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*Full Length Research Paper*

# Effect of various litter materials on ammonia concentration in broiler poultry houses

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Abstract

**In this study, the effects of various litter materials on the concentration of ammonia in the broiler poultry houses which have evaporation cooling (fan and pad) systems in around Adana province were determined. In the research, wood shavings were used as litter material which is widely used in the region. 4 kg of zeolite and 4 kg of basalt based two different materials were mixed to the 1 $m^2$ of floor space to the litter. In the research, ammonia gas concentration in the control department was found 1-6 ppm, 2-5 ppm in zeolite mixed department and 2-6 ppm in basalt mixed department in summer. In winter, these values changed as 9-12 ppm, 5-8 ppm and 4-6 ppm, respectively. In the research, it was determined that basalt material showed similar properties with the zeolite material. It is been determined that basalt, which is abundant and economical in the region, can be an alternative to the zeolite in the treatment of the litter material in poultry houses.**

**Key Words:** Poultry house, ammonia gas, litter, zeolite, basalt

## INTRODUCTION

Increasing the productivity per animal is possible with the use of races with high efficiency, their well balanced and sufficient nutrition and providing optimum environmental aspects. Among these, 30% of the production obtained is provided by high efficient races and 70% is provided by environmental aspects. Animals are under two different environments. One of them is climatic environment which is about ambient temperature, relative humidity and air movement, the other is the chemical environment which is about dust in the environment, ammonia, hydrogen sulphide, carbon dioxide and other gases. Among the harmful gases, hydrogen sulphide and carbon dioxide have important effect on the efficiency and growth of animals.

Ammonia is a colorless, odorless, water-soluble gas and lighter than the air. Ammonia gas formed in shelters has two sources. These are; the digestive systems of the animals and microbiological decomposition of fertilizer. The studies reveal that a big part of ammonia gases occurred in shelters is formed by microbiological decomposition. For that reason, it is very important that the litter should be kept clean besides having a good ventilation system in reducing ammonia concentration. In other words, it is stated that concentration of ammonia gas can be lowered to a level which wouldn't affect the animals (Ozturk  Olgun 1995; Gürkan 2003; Yıldız et al 2010).

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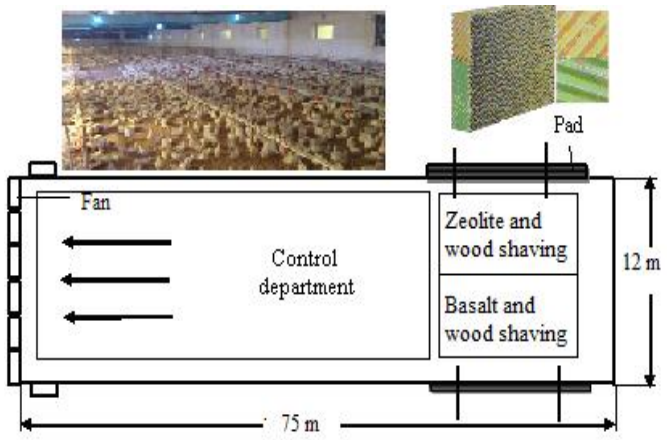



**Figure 1:** The plan of the poultry house and cooling system

The studies indicated that consumption of food and the live weight increase of the animals reduce when ammonia concentration is over 50 ppm and this aggravates utilization of the food, as for over 100 ppm, it is stated that rate of death soars (Nimmermark 1984; Reece et al 1981; Maurice et al 1998). In the studies conducted by Kristensen  Wathes (2000) and Purswell et al (2013), it was stated that the limit value of the ammonia gasses concentration in the broiler houses was 25 ppm.

Zeolites are volcanic rocks which have porous structure and high moisture retention property. Due to these features, it is thought as a natural source for the issues caused by wet base area and the level of high ammonia in broiler breeding. Therefore, because of the porous structure of zeolite mixed to the litter, it has the ability of absorbing excessive moisture and ammonia nitrogen.

