature reduces the relative humidity in the room. However, in the bird house, temperatures were inversely related to the relative humidity, accordingly, the maximum RH typically found at night (Seedorf *et al.*, 1998). Since, poultry litter is waste containing broiler excreta mixed with rice husk, water, intestinal mucosa, feathers, undigested feed, etc. (Rico-Contreras *et al.*, 2017), thus elevated temperature is playing an important role in gas emission. Gas emission generated from wastes of poultry farms constitute hazard to public health (Wu *et al.*, 2019). Furthermore, thick litter developed in poultry buildings as a result of the influence of humidity and temperature of ambient air on waste floor, resulting in significant concentrations of pollutants in the air and gas emission inside the poultry buildings (Nimmermark and Gustafsson, 2005; Golbabaei and Islami, 2000).

The present results are similar to those recommended used temperature and relative humidity for chickens that to be between 30-33 °C and 40-70% within the first 1-2 weeks, and 18-20 °C and 65-70% within the next 5-8 weeks (Akyuz and Boyaci, 2010). However, Polat (2015) mentioned that 57-77% was the normal range of relative humidity, and comparing with the present results, there was a wider range of humidity (22-83%) recorded in the investigated farms. High dust concentration in poultry houses leads to increase relative humidity resulting in respiratory diseases of animals and workers (Cormier *et al.*, 2000).

Exposure to Inhalable Dust (PM_{10})

From Table (4), it was seen that the highest mean PM_{10} of the four poultry farms was at level of 215 µg/m^3 for poultry farm D. The mean PM_{10} of poultry farms B and A were 211 µg/m^3 and 148 µg/m^3, respectively. Meanwhile, the lowest mean of PM_{10} of the four poultry farms was 99 µg/ m^3 and recorded in poultry farm C. According to statistically analysis, there was highly significant difference ($p \leq 0.001$) between the four poultry farms of PM_{10} during the fattening cycle. Multiple Range Comparisons (PostHoc tests: Tukey HSD) detected very high significant tests: Tukey HSD) detected very high significant difference ($p \leq 0.001$) between each of the poultry farm and others except the comparing between poultry farm A with B. As shown in Figure (2), the mean percentage of PM_{10} during the rearing period was recorded in the four poultry farms as follow: Farm poultry D 35.7% > B 32.7% > A 19.5%> C 12.1%.

Table (3): The variations in temperature and relative humidity parameters measured during the rearing period of poultry farms.

Fattening cycle day	Temp (^{o} C)				Humidity			
	Farms				Farms			
	A	B	C	D	A	B	C	D
After disinfection	17.9	19	20.2	19.6	44	61	57	46
st day	31.2	30.4	25.9	26	55	70	59	79
4th day	29.6	23.1	22.3	23.7	70	77	58	83
7th day	28.4	24.3	23.4	21.6	73	69	41	77
11th day	28.3	22.3	20.9	21	63	69	65	69
14th day	26	20.5	25.4	20.5	62	65	41	63
17th day	24.7	23.4	23.1	19.6	59	54	46	73
22nd day	25.5	19.2	20.3	22.5	65	64	58	68
25th day	27	21.8	22.1	22.8	54	39	53	70
28th day	26.7	20.8	23.9	17.6	62	56	54	67
31st day	24.6	21.4	22.9	22.2	62	38	56	69
35th day	24.8	19.5	22.2	22	60	52	59	69
39th day	23	21.1	21.4	20.8	62	53	62	66
43rd day	20.3	21.1	-	21	59	54	-	67
Mean ±SD	26.16±2.87^{b}	22.22±2.86^{a}	22.82±1.68^{a}	21.64±2.02^{a}	62.00±5.24^{b}	58.46±11.86^{b}	54.33±7.82^{b}	70.77±5.70^{a}
Cleaning Stages								
Before	15.9	19.9	21.4	21.0	38	40	67	71
During	21.6	22.7	20.9	22.3	33	22	64	63
After	13.9	21.1	21.0	23.0	49	27	59	59

-, not detected; * Values are represented as the means ± SD; * Means with different letters per each measured parameter are significantly different at $p \leq 0.05$

