Yuzuncu Yil University
Journal of Agricultural Sciences
(Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi)
https://dergipark.org.tr/en/pub/yyutbd

ISSN: 1308-7576 e-ISSN: 1308-7584

Research Article

Removing Harmful Gases from Litter Used in a Broiler House by UV Lights

Umut KILIÇ[1], Ahmet Hakan YILMAZ[2], İlker KILIÇ*[3]

[1,2,3]Department of Biosystems Engineering, Faculty of Agriculture, Bursa Uludağ University, 16285 Nilüfer, Bursa, Türkiye

[1]https://orcid.org/0000-0002-2389-3249, [2]https://orcid.org/0009-0004-5408-7460, [3]https://orcid.org/0000-0003-0087-6718

*Corresponding author e-mail: ikilic@uludag.edu.tr

Article Info

Received: 05.02.2026
Accepted: 04.08.2026
Online published: 24.08.2026
DOI: 10.29133/yyutbd.1882490

Keywords

Ammonia,
Broiler House,
Carbon Dioxide,
Treatment,
UV-A,
UVC

Abstract: Over the years, the growth in chicken production has brought with it certain problems. Pollutants from poultry farms cause environmental and health problems. Various measures must be taken to properly manage these issues and mitigate their effects. Proper ventilation and litter management within the broiler house are the primary measures. Additionally, the treatment of pollutants in litter using UV rays is an alternative method. In this study, NH_3 and CO_2 gases originating from litter material obtained from a broiler farm operating in the Bursa region were treated using UV rays on a laboratory scale. Litter samples were exposed to UV-A and UV-C rays at different exposure times and distances, and their treatment efficiencies were determined. The data obtained as a result of the study show that UV rays are effective in reducing livestock-derived pollutant gases. When the treatment efficiencies of the parameters are evaluated independently, the highest CO_2 treatment efficiencies in terms of exposure time were observed at the 120th minute (93.56% for UVA and 100% for UVC). For NH_3 gas, the highest efficiencies over time were recorded at the 60th minute (90.50% for UV-A) and at the 90th minute (95.33% for UV-C). When the application distances were examined individually, it was determined that the highest purification performance for both gases and lamp types (UVA and UVC) was achieved at 40 cm. In this context, it has been determined that the UV-C lamp shows the highest treatment efficiency for CO_2 gas, and the UV-A lamp for NH_3 gas, at a distance of 40 cm for both gases.

To Cite: Kılıç, U, Yılmaz, A H, Kılıç, İ, 2026. Removing Harmful Gases from Litter Used in a Broiler House by UV Lights. *Yuzuncu Yil University Journal of Agricultural Sciences*, (1): 1882490. DOI: https://doi.org/10.29133/yyutbd.1882490

1. Introduction

As of 2021, there are approximately 7.9 billion people living in the world. This number has been increasing rapidly since the mid-20th century. According to predictions, the world population is expected to reach 9.8 billion by 2050. This continuous increase in population has led to a parallel increase in the demand for chicken meat. Chicken meat offers an important option for a balanced diet in terms of health and economy, due to its rich protein and B vitamin content, as well as its lower fat and cholesterol content compared to red meat and its generally more affordable price The growth in chicken production due to increased food demand is leading to environmental problems (İskender et al., 2015; Feng et al., 2018; Jameel, 2019; Yerlikaya and Özkaya, 2020; United Nations, 2021; Rotimi, 2025).

In broiler house, chickens are generally raised indoors. In chickens with this type of farming, a cage system is not used, and the chickens roam freely on litter placed on the broiler house floor to absorb droppings and moisture. In broiler houses, manure accumulates on the litter material spread on the floor. The choice of litter material for broiler houses varies depending on factors such as environmental conditions, cost, and ease of cleaning. The litter material used increases animal welfare by keeping the chickens' living area clean, dry, and hygienic, preventing skin diseases, and thus preventing stress-related behavioral disorders (Şekeroğlu et al., 2013). However, one of the most important issues is its significance within manure management. Manure management and feed rations are the primary sources of the pollutant gases in broiler houses. The improper management of manure within the broiler house, combined with indoor climatic conditions, increases the concentration of these gases. These emerging pollutants are released into the environment through ventilation, contributing to pollution.

Examples of these pollutants include ammonia (NH_3), carbon dioxide (CO_2), hydrogen sulfide (H_2S), and odorous volatile organic compounds (VOCs). NH_3 gas causes soil and river acidification, tree tissue death, odor formation, throat and eye irritation, respiratory problems, and deaths in broiler houses. The source primary of CO_2 gas are the respiration of animals and humans as well as the aerobic breakdown of uric acid in litter material. The limit value in the broiler house environment is specified as 5000 ppm. CO_2 gas, in addition to its role in global warming and the greenhouse effect, also has negative impacts on the health of workers and animals. Furthermore, odorous VOC emissions with odors can create an unpleasant smell in the broiler house environment. Therefore, controlling all these harmful gases is an crucial for reducing the environmental impact of broiler houses and protecting environmental health (Miles et al., 2006; Kılıç and Şimşek, 2009; Kılıç and Arıcı, 2013).

Various applications are used to control harmful gases from broiler houses. Ultraviolet light treatment methods have become increasingly popular in recent years. UV-A and UV-C rays affect the DNA and RNA of microorganisms, rendering bacteria, viruses, fungi, and other pathogens ineffective. They are widely used for microbial control across many industrial and medical applications, including water and air treatment. Due to these properties, UV-A and UV-C lights are an important method for controlling pollutants originating from broiler houses. Ultraviolet (UV) light is in the 200 to 400 nm range of the electromagnetic spectrum and is next to the violet band, which is invisible to the human eye. UV-A (~315-400 nm) ray is considered the least toxic form of UV ray for short-term exposure and is used in applications such as solariums. UV-C (200-280 nm) is considered the most effective ultraviolet light for inactivating microorganisms (Guerrero-Beltran and Barbosa-Canovas, 2005; Aydın, 2009; Koca et al., 2018; Korkmaz and Tiryaki Gündüz, 2018; Kavas et al., 2023).