In Turkey, Cukurova region including the city of Adana has an important potential of broiler production after Marmara and Central Anatolia. In order to prevent the stress of high temperatures on animals especially in summer season there are cooling systems with evaporation in poultry houses. Because of high relative humidity in the region, the systems work only in daylight hours (from 10 a.m to 5.00 p.m). In the periods the system works, relative humidity reaches to 90-95 % in the poultry houses. With the dropping of the animals, relative humidity of air stays at high levels and affects deterioration of the litter used. By increasing its effect after the 4$^{th}$ week of the production, this case accelerates the formation of hazardous gases such as ammonia. Numerous studies have been made on determining the effects of adding different amounts of zeolite to the feed ratios and base materials on the broiler performance, litter properties and inside ammonia concentration of the poultry house. However, even though basalt material with similar physical and chemical properties with zeolite are abundant in the region, there is no study on the use of basalt material as litter material in the poultry houses in the region yet.

In this experimental study, the effects of addition various materials on the concentration of ammonias in the broiler poultry houses which have evaporation cooling (fan and pad) systems in and around Adana province were determined. Therefore, it was aimed to gain the information that will direct the cooling system designers and the ones setup the program about providing the optimum environmental aspects for animals.

## MATERIAL AND METHODS

### Description of Broiler House

The study was done in a commercial broiler poultry house with a capacity of 15.000 animals in Ceyhan town of Adana. The width of the poultry house handled in the study was 12 m, length of it is 75 m and its height is 2.90 m. The long side of the poultry house was in the direction of North and South. The walls were made of 18 cm thick block brick and inner-outer sides the wall were coated with 1-1.5 cm thick plaster. The roof's upper section was covered with trapeze-cut zinc and the lower section, used as insulation, was made from 6 cm thick fiberglass. There was a fan-pad cooling system in the poultry house. There were five pads material (CELdek R 7060-15, Munters AB, Kista, Sweden) made from cellulose sized as 1.50x3.0 m on the long wall in North-South direction. There were eight fans in the cooling system. Six of the fans were on the short wall and the rest two are on the long wall. The flow rate of the fans was 5.400 $m^3$/h and had six speed levels. The motion was given to the fans by a 1.1 kW powered electrical power engine. The transfer of motion was provided by a belt pulley system. Cooling system was directed from automatic control board. There were 11 single-glassed PVC airing windows which are 55 110 cm on the North-South wall in the poultry house. The plan of the poultry house and cooling system was given in Figure 1.

The wood shaving was used as base material which is commonly used in the region. Natural zeolite is widely used to remove the smell and to create healthier environmental aspects with the control of humidity ingredient in animal shelters. Therefore, in the study, zeolite and basalt latter material which is common and produced in the region (Osmaniye and vicinity) was chosen as an alternative to wood shaving. These two selected materials were mixed to the latter separately in a way that 4 kg will fit on 1 $m^2$ of floor space. Mixed forms of wood shaving+zeolite and wood shaving+basalt materials were laid out as 5 cm thick in summer and 7 cm in winter. In the region, the thickness values of the litter are chosen by the produces according to summer and winter. In the study, choosing basalt material as an alternative to zeolite material was because of its similar qualities and porous structure, water absorbing capacity and keeping azotes in itself.

**Table 1:** Physical and chemical analysis of basalt material (Yasar ve Erdogan 2001)

| Chemical features (%) | | Physical features | |
|---|---|---|---|
| $SiO_2$ | 45.95 | Density (g/cm$^3$) | 1.09 |
| $Al_2O_3$ | 19.95 | Specific gravity (g/cm$^3$) | 2.48 |
| Fe A | 7.53 | Porosity (%) | 53.56 |
| CaO | 13.23 | Water absorption (%) | 21.28 |
| MgO | 6.24 | | |
| $Na_2$+$K_2O$ | 6.69 | | |
| Diğer | 0.41 | | |
| Total | 100.00 | | |