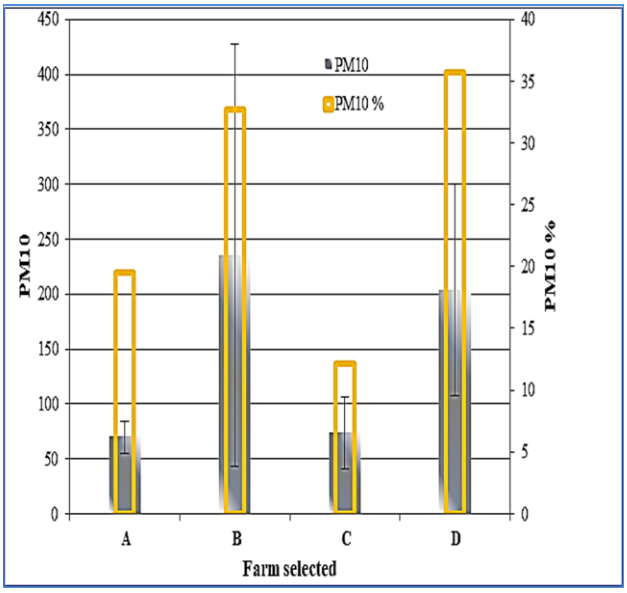

Figure 2: Mean values of PM10 and PM_{10} in percentage in all studied farms during rearing period.

Exposure to respirable dust ($PM_{2.5}$)

As shown in Table (4), the highest mean $PM_{2.5}$ of the four poultry farms was 196.46 (µg/ m^{3}), which recorded at farm D. The mean PM_{10} of poultry farms B and A were 193.69 and 115.15(µg/m^{3}), respectively. However, the lowest mean PM_{10} of the four poultry farm was 71.50±30.8 µg/ m^{3} recorded in poultry farm C. The concentration of respirable dust in this study was higher than the limit recommendations for human reported by Pedersen *et al.*, (2000) which are 230 µg/m^{3} of respirable dust and exceed the (MAC) value recommended by Ministry of Environmental Protection, 1999 is 150 µg m^{3}. According to the Egyptian Environmental Affairs Agency (EEAA, 1994) and the World Health Organization (WHO, 2004), the maximum permissible dust concentration is 70 g/m3. The average $PM_{2.5}$ level in the four farms in our study exceeded this limit except for Farm C. According to statistical analysis, there was a highly significant difference in $PM_{2.5}$ during the fattening cycle across the four farms. Using Multiple Ranges (Post Hoc Tukey

Table (4): Mean Concentrations of Poultry Workers' Exposure to Inhalable (PM10) and Respirable ($PM_{2.5}$) Dust (µg/m3) in the Four Poultry Farms.

Fattening cycle	Inhalable Dust Concentration (PM_{10}) (µg/m^3)				Respirable Dust Concentration ($PM_{2.5}$) (µg/m^3)			
	Farms				Farms			
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**
After disinfection	70	62	57	53	54	52	47	44
1st day	693	61	77	203	626	47	53	174
4th day	78	62	90	283	62	50	67	270
7th day	27	47	31	223	22	37	20	209
11th day	86	187	73	242	75	176	50	222
14th day	79	89	33	112	64	79	28	107
17th day	55	71	41	46	41	60	30	37
22nd day	83	70	48	287	64	56	38	273
25th day	55	93	53	307	40	88	44	289
28th day	58	107	76	54	44	95	67	44
31st day	64	243	106	224	46	212	79	210
35th day	52	403	108	237	39	332	94	222
39th day	91	521	122	257	82	447	104	242
43rd day	76	564	-	270	66	473	-	255
Mean ±SD	115.15±174.5 [b]	193.69±183.9 [c]	71.50±30.8 [a]	211.15±86.3 [c]	97.77±159.6 [b]	165.54±155.3 [c]	56.17±26.6 [a]	196.46±83.7 [d]
Cleaning stages								
Before	104	75	47	266	96	61	39	174
During	781	898	320	550	720	817	270	516
After	61	39	298	41	49	33	264	34

*****Exposure allowable (MAC) limits of PM: 70µg/ m^3 (EEAA, 1994; WHO, 2004); * Values are represented as the means ± SD; * Means with different letters are significantly different at $p \leq 0.05$.