In broiler houses, there is a very delicate balance due to the significant impact of lighting on the health and productivity of chickens (Barros et al., 2020; Yaylı and Kılıç, 2021). Therefore, the poultry industry generally adopts light-based technologies. However, carefully designed studies are needed to advance UV-based treatments that improve air quality without jeopardizing current production practices.

This study aims to treat NH_3 and CO_2 gases originating from litter and manure obtained from a broiler house operating in the Bursa region using UV-A and UV-C. In this study, a system design will be implemented to achieve this goal.

2. Materials and Methods

2.1. Study area

Bursa is one of Türkiye's leading regions for broiler production. As of 2023, the city has a total of 10 446 329 chickens, including 5 079 951 meat chickens (Republic of Türkiye Ministry of Agriculture and Forestry, 2024; Turkish Statistical Institute, 2024). Bursa has become one of the important centers for meat chicken production, with millions of meat chickens produced annually, thanks to its suitable climate, geographic location, and agricultural infrastructure for raising them. This situation is of significant importance to both the local and national economies, while also providing employment opportunities for thousands of people (Petek, 1996).

2.2. Litter material used ın the study

The litter material used in the study was obtained from a commercial broiler house located in the Bursa region. The broiler house is 90 meters long and 15 meters wide. During that production period, the broiler house has 22500 broilers, corresponding to a stocking density of 17 broilers m^{-2}.Tunnel ventilation is used in the broiler house. Ventilation is provided by 10 mechanical fans, each measuring 1.2 x 1.5 meters. Within the broiler house, measurements are collected using temperature and humidity sensors for continuous, real-time monitoring to improve animal welfare, mitigate heat stress, and enhance litter conditions.Rice husk with a thickness of 5 cm is used as the litter material at the beginning of the production period. During the period when litter samples were obtained from the broiler house, the litter's physical properties were standard, and its physical and chemical properties were analyzed in the laboratory. Automatic feeding and drinking systems are used to meet the broilers' food and water needs. In the broiler house, a forced air heating system is used for heating purposes, while cooling pads are used for cooling. Litter samples for analyses were collected in the summer period, in the middle of the production cycle (Day 20-25).

Litter samples were collected from three sections of the broiler house (right, middle, and left) using a clean scoop at nine specific points (three per section) and placed in polyethylene bags (Figure 1). Samples collected from different points were combined into a single homogeneous pool to ensure identical initial characteristics for all groups. Then, a portion of the litter sample from this pool was separated as a control group for comparison with the physical and chemical analyses and the gas quantities of the treated samples. The remaining samples were stored in the refrigerator (4 °C) during the measurement period.

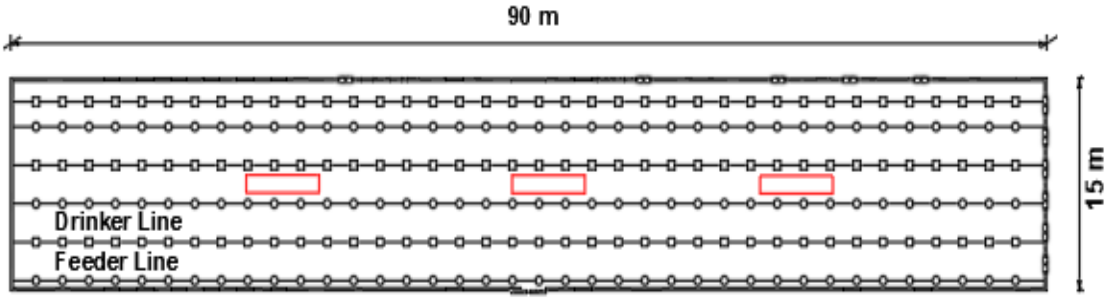


Figure 1. Points where litter material was taken from the broiler house.

2.3. Determination of the physical and chemical properties of litter materials

In this study, characterization analysis was performed to determine the physical and chemical properties of the control and treated litter material samples.Within this scope, the pH, electrical conductivity (EC), moisture content, and total dissolved solids (TDS) of the litter material were analyzed.

A moisture analyzer (MOC63u, Shimadzu Corporation, Japan) was used in the study to determine the moisture content and dry matter quantity of the litter material. The initial 15-gram samples were used. After these samples were dried in a moisture analyzer at 150 ˚C, and their final weights were recorded to calculate moisture content and dry matter.

For TDS, EC, and pH measurements, 36 ml of distilled water was added to a sterile skirted centrifuge tube, followed by the addition of litter material until the volume reached 40 ml. The resulting mixture was homogenized with a mixer (Visemix VM-10, witeg Labortechnik GmbH, Deutschland) for 5 minutes and then allowed to rest for 30 minutes. Following the settling process, TDS, EC, and pH measurements were performed using a portable conductivity meter (HI99300, Hanna Instruments, Italy) and a portable pH meter (Ph 3110, WTF, Germany).

2.4. UV-A and UV-C applications

In the study, gas measurements were conducted to determine the treatment efficiency after exposure to the UV system under room conditions in the laboratory. The system used in the study is made of black wooden medium-density fiberboard material and is 87.5 cm high, 73.6 cm wide, and 35

cm deep. A hole with a diameter of 11 cm has been drilled in the middle of the shelf, which is located 36 cm above the ground inside the system. This hole can be opened and closed with a sliding wooden cover that is controlled from the outside. The lamps are placed on the ceiling of the wooden box. The appearance of the system to be used for the treatment of litter material taken from the broiler house where meat production farming is carried out, with UV-A and UV-C rays, is shown in Figure 2 and Figure 3.