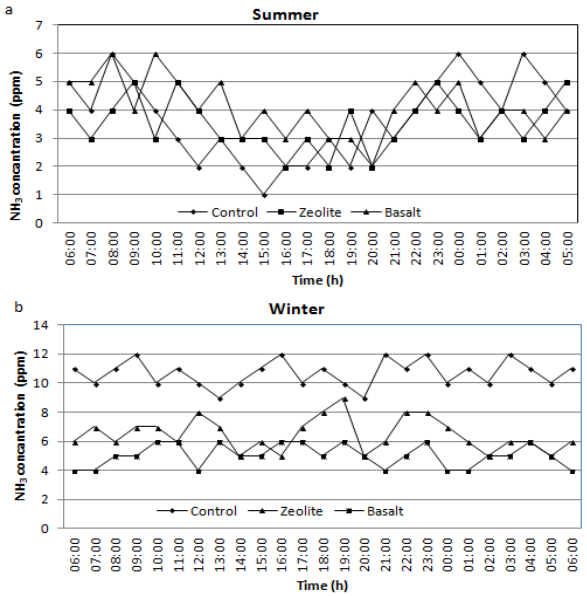



**Figure 2:** Time dependent variation of $NH_3$ gas in summer (b) and winter (b) production seasons

In the research, natural zeolite which has commercial name ZETA (Dimensioned 2.5-3.6 µm, water absorption %32.3, density 1.34 g/cm$^3$) was used. Basalt material was chosen as alternative to zeolite taken from Delihalil district of Tüysüz village which is in 5 km South of Mustafabeyli town of Osmaniye. Physical and chemical analysis results conducted in the Laboratory of Mining Engineering Department of Cukurova University is given in Table 1.

When the cooling systems function in summer, especially the litter materials closer to pad materials are exposed to humidity more than other areas, and the litters in these areas get spoiled earlier. Therefore, 5 meters distance were measured from the forefront of the pads located on the East-West walls where pad material of the poultry house was placed and 6□ 5 m sized two department were formed by dividing the length of short wall into two equal sections. These were covered with 1.5 meter height plywood to prevent the air stream between the departments. Wood shaving + Zeolite and Wood shaving+ Basalt mixture were laid out to these two departments formed. The other department of the poultry house was used as control department (Figure 1) The density of animals were 15 animal per m$^2$ in summer and 17 animal per m$^2$ in winter.

## Measurements and data analyses

In the poultry house evaluated in this study, measurement was performed in summer (July-August) and winter (January-February) months. A significant part of ammonia gas composed in the poultry houses was consisted of microbiological decomposition of the fertilizer. Therefore, concentration of the ammonia gas was examined in three departments as wood shaving+zeolite and wood shaving+basalt and control in this study. INDUSTRIAL SCIENTIFIC-OLDHAM branded gasometer was used to fix the presence of ammonia gas. Gasometer had the capacity to measure ammonia gas up to 100 ppm. Sensors were placed up to approximately 40 cm above the ground from the middle part of the divisions during gas measurements. By this way, the time-dependent variation of ammonia gas was recorded 24 hours long at the level of the animals stand.

Because of the importance of inside temperature and humidity in the formation of this gas, these values were measured during gas measurement. An electronic data logger (Delta-T Logger, DL2e, Delta-T Devices, Cambridge, UK) was used during measurement. Temperature and humidity measurements were done nearly 40 cm above the middle parts of the departments and the ground.

It was stated in the study that the concentration of ammonia gas formed in the poultry house was not at significant level until the 4$^{th}$ week of the 6 weeks breeding period. Therefore, a variation of gas and temperature was measured for 24 hours when animals reached to their slaughtering phase in the 6$^{th}$ week. Owing to a significant part of ammonia gas was composed of microbiological decomposition of the fertilizer, ammonia gas was measured again by stirring the litter with a rake after the animals were sent for slaughtering at the end of the 6$^{th}$ week.

The litter humidity ingredient was another effective factor for the concentration of ammonia gas in poultry house. Therefore, 250 g of base samples were taken from each part and humidity ingredient of these samples was done by drying 24 hours at 105 $^{o}$C according to ASEA standards. In the research, the animals raised in 3 different departments were weighed before the animals were sent for slaughtering in the 6th week.

## RESULTS AND DISCUSSION

Some features detected in gas measurement periods are given in Table 2. $NH_3$ gases measured in the poultry house in summer (a) and in winter (b) and variation of inside and outside temperature and relative humidity values (c,d) were given in Figure 2. As it can be seen in the Figure 2, in 24 hours measurement period, inside

**Table 2:** Some features detected in the poultry house

| Breeding (week) | Summer | | | Winter | | |
|---|---|---|---|---|---|---|
| | Control | Zeolite | Basalt | Control | Zeolite | Basalt |
| The average live weight (kg) | 2195±62[a] | 2218±52[a] | 2234±91[a] | 2116±15[a] | 2242±43[a] | 2254±83[a] |
| Animal density (animal.m$^{-2}$) | 15 | 15 | 15 | 17 | 17 | 17 |
| The litter humidity content (wb) | 29.7 | 17.8 | 10.1 | 31.5 | 15.7 | 11.9 |

**Table 3:** Variation of the ammonia gas concentration measured after raking

| Features | Summer | | | Winter | | |
|---|---|---|---|---|---|---|
| | Control | Zeolite | Basalt | Control | Zeolite | Basalt |
| $NH_3$ concentration (ppm) | 52 | 33 | 38 | 45 | 30 | 34 |

temperature changed between 27.9-30.6 $^{o}$C, relative humidity changed 85.4-92.8 % intervals in the summer season, but in the winter these values were between 19.0-22.5 $^{o}$C and 85.9-92.5 %, respectively. In other words, there wasn't a significant difference at the inside temperature and the relative humidity values in the measurement period.