HSD) farm C had less polluted value (56.17±26.6) falls with permissible $PM_{2.5}$ value (Table 4). Despite the fact that the rest of the farms surveyed were heavily polluted, farm D had the highest pollution level (196.46.83.7).

For PM_{10} analysis, there also a very highly significant difference ($p \leq 0.001$) among the studied farms during the fattening cycle where farm C recorded the less pollutant value (71.50±30.8) compared to the rest of the surveyed farms (Table 4). Farm D recorded the highest significant PM_{10} value followed by farm B with no significant difference between them (211.15±86.3 and 193.69±183.9, respectively). Meanwhile, after cleaning farm D was the best and had the lowest PM_{10} value (41µg/m^3).

The mean percentage of $PM_{2.5}$, during the FP, recorded in the four poultry farms, was ordered: farm poultry D, 38.1% > B, 32.1%> A, 18.9% > C 10.9% (Fig.3). According to the above results, the high levels of particulate matter may refer to the designer of the farm where no additional ventilation and were left as naturally ventilated. The obtained data are in confirmation with studies done by Oppliger *et al*., (2008); El-Gammal (2005). In their studies they found that many factors, such as environment variables; whether there is an air purification technology, birds stocking density, type of birds and age, manure management and ventilation rate and the PM size distribution may play a role in the differences among the farms. In a report concerns human diseases, aerosols are listed as one of the most important disease agents (Num and Useh, 2014). Meanwhile, a recent study discovered that dust was spread randomly in well-ventilated airspace inside chicken farms, with dust particle concentrations ranging 30 times from the lowest to the highest interior (Xiang et al., 2019).

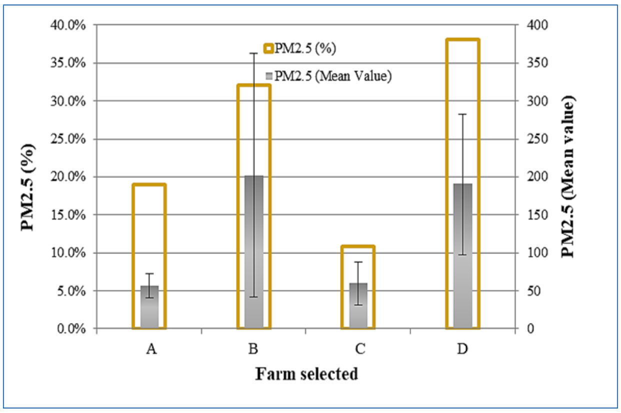

Figure 3: Mean values of $PM_{2.5}$ and $PM_{2.5}$ in percentage in all studied farms during rearing period

Kirychuk *et al*., (2010) also discovered that other factors of poultry production farms must be considered, such as floor installation and operation of facilities in the cage, as well as bear the burden, because litter is utilised in high concentrations of dust. The hall's chicken growth, as the chicks mature, their exercise and food intake. As a result, the amount of waste produced rises, and these variables contribute to higher output during the first 43 days of dust generation (Golbabaei and Islami, 2000). In addition to these factors, as the chicks mature, they shed their early feather barbules and begin to grow permanent feathers. As a result, in addition to wood particles and food waste, feathers contribute to the spread of dust in the air. A significant positive connection was discovered between dust content and the age of the chickens (Viegas *et al.*, 2013).

Deep litter systems exhibit a high concentration of particulate matter in all seasons. Morrison *et al.* (1993) reported 100-1000 µg/m^3 of respirable; Takai *et al.* (1998) reported the size range of 420-1140 µg/m^3 as respirable. Studies related to a high concentration of matter from polarity farms conducted by different researchers: Ellen *et al.*, (2000) reported that average dust concentrations, ranging from 662-1564 µg/m^3, were lower than the standards, but higher than those reported in Europe, where the measured dust concentration ranged between 190 and 640 µg/m^3 for respirable dust, and lower than that between 2400 and 13000 µg/m^3 for inhalable dust samples and also similar to Lawniczek-Walczyk *et al.*, (2013) who reported that during all sampling sessions, the concentrations of PM_{10} poultry facilities does not exceed 4500 µg/m^3. Moreover, Skóra *et al.*, (2016) studied the highest concentration of airborne dust is found in the PM_{10} dust fraction (mean: 875 µg / m^3, maximum: 2128 µg/m^3) in poultry farms. Dust particles with low diameters PM_1, $PM_{2.5}$, PM_4 are found in the levels 480–541 µg/m^3.