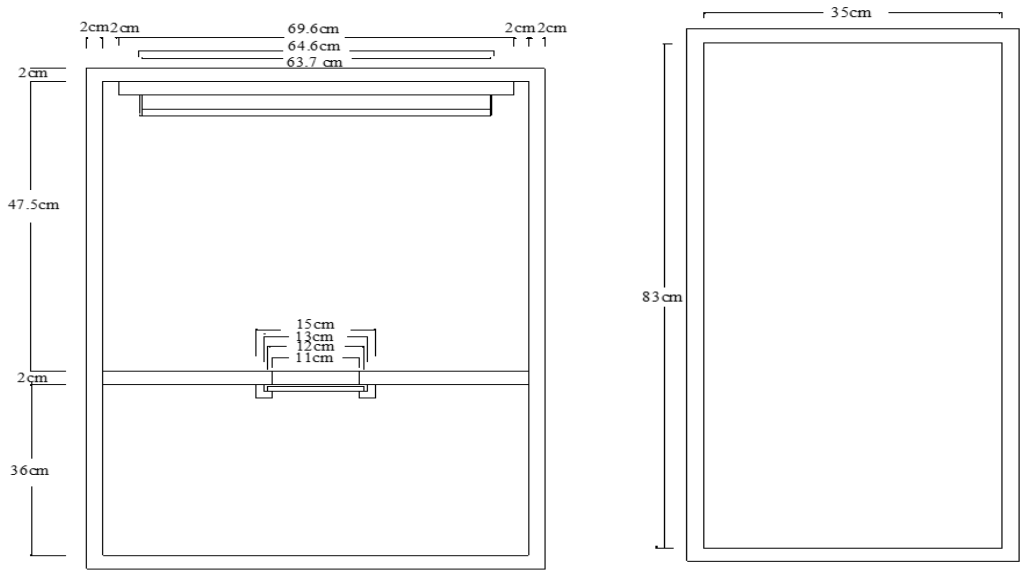


Figure 2. Cross-section and side view of the treatment system.

In the study, two Philips brand UV-C lamps, each with a power of 15 W, a length of 45 cm, and a wavelength of 253.7 nm, were used. The UV-A lamps, on the other hand, had the same physical properties (power and length) as the UV-C lamps but were of the Osram brand (2 units) with a wavelength of 365 nm. The system was operated for 30 minutes to stabilize the light efficiency before treatment with UV-A and UV-C lamps. Applications with different combinations were performed to determine the effects of factors such as the distance between the UV lamps and the litter material, and exposure time on the treatment rate. These combinations are important for determining the effect of UV rays on microorganisms. In the literature, wide kinetic monitoring intervals ranging from 1 to 240 minutes have been adopted for the treatment of poultry-derived organic waste using the UV photocatalytic method (Raju et al., 2014). In this context, a monitoring interval of 30 to 120 minutes was established for our study. The 30-minute duration was chosen to track the initial reaction, while the 120-minute duration was selected to capture the point at which the process reaches stabilization. During treatment with the UV system, the radiation intensity decreases inversely with the square of the distance between the lamps and the litter material (Giri and Samal, 2018). Therefore, two different distances were used in the study to determine the effect of distance and radiation power on treatment efficiency. Specifically, exposure times were set to 30, 60, 90, and 120 minutes, while the distance from the litter to the UV lamp was set to 40 and 80 cm. A total of 16 samples were used for the two lamps, with 8 per lamp. The experiments were conducted in 3 repetitions, resulting in a total of 48 measurements.



Figure 3. Images of the treatment system.

Each measurement result was compared with the control group from the broiler house, which was stored in the laboratory refrigerator. The control group refers to samples taken from the broiler house that have not undergone any UV rays treatment. Control and treatment samples were measured for NH_3 and CO_2 levels for 1 hour using a MultiRAE Lite multi-gas monitor in a closed box.

2.5. Calculation of treatment efficiency

In the study, following the analysis stages, calculations of treatment efficiency were carried out to evaluate the performance of the UV system and to determine the differences between the treated samples and the control group samples. Equation 1 was utilized for treatment efficiency calculations (Lee et al., 2020a).

$$TE = \frac{C_{control} - C_{treatment}}{C_{control}} x\ 100 \quad (1)$$

Where:
TE: Treatment Efficiency (%)
Ccontrol: Gas concentration of the control group (ppm)
Ctreatment: Gas concentration of the treated samples (ppm)

2.6. Statistical analyses

In this study, variance analysis was used to determine whether the differences in exposure time and distance parameters during treatment of the litter material with UV-A and UV-C lamps were significant. Additionally, the effect of characteristic properties such as pH, TDS, EC, and humidity, which were analyzed in the study, on treatment efficiency was determined by regression analysis. SPSS 23 software was used for statistical analyses (IBM Corp., 2015).

3. Results and Discussion

3.1. Characterization of broiler litter

According to studies in the literature, the moisture content of litter material in broiler houses is above 50% (Khodadadi et al., 2024). The pH parameter varies between 8 and 10 during production, while the dry substrate material is expected to be at pH 7 (Şekeroğlu et al., 2013). In the study, the physical and chemical properties of the control group samples, which were obtained from the broiler house on the same day, were analyzed. While the litter material had a moisture content of around 60%, the pH ranged from 7.7 to 7.9. Compared with the literature values, the results were found to be within

expected levels. The characterization values for the litter material used in the study are given in Table 1.

Table 1. Characterization values for the litter material used in the study

Parameters	UV-A	UV-C
Humidity (%)	66.10	60.99
pH	7.70	7.90
TDS (ppm)	680	565
EC (µS)	1366	1130

3.2. The effect of exposure time on treatment efficiency

The effect of the litter material's exposure time to UV rays treatment efficiency has been determined. For NH_3 gas, the most successful results were obtained with an average treatment efficiency of over 80% in 60 and 90 min exposure times under UV-A rays. For CO_2 gas, the most successful results were obtained at 30 and 120 minutes, with 74.48% and 83.35% efficiency, respectively. When overall performance is evaluated, it can be inferred that CO_2 gas treatment is more successful when the exposure time to UV-A ray is very short or very long, and NH_3 gas treatment is more successful when the exposure time is moderate, due to the different dynamics of both gases. According to the variance analysis, the differences in exposure time between CO_2 and NH_3 treatments are statistically significant ($P<0.05$). The change in treatment efficiency with exposure time to the UV-A lamp is shown in Table 2.