While the ammonia gas concentration showed a variation between 1-6 ppm in the control department, it was between 2-5 ppm in zeolite mixed department and 2-6 ppm in the basalt mixed department in the summer. The measured ammonia gas concentration showed similar variations with each other in three different department in the 24 hours measurement period. The measured values in the poultry house in the summer were considerably under the given limit values (25 ppm). This shows that the cooling system operated in daytime and the fans at night were sufficient.

The ammonia gas concentration measurement in the winter varied between 9-12 ppm in the control department, 5-8 in the zeolite mixed department and 4-6 ppm in the basalt mixed department. The ammonia gas concentration in the basalt mixed department was at a lower level when compared to the control and zeolite mixed departments. However, the ammonia gas values in all three departments were under the limit value (25 ppm) for animals. In the winter production season, operating the fans at a lower capacity to keep the temperature of the poultry house caused the ammonia gas in the control department to reach 12 ppm. Because of their porosity, the zeolite and basalt materials have the property of absorbing humidity with the other harmful gases and ammonia from the feces of the animals. Because of this feature, it was thought that the ammonia gas concentrations in the zeolite and basalt mixed divisions were effective at lower levels. Maurice et al (1998), stated that the measured ammonia gas concentration in the 6$^{th}$ week of the production was 12 ppm, in their study to determine the effect of alum sludge and zeolite mixture to the litter composition for broiler poultry. Corekci et al (2003) stated that the ammonia concentration in the 6$^{th}$ week of production was 20 ppm in the control department and 10 ppm in the zeolite mixed experiment group in their study conducted to determine the effects of zeolite addition to the litter quality in broiler poultry. In this study, the measured values showed similar features with the literature.

The variation of the ammonia gas concentration measured after raking three different departments after the animals sent to slaughtering was given in Table 3. After the animals have sent to slaughtering, the ammonia gas concentration was measured after raking the base with a rake in all three departments in the empty poultry house. In this measurement, the highest values were determined as 22 ppm in the control department, 37 ppm in zeolite mixed department and 36 ppm in the basalt mixed department in the summer. In the winter these values were determined as 35-37 and 53 ppm, respectively. In other words, the ammonia gas concentration in the zeolite and the basalt materials added departments were observed higher than in the control department in both summer and winter.

In the research after sending the animals to slaughtering by mixing the litter with a rake caused the measured ammonia in the control department to result in higher levels according to the zeolite and basalt mixed departments, this result verifies the gas and humidity absorbing property of zeolite and basalt materials The reason of that there was no significant difference between the three different divisions ammonia gas concentration was thought to be the effective implementation of cooling system in the poultry house in summer.

In the research, litter humidity was varied as 29.7 % in the control department, 17.8% in the zeolite mixed department and 10.1% in the basalt mixed department in the summer. This value was determined as 31.5%, 15.7% and 11.9%, respectively in the winter. (Table 2) The litter humidity in the winter remained high when compared to the summer because of keeping the heat inside and insufficient air-conditioning. It was observed in the summer and the winter season that the litter in the control department had completely gone bad by caking. It was identified that the litters in the two other departments

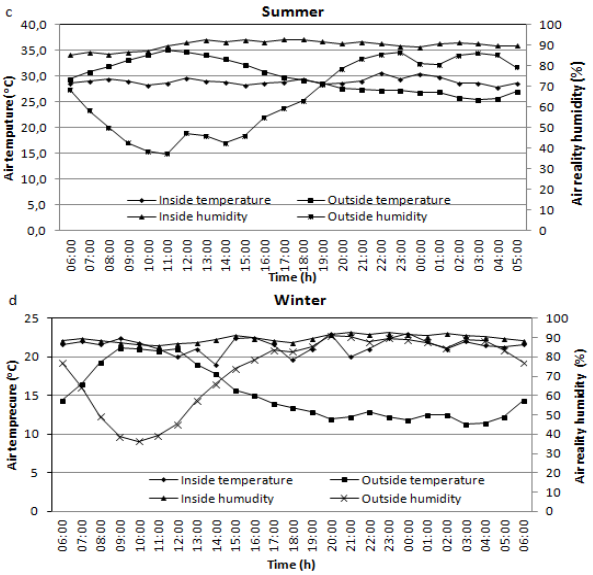



**Figure 3:** Time dependent variation of inside temperature and relative humidity values in summer (c) and winter (d) production seasons




**Picture 1:** Comparison of the material basalt with the control department in the winter season

were still good for using during the following breeding period (Picture 1).