With rising temperatures, the average rate of dust emission increased, which can be explained by increased poultry moulting. Furthermore, enhanced ventilation combined with high temperatures aided in the extraction of dust from the farm (Mostafa, 2012). Low relative humidity has resulted in higher dust concentrations in the environment, posing a health risk to animals and employees (Yahav *et al.*, 2001). The current findings are consistent with those of Vučemilo *et al.*, (2008), who found that relative humidity and temperature have the greatest impact on dust concentration. For all the fattening period, the multiple regressions revealed a statistical significance ($p \leq 0.05$) between dust concentration and relative humidity, which was explained by high air humidity accelerating the rate of deposition of dust particles, while low humidity leads to a higher concentration of dust carried in the air. As a result, the concentration of endotoxins in the air rises.

Role of environmental parameters on the level of exposure to Inhalable and respirable dust

Pearson correlation between air temperature, humidity and particulate

The correlation coefficient (r) between air temperature, humidity and particulate matters of farms under investigation is shown in Table (5). Temperature showed high significant correlations with PM_{10} and $PM_{2.5}$ ($p \leq 0.01$). Humidity showed high significant correlations with PM_{10} and $PM_{2.5}$ ($p \leq 0.01$). PM_{10} exhibited highly significant correlations with $PM_{2.5}$ ($p \leq 0.01$).

Table (5): Pearson's product-moment correlation (r) between air temperature, humidity and particulate maters in the investigated poultry farms.

Air parameter	Temperature	Humidity	PM_{10}	$PM_{2.5}$
Temperature	1			
Humidity	0.075	1		
PM_{10}	-0.643**	0.607**	1	
$PM_{2.5}$	-0.646**	0.636**	.997**	1

Data with ** are significant at $p \leq 0.01$

Relative humidity in bird farms is inversely related to temperature; therefore, the maximum RH is typically found at night. (Seedorf *et al*., 1998). According to Pereira (2017), the high indoor temperature and low relative humidity in comparison to outdoor conditions are linked to the heating system by boiler, which introduces sensible heat into the broiler houses resulted in decreasing the indoor relative.

Soliman *et al*., (2017) mentioned that the low air temperature values induced higher relative humidity levels and decrease with the indoor air circulation increase. The mean inhalable dust emission rates were higher with high temperature. This result can be explained by the fact that the birds moulted around this time, causing an increase in dust. Furthermore, the enhanced ventilation caused by the warmer temperatures aided in dust extraction from the unit (Mostafa, 2012). The present results in agreement with Yahav *et al*., (2001) who documented that the dust concentration was mostly influenced by relative humidity and temperature. Multiple regression showed a statistical significance ($P \leq 0.05$) between the dust concentration and relative humidity for all five fattening weeks, as well as dust concentration and temperature, high air humidity may precipitate the rate of dust particle sedimentation, whereas low humidity results in a high airborne dust concentration.

Cluster analysis classification of farms under investigation

According to Physical Air Parameters

The cluster analysis program analyzes the input data of temperature, humidity, PM_{10} and $PM_{2.5}$ values of different investigated farms during the rearing period of each farm then grouped them where, the high similarity index in physical air parameters values between each farm appears within the same group, while differential index physical air quality values separate them in different groups (A and B). The application of cluster analysis based on the similarity in physical air parameters values of different investigated farms during the fattening periods (4 variables) led to the recognition of two groups (Fig. 5). Group A comprises two Farms; Farm A and Farm B. Group B comprises also two Farms; Farm C and Farm D.