Table 2. The effect of UV-A rays exposure time on treatment efficiency

Parameters	CO_2			NH_3		
	Control (ppm)	**Treated (ppm)**	**Treatment Efficiency (%)**	**Control (ppm)**	**Treated (ppm)**	**Treatment Efficiency (%)**
			30 min			
Average	1216^{a}	295^{b}	74.48^{b}	85^{a}	40^{a}	54.80^{c}
Min.	975	150	67.85	63	22	27.84
Max.	1725	375	90.16	92	68	67.16
Std. Deviation	242	58	6.37	10	15	13.57
			60 min			
Average	998^{c}	818^{a}	16.80^{c}	93^{a}	11^{b}	88.16^{a}
Min.	900	725	9.34	88	9	85.56
Max.	1125	925	24.74	96	14	90.50
Std. Deviation	75	56	4.93	2	2	1.87
			90 min			
Average	1152^{b}	827^{a}	22.72^{c}	67^{b}	12^{b}	82.04^{a}
Min.	975	750	10.19	39	6	55.23
Max.	1625	850	53.87	76	19	92.67
Std. Deviation	212	41	15.22	11	5	10.84
			120 min			
Average	1152^{b}	191^{c}	83.35^{a}	30^{c}	12^{b}	62.40^{b}
Min.	975	100	77.72	18	5	34.08
Max.	1425	225	93.56	43	24	79.44
Std. Deviation	171	49	5.75	9	7	14.34
P-value	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001

$^{a-c}$The differences between the averages represented by different letters are statistically significant ($P<0.05$).

The change in treatment efficiency with exposure time of the litter material to UV-C rays parallels the efficiency rates obtained with a UV-A lamp. The maximum treatment efficiency for NH_3 gas was 95.33% at an exposure time of 90 minutes. For CO_2 gas, the maximum treatment efficiency was achieved at an exposure time of 120 minutes. This situation shows that the increase in exposure time for both lamps also leads to an increase in treatment efficiency.Consistent with our results, studies in the literature show that increasing UV exposure time enhances the efficiency of greenhouse gas and odor removal (Lee et al., 2020b). Additionally, increasing the exposure time with a UV-A lamp enhances the

treatment efficiency of NH_3 gas (Lee et al., 2020a). According to the variance analysis, the differences in exposure time between CO_2 and NH_3 treatments are statistically significant ($P<0.05$). The change in treatment efficiency with exposure time to the UV-C lamp is shown in Table 3.

Table 3. The effect of UV-C rays exposure time on treatment efficiency

Parameters	CO_2			NH_3		
	Control (ppm)	Treated (ppm)	Treatment Efficiency (%)	Control (ppm)	Treated (ppm)	Treatment Efficiency (%)
			30 min			
Average	1505[a]	316[c]	73.06[b]	82[b]	59[a]	29.64[c]
Min.	975	200	65.93	50	31	7.50
Max.	2350	400	89.76	100	93	41.24
Std. Deviation	477	57	7.56	20	24	13.61
			60 min			
Average	1009[d]	679[a]	29.76[d]	96[b]	22[b]	77.45[b]
Min.	700	550	18.65	77	13	73.25
Max.	1350	825	40.83	100	27	83.00
Std. Deviation	239	94	7.53	8	4	3.12
			90 min			
Average	1032[c]	488[b]	54.06[c]	263[a]	16[c]	84.10[a]
Min.	825	475	45.19	238	5	65.44
Max.	1525	500	67.59	300	34	95.33
Std. Deviation	228	13	7.40	24	9	8.32
			120 min			
Average	1050[b]	55[d]	94.57[a]	35[c]	11[d]	70.39[b]
Min.	750	0	91.06	18	2	41.53
Max.	1650	75	100.00	56	29	87.49
Std. Deviation	288	27	3.23	14	8	14.52
P-value	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001

[a-c]The differences between the averages represented by different letters are statistically significant ($P<0.05$).

3.3. The Effect of lamp distance on treatment efficiency

In the present study, treatment was carried out at two different heights to determine the treatment efficiency of UV-A and UV-C lamps as a function of distance from the litter material. Maximum treatment efficiencies in both gases were achieved at a distance of 40 cm for both UV-A and UV-C lamps. Lee et al. (2021) reported that radiation power directly affects treatment efficiency in reducing odor and gas emissions from animal waste sources via UV-A and UV-C rays. In UV systems, the distance between the lamps and the contaminant is inversely proportional to the radiation power (Giri and Samal, 2018). In this context, reducing the distance between the UV lamps and the pollutant source directly increases treatment efficiency. This principles perfectly aligns with our results, where the highest efficiency was recorded at the 40 cm proximity. According to the variance analysis, the differences in distance to the lamp between the CO_2 and NH_3 treatments are significant ($P<0.05$). The change in the litter material's treatment efficiency with distance from the UV-A and UVC lamps is shown in Table 4.

Several similar studies in the literature have aimed to treat pollutants from livestock operations using UV rays. Guarino et al. (2008) aimed to determine the treatment rates of pollutants in a pig farm in Italy using the UV/TiO2 method in a study they conducted in the delivery room. Within the scope of the study, the UV/TiO2 method was used in one delivery room for a production period, while an identical delivery room served as a control. As a result of their studies, they determined that reductions of 30.37%, 15%, and 10.52% were achieved for the pollutant gases NH_3, CH_4, and CO_2, respectively. They have stated that the UV/TiO2 method has shown successful results in pig farms and therefore has the potential to be used in different types of farming.

Koziel et al. (2008) utilized UV rays for laboratory-scale treatment of pollutants originating from livestock farming. In their study, they reported that, while VOC and H_2S levels varied depending on exposure time, the use of UV rays resulted in 80-100% treatment efficiency.

Rockafellow et al. (2012) conducted a laboratory-scale study to treat NH_3 emissions in the indoor environment of animal farms using UV rays. In their studies, they determined that the treatment rate varied between 45% and 98% at different exposure times in NH_3 concentration.