Humidity contain of the litter affects importantly the concentration of the ammonium gases in the poultry houses. That the litter humidity contain was at low levels in the zeolite and the basalt mixed departments despite the fans had been operated at low levels in the winter caused the ammonia gas concentration in those departments was lower than the control department.

By mixing the zeolite to the animal litters, their usage with their porous structure by absorbing the humidity, it was provided that the poultry house to be cleaner and pest formation could be avoided or decreased. It was observed in the research that this positive specialty of zeolite on the litter quality showed similar properties with the basalt material. The litter humidity content was found 25 % lower than the values given in literature in the research in the departments contain zeolite and basalt mixed material in the summer and winter seasons. Corekci et al (2003), stated that litter humidity was lower than the control group and so zeolite had positive effect on the litter humidity in their research which was on the effects of zeolite addition on the litter quality. In another similar study, Altan et al (1998) determined that zeolite addition effected litter humidity positively and litter humidity content for the control group was 41.00% and 29.17% for the zeolite group. The research shows that gathered values are coherent with literature data.

In the research, there was no significant difference in the average live weight of the animals brought up in three different departments in the summer and winter seasons. In the summer, average live weight was 23 g heavier in the zeolite-mixed department and 39 g heavier in the basalt-mixed department, compared to the broiler in the control department. In the winter, this value was found as 126 g and 138 g, respectively. In all three experiment groups there were no significant difference in their average live weight when compared to each other in summer and winter seasons in the statistical analysis ($P<0.01$) (Table 2). Maurice et al (1998), stated that mixing natural zeolite to the litter had no important statistical effect on the growing and rate of utilization from the feed in the 3$^{rd}$ and 6$^{th}$ week of the broilers and zeolite had no effect on the properties of litter material such as ammonia, nitrogen and pH.

Altan et al (1998) and Sarıca et al. (1996), in their study to determine the effects of zeolite admixture material to the litter on the performance of broiler poultry performance, identified that zeolite mixture had no negative effect on the live weight, feed consumption, utilization and death rate. Aksit et al (2000), examined the effects of different levels of zeolite mixture to the litter on performance and litter structure for the broilers feed by different forms of feed. In the study, zeolite mixture effect was found insignificant on the feed consumption, utilization, live weight and vitality of the broilers feed differently ($P>0.05$). But the effect of feed form on performance was found significant ($P<0.01$) Furthermore, it was stated that litter humidity decreased by increasing the zeolite mixture but there was no significant decrease in the ammonia level of the poultry house.

## CONCLUSION

In the research, the ammonia gas concentration in the control department was found 1-6 ppm, 2-5 ppm in the zeolite mixed department and 2-6 ppm in the basalt mixed department in the summer. In the winter, these values changed as 9-12 ppm, 5-8 ppm and 4-6 ppm, respectively. The litter humidity varied as 29.7 % in the control department, 17.8 % in the zeolite mixed department and 10.1 % in the basalt mixed department in the summer. This value was found as 31.5 %, 15.7 % and 11.9 % respectively in the winter. In the summer

season, the measured ammonia gas concentration in three different department showed similar alteration with each other. In the winter, the ammonia gas concentration in the litter basalt mixed department was lower than wood shaving+zeolite mixed department and the control department.

Zeolite has been used in the poultry houses in order to remove malodor and control litter content for many years. Due to this feature of zeolite, healthy conditions can be created in the poultry houses for both animals and the work force. It was determined that basalt material used in the research carries similar properties with the zeolite material. It was observed that the litter of the zeolite+wood shaving and basalt+wood shaving mixed departments didn't get spoiled and the zeolite and basal materials increased humidity keeping property and provided the continuous ventilation of the litter. Additionally, It has been identified that basalt, which is widely available and economical in the region, can be an alternative to the zeolite in the treatment of the litter material in poultry houses.

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