Poultry workers' exposed to various environmental exposures in the four poultry farms

The chosen poultry workers, as a comparison between the exposed to non-exposed groups, to the physical parameter showed that 25 non-smoking male poultry workers were 26-56 years old, with mean average of 40±10.01 years old. Twenty-five of unexposed control group were around 32 to 57 years old with an average mean of 38 ± 10. 57 years old. Body mass index (BMI) of workers ranged from 0.37 to 0.71 kg/m^2, with a mean of 0.5±0.09. The control group's BMI ranged from 0.38 to 0.58 kg/m^2, with an average of 0.51 0.08. For working in these poultry farms, the duration of exposure ranged from 1 to 40 years, with a mean of (20 13.65) years.

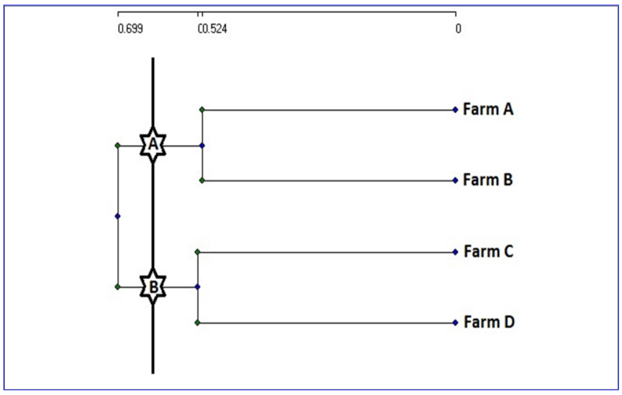

Figure (5): Cluster analysis of investigated farms according to physical air parameters during the fattening pigueriod of each farm.

Effect of bio-aerosols on hematological parameters of poultry farm workers

As seen in Table (7), the mean values of Hb content, RBCs were significantly decreased and platelets were highly significant decreased in farm workers, by (-7.13%, - 4.84% and -14.14%) to be 13.29 ±1.27, 5.08 ±0.62 and 201.92 ±54.32, respectively, comparing with controls which were 14.31 ±0.37, 5.34 ±0.17 and 235.16 ±17.21, respectively. As shown in Table (7), the mean WBCs, neutrophils and Basophils values were significant increased, MCV and MCH were highly significant increase and monocytes were very highly significant increase in farm workers, by (3.79%,3.97%, 100%, 3.38%, 3.39% and 16.60%) to be 8.07 ± 2.41, 56.52 ±6.15, 0.02 ±0.04, 83.08 ±4.20, 27.78 ±1.37 and 8.40 ±0.93, respectively, in comparing with controls which were (7.77 ±1.72, 54.37 ±7.79, 0.00 ±0.00, 80.36 ±3.25, 26.86 ±1.14 and 7.20 ±0.94), respectively.

Correlation between blood picture analyses of control and workers

The Canonical Correspondence Analysis (CCA) program analyzed the input data of all blood picture analyses (CBC) of control and workers for different farms then detects the degree of different correlation between each blood analyses of control with workers. The arrow length of each parameter represents the difference degree of this parameter from control to workers. The correlation between blood picture analyses (CBC) for control with them workers was produced on the ordination diagram produced by Canonical Correspondence Analysis (CCA) as shown in Fig. (6).

Table (6): Demographic characteristics of controls and poultry farm workers.

Parameters	**Groups**	
	Control	**Farm workers**
Number	25	25
Sex	Male	Male
Age (yrs)	38 ± 10.57	40 ± 10.01
Exposure time (yrs)	-	20 ± 13.65
B.M index (kg/m^2)[†]	6	29.7± 5.50

[†]B.M, Body mass.

It is clear that, Lym, Neu and MID showed a high significant difference of blood picture analyses (CBC) and HGB, MCHC, PLT, RBC, HCT and Eos exhibited a significant difference between control and workers under investigation at the first and second axes (Fig. 6). The traditional approach has been to use the readily available blood cells (e.g., lymphocytes and red blood cells) as biomarkers of exposure mutagenic effects (Yano et al., 2009). Although long-term diseases are not expected from the affected blood cells, it is generally accepted that the blood cells can be used as sentinel cells types to provide early warning signals for adverse health outcome. It is also suitable to determine whether the biomarker effects observed in blood cells are consistent with those in available target cells (Oliveira *et al*., 2011). In addition, Smit *et al*. (2014) stated that there was a statistically significant negative association with PM_{10} in poultry farms and asthma, allergic rhinitis and chronic obstructive pulmonary disease (COPD) of workers.