Table 4. Change in treatment efficiency of the litter material according to distance from the UV rays

Parameters		CO_2			NH_3		
		Control (ppm)	Treated (ppm)	Treatment Efficiency (%)	Control (ppm)	Treated (ppm)	Treatment Efficiency (%)
UV-A				80 cm			
	Average	1116[b]	570[a]	46.04[b]	62[b]	15[b]	73.82[a]
	Min.	975	450	39.63	54	9	61.86
	Max.	1413	650	63.02	65	20	81.31
	Std. Deviation	154	57	8.80	3	4	6.17
				40 cm			
	Average	1143[a]	495[b]	52.62[a]	76[a]	23[a]	69.82[b]
	Min.	938	425	46.35	65	11	42.03
	Max.	1463	538	67.81	81	41	82.73
	Std. Deviation	179	31	6.65	5	10	13.37
	P-value	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
UV-C				80 cm			
	Average	1059[b]	437[a]	57.62[b]	77[b]	33[a]	56.91[b]
	Min.	733	367	48.84	55	16	34.63
	Max.	1563	500	69.95	86	52	69.66
	Std. Deviation	287	41	7.07	10	12	12.07
				40 cm			
	Average	1238[a]	327[b]	68.67[a]	155[a]	22b	73.14[a]
	Min.	888	288	64.05	134	11	60.36
	Max.	1838	375	77.71	187	38	77.63
	Std. Deviation	323	29	4.63	16	10	6.45
	P-value	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001

[a-b]The differences between the averages represented by different letters are statistically significant (P<0.05).

3.4. The effect of the litter's chemical properties on treatment efficiency

The study determined the effect of the chemical properties of the litter material on UV light treatment efficiency. Analysis using a UV-A lamp showed that pH, EC, TDS, and humidity parameters exhibit an inverse relationship with the treatment efficiency of NH_3 gas. A decreasing trend in treatment efficiency was observed with increasing chemical properties. Although there is a negative correlation between treatment efficiency and chemical properties, the regression coefficient is extremely low. This situation indicates a weak relationship. The effect of the chemical properties of the litter material on the treatment efficiency of NH_3 gas by the UV-A lamp is shown in Figure 4.

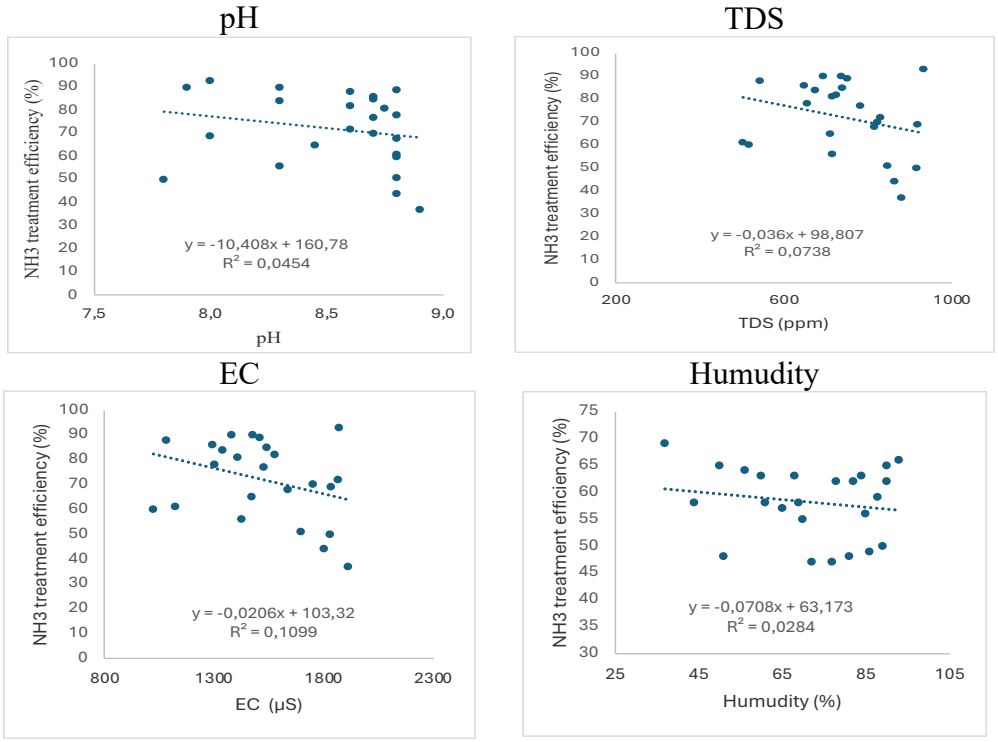


Figure 4. Effect of the chemical properties of the litter material on the treatment efficiency of NH_3 gas by the UV-A lamp.

The effect of the chemical properties of the litter material on the efficiency of CO_2 gas treatment by the UV-A lamp is shown in Figure 5. Here, unlike NH_3 gas, there is a positive correlation between the chemical properties (pH, TDS, and EC) and treatment efficiency. Increases in chemical properties have also positively impacted treatment efficiency. However, in the moisture parameter, there is an inverse relationship, just like with the UV-A lamp. A low regression coefficient indicates a weak relationship between chemical properties and treatment efficiency.

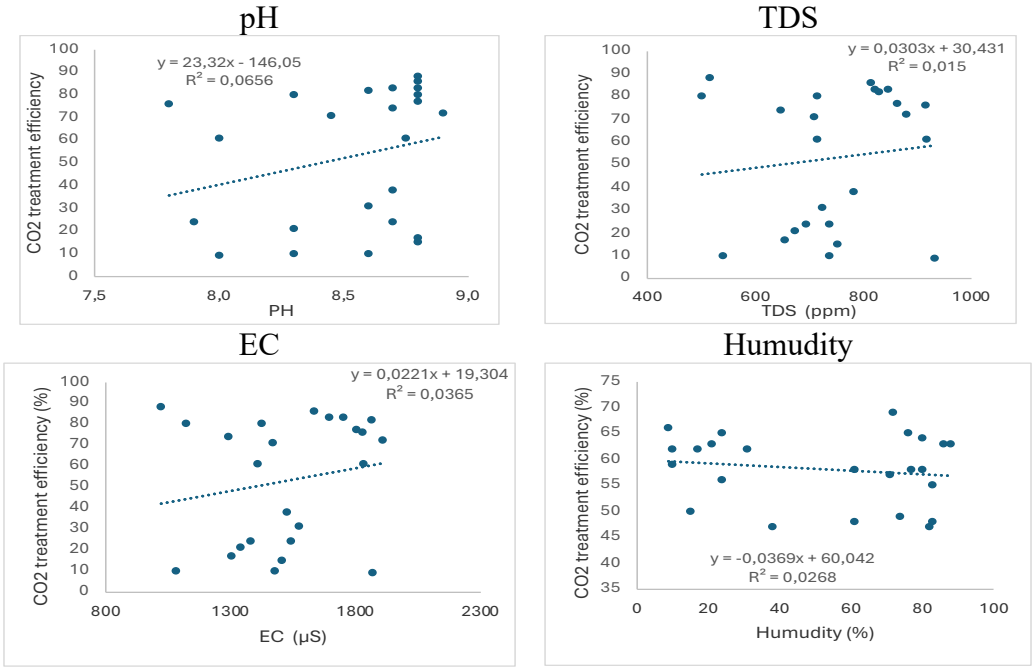


Figure 5. Effect of the chemical properties of the litter material on the treatment efficiency of CO_2 gas by the UV-A lamp.