The unusual increase in WBCs may also be due to inflammation of any organ and/or to infectious conditions because an essential function of WBCs is to provide primary defense (Kamal and Malik, 2012). El-Gammal, (2005) also reported that exposure to dust resulted in increase in total WBC and neutrophils. In contrast, there was a significant decrease for workers in lymphocyte ($p< 0.01$) and ($p< 0.05$) in esinophils. These results were in agreement with Ahman *et al.*, (1995) who suggested the percentage of neutrophils was (56%) in exposed subjects higher than control subjects, this similar to the present results.

Gripenback *et al*,. (2005) also recorded an observation that any exposure to dust leads to the recruitment of inflammatory cells to the airway of workers. They observed also exposure to dust resulted in increased differential count of WBCs. These results may be related to the increased risk of developing

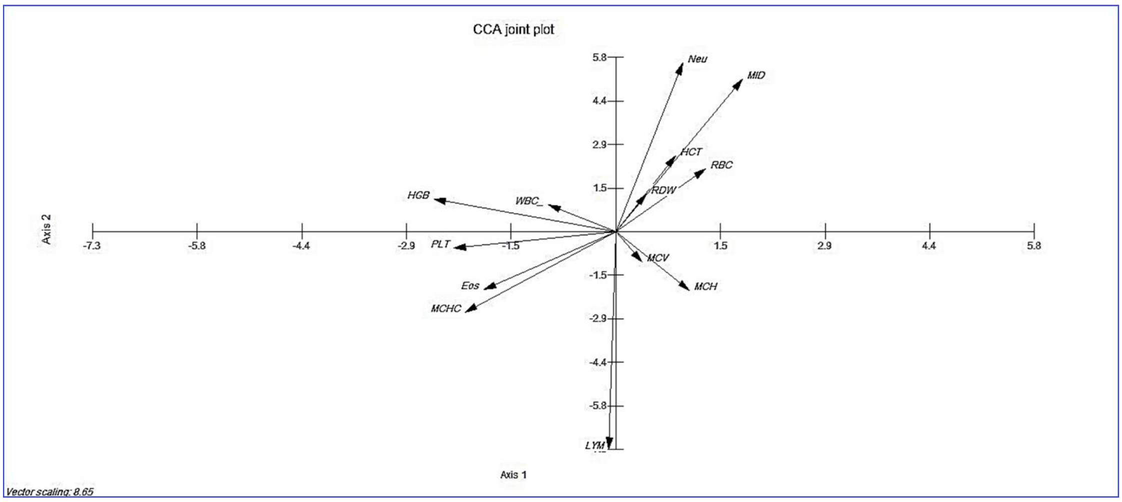

Figure (6): Canonical Corresponding Analysis (CCA) ordination diagram of (CBC) of workers according to the gradient of blood analyses of control parameters (arrows) in the investigated poultry farms.

respiratory disorders among workers.Dust has also been reported to include endotoxins. However, exposure to endotoxins results in recruitment of neutrophils (Sandstrom, *et al.*, 1992). Ek *et al*., (2004) reported that swine dust exposure causes an inflammatory reaction characterized by a massive influx of neutrophils and other inflammatory cells, as well as the release of inflammatory mediators and cyto-kines in the upper and lower airways, all this may explain the increase in WBCs, differential count of WBCs and decrease in RBCs and platelets.

CONCLUSION

It is obvious that reducing existing exposure will take a lot of effort; completely eliminating the health dangers provided by chicken farm pollution will be an even more challenging. The need of enforcing this health-based limit and many safeguards, as well as the following thoughts, should be considered the followings: a, during the rearing phase, replace the litter under the chicken every two weeks because the accumulation of dung, water, and food leftover

Table (7): Effect of bio- aerosols on hematological parameters in workers compared to control group.