The UV-C wavelength, on the other hand, has a linear relationship with the treatment efficiency of the chemical properties of TDS, EC, and humidity for NH_3 gas. As for the relationship between the pH value of the litter material and treatment efficiency, there is an inverse relationship. The low R^2 value for the relationship between all chemical properties and treatment efficiency indicates that these properties have a limited effect on treatment efficiency. The effect of the chemical properties of the litter material on the treatment efficiency of NH_3 gas by the UV-C lamp is shown in Figure 6.

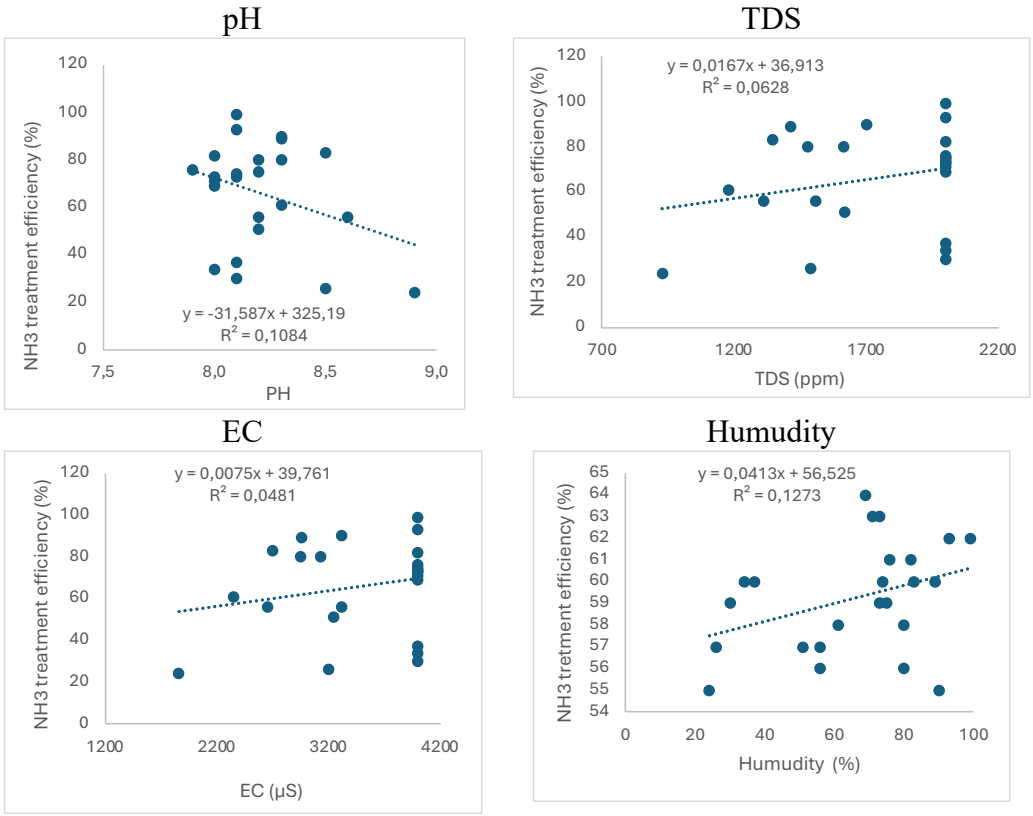


Figure 6. Effect of the chemical properties of the litter material on the treatment efficiency of NH_3 gas by the UV-C lamp.

When examining the relationship between the litter material's chemical properties and CO_2 gas treatment using a UV-C lamp, there is a positive relationship with pH and an inverse relationship with EC, TDS, and Moisture. However, the R^2 value is low, similar to that for NH_3 gas and the UV-A lamp. This situation, along with the other results, indicates that the relationship between chemical properties and treatment efficiency is weak. By increasing the number of samples analyzed in future studies, statistically more reliable results can be obtained. When UV rays contact a substance, the presence of particles within it provides some protection for the target components. This situation can be explained in the literature by the shielding effect of microorganisms (Koutchma, 2009). While the aforementioned shading effect is effective at the depths of the litter material, it does not create the same barrier on the components in the gas phase. As a result, although gas treatment efficiencies are high, no significant changes are observed in various litter properties. Consequently, the weak correlation between the treatment efficiencies of NH_3 and CO_2 gases under different UV lamps and at different pH, humidity, EC, and TDS levels is due to this. The effect of the chemical properties of the litter material on the efficiency of UV-C lamp CO_2 gas treatment is shown in Figure 7.

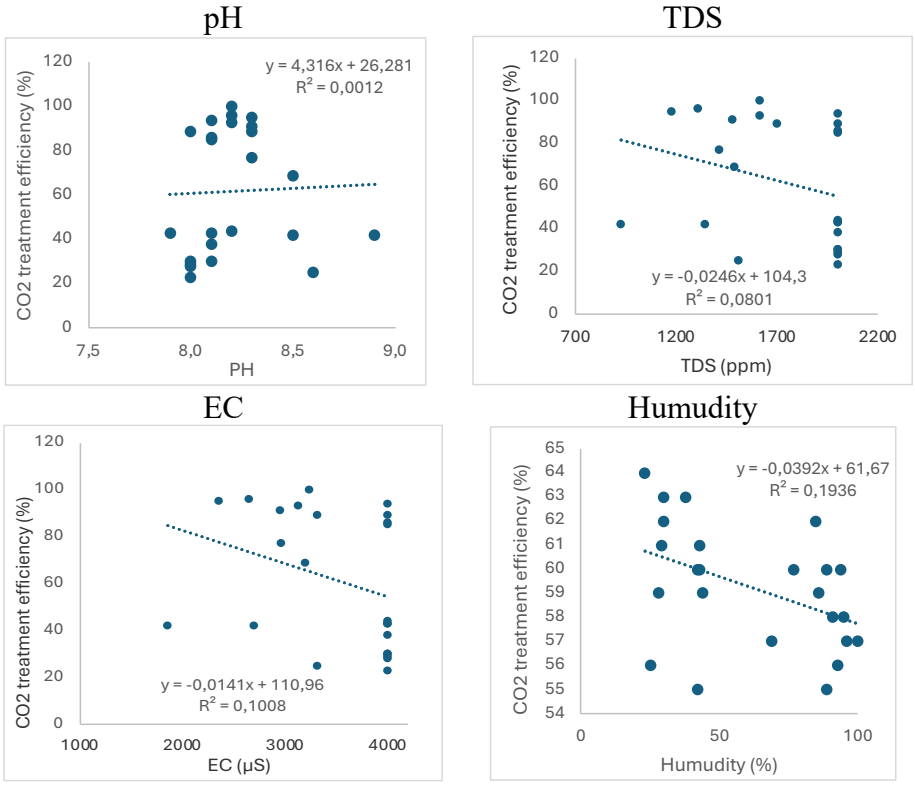


Figure 7. Effect of the chemical properties of the litter material on the treatment efficiency of CO_2 gas by the UV-C lamp.

Conclusion

The effect of the litter material's exposure time to UV rays on treatment efficiency has been evaluated. The treatment efficiency of CO_2 gas from the litter material with UV-A rays is 74.48% at an exposure time of 30 minutes, while this rate is 54.80% for NH_3 gas. When the exposure time is increased to 60 minutes, the CO_2 gas treatment efficiency decreases to 16.80%, while it increases to 88.16% for NH_3 gas. When looking at the maximum treatment efficiencies, the most successful results were obtained from measurements taken at 90 and 120 minutes. For CO_2 gas treatment efficiency under UV-C rays, the highest success rate was achieved in 120 minutes (94.57%), while the highest efficiency for NH_3 gas treatment was obtained in 90 minutes (84.10%). The acceptable average treatment efficiency for CO_2 and NH_3 gases was determined to be 54.06% and 84.10%, respectively, for a 90-minute exposure time. Furthermore, consistent with the UV-A results, extended periods with UV-C lamp demonstrated comparable treatment trends.

The effect of the distance between UV lamps and the litter material on the treatment efficiency of contaminant gases has been investigated. With UV-A lamps, the maximum treatment efficiency for CO_2 gas originating from the litter material was achieved at 40 cm (67.81%), while the maximum for NH_3 gas was achieved at 40 cm (82.73%). For UV-C lamps, the most successful results for CO_2 and NH_3 gas treatment were determined to be 68.57% and 73.14%, respectively, at a distance of 40 cm. The results showed that the distance between the UV lamps and the litter material effected treatment efficiency. When the litter material was closer to the lamps (40 cm), the maximum treatment efficiencies were higher for both gases.

The study found that UV rays can effectively improve the quality of litter material. The results of the study suggest that adjusting exposure time, depending on the type of target pollutant, may improve performance. Additionally, the increased treatment efficiency observed at closer distances to the UV source indicates that more successful results can be achieved by optimizing this parameter. Therefore, changes to the method will significantly contribute to the development of more sustainable and effective solutions for the treatment of litter material using UV-A and UV-C rays.

Ethical Statement

Ethical approval is not required for this study.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Artificial Intelligence Declaration

The authors declare that no generative artificial intelligence tools were used at any stage of the preparation of this manuscript, including the writing, editing, or refinement of the text, or the creation of any images, figures, graphics, tables, or related titles.

Funding Statement

This study was supported by TÜBİTAK under the 2209/A Research Project Support Programme for Undergraduate Students.

Author Contributions

The authors contributed equally to the article.

References

Aydın, K. (2009). Ultraviyole ışınları ile suların dezenfeksiyonu [Disinfection of water by ultraviolet rays]. In *IX. Ulusal Tesisat Mühendisliği Kongresi* [9th National Plumbing Engineering Congress]. İzmir, Türkiye.

Barros, J. D. S. G., Barros, T. A. D. S., Sartor, K., Raimundo, J. A., & Rossi, L. A. (2020). The effect of linear lighting systems on the productive performance and egg quality of laying hens. *Poultry Science*, *99*(3), 1369–1378. https://doi.org/10.1016/j.psj.2019.11.007

Feng, Y., Cai, Y., Fu, X., Zheng, L., Xiao, Z., & Zhao, M. (2018). Comparison of aroma-active compounds in broiler broth and native chicken broth by aroma extract dilution analysis (AEDA), odor activity value (OAV), and omission experiment. *Food Chemistry*, *265*, 274–280. https://doi.org/10.1016/j.foodchem.2018.05.043

Giri, H. C., & Samal, G. (2018). Standardization of UV dose fluence techniques bench-scale uv experiments for decision-making. *International Journal of Engineering, Management, Humanities and Social Sciences Paradigms*, *30*.

Guarino, M., Costa, A., & Porro, M. (2008). Photocatalytic TiO2 coating—to reduce ammonia and greenhouse gases concentration and emission from animal husbandries. *Bioresource Technology*, *99*(7), 2650–2658. https://doi.org/10.1016/j.biortech.2007.04.025

Guerrero-Beltran, J. A., & Barbosa-Canovas, G. V. (2005). Reduction of Saccharomyces cerevisiae, Escherichia coli, and Listeria innocua in apple juice by ultraviolet light. *Journal of Food Process Engineering*, *28*(5), 437–452.

IBM Corp. (2015). *IBM SPSS Statistics for Mac* (Version 23.0) [Computer software].

İskender, H., Kanbay, Y., & Özçelik, E. (2015). Consumer Preference for Chicken Meat among the Students of Artvin Coruh University. *Fırat University Veterinary Journal of Health Sciences*, *29*(1), 9–13.

Jameel, F. R. (2019). *In vitro antimicrobial effect of nisin, fluid whey, and Nigella sativa essential oil on experimentally infected chicken meat with Campylobacter jejuni* [Doctoral dissertation, Erciyes University]. Erciyes University Graduate School of Natural and Applied Sciences, Kayseri, Türkiye.