Parameters	Groups		Normal range (Reference)
	Control	Farm workers †	
No. of individual	25	25	
RBCs (10^6/mm^3)	5.34 ± 0.17	5.08 ± 0.62* (-4.87%)	**4.3-6**
Hb (g/dl)	14.31 ± 0.37	13.29 ± 1.27* (-7.13%)	12-17
HCT (%)	42.86 ± 1.23	42.46 ± 4.41 (-0.93%)	**39-50**
MCV (fl/cell)	80.36 ± 3.25	83.08 ± 4.20* (+3.39%)	**80-100**
MCH (pg/cell)	26.86 ± 1.14	27.78 ± 1.37* (+3.43%)	**27-34**
MCHC (g/dl)	33.43 ± 0.64	33.54 ± 0.66 (+0.33%)	**32-37**
RDW (%)	14.24 ± 0.78	14.02 ± 0.74 (-1.55%)	**11.1-14**
WBCs (10^3/mm^3)	7.77 ± 1.72	8.87 ± 2.41* (+14.16%)	**4-11**
Neutrophils (%)	54.37 ± 7.79	59.52 ± 6.15* (+9.47%)	**40-75**
Lymphocytes (%)	34.74 ± 7.41	37.53 ± 8.70 (+8.03%)	**18-44**
Monocytes (%)	7.20 ± 0.94	8.40 ± 0.93* (+16.67%)	**0-8**
Eosinophils (%)	0.96 ± 0.05	0.97 ± 0.05 (+1.04%)	**0-3**
Basophils (%)	0	0.02 ±0.04	**0-1**
Platelet (10^9/1)	235.16 ± 17.21	201.92 ± 54.32* (-14.14%)	**100-400**

†The values written between brackets represent the % of changes compared to control; * data are significant at $p \leq 0.05$; RBCs, red blood corpuscles; Hb, hemoglobin; HCT, hematocrit; MCV; mean corpuscular volume; MCH; corpuscular hemoglobin; MCHC; corpuscular hemoglobin concentration; RDW, red blood cell distribution width; WBCs, white blood cells. Data measured were given in Mean ± SD.

releases a variety of toxins, including particle matter, which can be harmful to the health of poultry and farm employees. b, Modern and appropriate ventilation systems, such as bio-aeration, should be used in poultry farms, since bioaerosol conc-entrations are highly affected by ventilation efficiency and rate. c, Using personal protective equipment such as a face mask and a mask filter to decrease pollution exposure, especially during sterilisation.

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تقييم أثر الغبار القابل للاستنشاق والتنفس لأربعة مزارع دواجن في محافظة الدقهلية، مصر

هناء توفيق البهنسي[1]، مي إبراهيم الجمال[2]، أحمد الوزير هجرس[1]

[1] قسم علم الحيوان، كلية العلوم، جامعة المنصورة، مصر
[2] قسم العلوم البيئية، كلية العلوم، جامعة دمياط، مصر

الملخص العربــي

أجريت هذه الدراسة لتقييم الملوثات البيئية المنبعثة من مزارع الدواجن عن طريق قياس درجة الحرارة والرطوبة وجسيمات الغبار الدقيقة (الغبار المستنشق والغبار القابل للتنفس) على مدار دورة تسمين للدواجن وقد أجريت القياسات في 4 مزارع دواجن تقع في محافظة الدقهلية. مزارع الدواجن قيد الدراسة متباينة في كيفية تجهيزها واعدادها. تم جمع عينات الهواء خلال 3 مراحل مختلفة من دورة إنتاج الدجاج مرتين أسبوعيا، من نوفمبر 2018 إلى أبريل 2019. وتبين من نتائج هذه الدراسة أن الغبار القابل للاستنشاق يتراوح بين 99 و215 ميكروغرام/م^3 والغبار القابل للتنفس يتراوح بين 83 إلى 195 ميكروغرام/م3 في المزرعة C والمزرعة D على التوالي. يمكن استنتاج أن تراكم مخلفات الدواجن والمياه وبقايا الطعام قد يؤدي إلى العديد من انبعاث الملوثات التي لها آثار صحية خطرة على العمال ولذلك، يجب استخدام معدات الحماية الشخصية من قناع الوجه وقناع مرشح، وخاصة أثناء فترة تعقيم المزرعة للحد من التعرض للملوثات.