Kavas, S., Çoban, M. T., & Budak, E. (2023). Uv Lamp Applications and The Effect of Different Lamp Layouts on Performance. *Engineer and Machinery*, *64*(712), 453–475. https://doi.org/10.46399/muhendismakina.1206427

Khodadadi, M., Masoumi, A., & Sadeghi, M. (2024). Drying, a practical technology for reduction of poultry litter (environmental) pollution: Methods and their effects on important parameters. *Poultry Science*, *103*(12). https://doi.org/10.1016/j.psj.2024.104277

Kılıç, İ., & Arıcı, İ. (2013). Effects of Air Pollutants in Animal Barns on Environment and Health of Animal and Worker. *Yuzuncu Yıl University Journal of Agricultural Sciences*, *23*(3), 279–288.

Kılıç, İ., & Şimşek, E. (2009). The gaseous emissions from animal houses and their environmental impacts. *Uludağ University Journal of The Faculty of Engineering*, *14*(2). https://doi.org/10.17482/uujfe.41168

Koca, N., Saatli, T. E., & Urgu, M. (2018). Surface Applications of Ultraviolet Light in Food Industry. *Academic Food Journal*, *16*(1), 88–100. https://doi.org/10.24323/akademik-gida.417901

Korkmaz, A., & Tiryaki Gündüz, G. (2018). Mold Inhibition on Fruits and Vegetables by UV-C Light Treatments. *Academic Food Journal*, *16*(4), 458–469. https://doi.org/10.24323/akademik-gida.505539

Koutchma, T. (2009). Advances in ultraviolet light technology for non-thermal processing of liquid foods. *Food and Bioprocess Technology*, *2*(2), 138–155. https://doi.org/10.1007/s11947-008-0178-3

Koziel, J., Yang, X., Cutler, T., Zhang, S., Zimmerman, J., Hoff, S., Jenks, W., Laor, Y., Ravid, U., Armon, R., & Van Leeuwen, H. (2008). Mitigation of odor and pathogens from CAFOs with UV/TiO2: Exploring cost-effectiveness. In *Mitigating Air Emissions from Animal-Feeding Operations Conference*. Des Moines, Iowa, USA.

Lee, M., Koziel, J. A., Murphy, W., Jenks, W. S., Chen, B., Li, P., & Banik, C. (2021). Mitigation of odor and gaseous emissions from swine barn with UV-A and UV-C photocatalysis. *Atmosphere*, *12*(5), 585. https://doi.org/10.3390/atmos12050585

Lee, M., Li, P., Koziel, J. A., Ahn, H., Wi, J., Chen, B., Meiirkhanuly, Z., Banik, C., & Jenks, W. S. (2020a). Pilot-scale testing of UV-A light treatment for mitigation of NH3, H2S, GHGs, VOCs, odor, and O3 inside the poultry barn. *Frontiers in Chemistry*, *8*, 613. https://doi.org/10.3389/fchem.2020.00613

Lee, M., Wi, J., Koziel, J. A., Ahn, H., Li, P., Chen, B., Meiirkhanuly, Z., Banik, C., & Jenks, W. (2020b). Effects of UV-A light treatment on ammonia, hydrogen sulfide, greenhouse gases, and ozone in simulated poultry barn conditions. *Atmosphere*, *11*(3), 283. https://doi.org/10.3390/atmos11030283

Miles, D. M., Owens, P. R., & Rowe, D. E. (2006). Spatial variability of litter gaseous flux within a commercial broiler house: Ammonia, nitrous oxide, carbon dioxide, and methane. *Poultry Science*, *85*(2), 167–172. https://doi.org/10.1093/ps/85.2.167

Petek, M. (1996). *Production parameters and economic efficiency of different genotypes in the surroundings and broiler enterprises near Bursa city center* [Doctoral dissertation, Bursa Uludağ University, Institute of Health Sciences]. Bursa, Turkey.

Raju, A. C., Chandra, B. S., Shukla, A., Reja, V. K., Adusumilli, K. A., Neelancherry, R., & Kumar, M. (2014). Photocatalytic treatment of poultry wastewater by hectorite-TiO2 aqueous suspensions. In *International Conference on Chemical and Environmental Research*. Tamil Nadu, India.

Republic of Türkiye Ministry of Agriculture and Forestry. (2024). *Bursa tarımsal yatırım rehberi* [Bursa agricultural investment guide]. https://www.tarimorman.gov.tr/TRGM/TARYAT/Belgeler/Tarımsal%20yatırım%20rehberi/Bursa%20Tarımsal%20Yatırım%20Rehberi.pdf

Rockafellow, E. M., Koziel, J. A., & Jenks, W. S. (2012). Laboratory-scale investigation of UV treatment of ammonia for livestock and poultry barn exhaust applications. *Journal of Environmental Quality*, *41*(1), 281–288. https://doi.org/10.2134/jeq2010.0536

Rotimi, E. A. (2025). Morphometric characterization and discrimination of three broiler chickens using canonical discriminant analysis. *Yuzuncu Yıl University Journal of Agricultural Sciences, 35*(1), 81-90. https://doi.org/10.29133/yyutbd.1415067

Şekeroğlu, A., Eleroğlu, H., Sarıca, M., & Camcı, Ö. (2013). Yerde üretimde kullanılan altlık materyalleri ve altlık yönetimi [Litter materials and litter management used in floor production]. *Tavukçuluk Araştırma Dergisi*, *10*, 25–34.

Turkish Statistical Institute. (2024). Turkish Statistical Institute. https://www.tuik.gov.tr

United Nations. (2021). World population prospects. https://www.un.org/en/

Yaylı, B., & Kılıç, İ. (2021). Determination and Evaluation of Lighting Sufficiency in Cages Systems Laying Hens According to Standarts: Bursa Example. *European Journal of Science and Technology*, (31), 475–480. http://dx.doi.org/10.31590/ejosat.1008508

Yerlikaya, S., & Özkaya, N. (2020). Chicken Meat and Some Processed Chicken Meat Products. *Bayburt University Journal of Science*, *3*(1), 35–40.