



## **Use the Mixture of Rice Straw and the *Conocarpus erectus* L., 1758 Leaves as the Medium of the Biofilter to Reduce the Ammonia Emitted from Poultry Houses**

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**Abstract:** Poultry houses contribute 93% of the total amount of ammonia gas emitted from production facilities. The study aims to evaluate the efficiency of the biofilter for reducing environmental pollution by ammonia gas and using local and cheap materials. Two field experiments were conducted, A chicken (Ross 308, weigh 44.5 g) was raised in 35 days. Experiment unit dimensions are 1.2 x 1.5 x 2.5 length, width and height and each one of them was connected with a biofilter from the outside by air transport channel. The first experiment of three stocking densities (14, 16, 18) birds / m<sup>2</sup> and three replicates. The second experiment included the use of one SD (14 bird/m<sup>2</sup>), 3 mixtures of rice straw and the *conocarpus* leaves as the medium of the Biofilter and three replicates. The efficiency of the biofilter (mixture of 0.30 *Conocarpus* leaves with 0.70 rice straw) was 91%. The efficiency of the Biofilter was about 91.7% when media 0.25 of *Conocarpus* with 0.75 straw rice and characterized by a high content of total fungi compared to the other two.

**Keywords:** Ammonia gas, Biofilter, Poultry house, Broiler.

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### **Introduction**

Poultry houses contribute 93% of the total amount of ammonia gas emitted from production facilities. Ammonia is among the sources of environmental pollution locally, regionally and globally (Okoli *et al.*, 2004). Estimates of the manure excreted by 1000 birds per day (based on average daily live weights during the bird's production cycle) are approximately 120 kg for layer chickens, 80 kg for meet chickens (Williams *et al.*, 1999). Ammonia gas is derived from the

droppings of birds that contain nitrogen in the form of uric acid. Then by microbial fermentation processes turns into ammonium ion (NH<sub>4</sub><sup>+</sup>) with moisture content, temperature and pH, ammonium is converted to ammonia gas (Carlile, 1984; Kostadinova *et al.*, 2014).

In Europe, the regulations set out the so-called impact factor, which refers to the amount of ammonia gas that is not allowed to be exceeded and released by the air by poultry

projects. For example, select the effect factor of 45 and 80 g/bird annually in the Netherlands and Germany respectively (Ogink & Koerkamp, 2001).

There are different techniques for handling the emission of pollutants from animal production facilities. One of the most prominent techniques used is the biofilter. Two decades ago, researchers have praised the use of biofilters as a way to treat ammonia (Hong & Park, 2004; La Pagans *et al.*, 2005). By comparing biofilter technology with other technologies, (Maia *et al.*, 2012); it has the potential to treat a large volume of polluted air and at low concentrations in an efficient manner (Chen & Hoff, 2009; Deviny & Webster, 2017).

When the passage of the polluted air through the damp filter pad is taken from the mechanical ventilation fans, the process of absorbing the pollutant begins by media and analysing the pollutant by developing microbes in the media, Pagans *et al.* (2007) showed that the contribution of bio-degradation to ammonia is less than the absorption process. The main products of this treatment are gases, carbon dioxide, some salts, nitrate and nitrite ions by nitrification.

The efficiency of the biofilter in reducing ammonia emissions ranged from 43.4% to 100%. There was a marked contrast in the results of the research, even in the tests performed on the same type of biofilter media. The efficiency of the wood bark was ranged from 45.8 to 99.8%. Organic materials performed better than inorganic materials when used in the filter because they encourage the growth of microorganisms (Kim *et al.*, 2000).

The better porosity of the media biofilter and the less concentration of dust in the air, the pressure resulting from the filler resistance will decrease as the air passes through it. Nicolai & Janni (2001) found that the pressure drop increased by increasing the amount of compost to wood chips by closing the filling pores and recommending 20-30% compost based on weight to 70-80% wood chips (Yang *et al.*, 2011).

The volumetric distribution of media biofilter parts leads to increase pressure drop and consequent negative impact on filter

efficiency in ammonia removal (Nicolai *et al.*, 2006).

Prokop & Bohn (1985) recorded a good performance for the filter at a moisture content of 40-60% in Peat moss and 40-50% in compost 35-65 % In the covering of bark as well as the compost mixture and bark chips, and can be as high as 60-80% in media's such as pine bark and perlite (Chang *et al.*, 2004).

We did not notice the use of techniques to treat ammonia gas pollution from poultry fields in Iraq, despite the expansion of poultry projects in recent years. Therefore, the following objectives were identified in the current study:

Evaluation of the efficiency of low-cost biofilter in reducing the emission of ammonia gas under the influence of different concentrations of ammonia and evaluation of the effect mixture of the biofilter media materials (Conocarpus leaves with the rice straw) on the efficiency of the biofilter in reducing ammonia gas emissions to the external environment.

A large number of substances were used as a feedstock for the biofilter (Table 1).

### Materials and Methods:

Biofilter design: The design calculations were based on the use of locally available, inexpensive and untested materials. So we mixed the Conocarpus leaves with the rice straw.

$$V = Q \times EBCT \dots \dots \dots (1)$$

Where, V= Biofilter size; Q= Ventilation rate; EBCT= Empty Bed Contact Time

Q= 0.07 m<sup>3</sup>/s Was selected according to the need of birds / m<sup>2</sup>

$$EBCT=3 \text{ second (Schmid, et al., 2004)}$$

$$TPD = UPD \times D \dots \dots (2)$$

Where, TPD= Total Pressure Drop (mmH<sub>2</sub>O); UPD= Unit Pressure Drop; D= Depth of media

$$D= 0.25 \text{ m (Schmid et al., 2004)}$$

**Table (1): Types of media biofilter and its efficiency in reducing the emission of ammonia.**

Media	RE % *	Source
compost	99.9	(Maia <i>et al.</i> , 2012)
Wood chips	58	(Hoff <i>et al.</i> , 2009)
Wood chips	99.4-99.8	(Chen & Hoff, 2009)
Wood chips	45.8	(Lim <i>et al.</i> , 2012)
Western cedar (Wood chips)	43.4	(Chen & Hoff 2012)
Hard wood (Wood chips)	74	
Fuyolite	55-100	
Ceramics	50-100	
Polyurethane bed	97-99	(Ryu <i>et al.</i> , 2011)
Lava rock	56	(Akdeniz <i>et al.</i> , 2011)
40:40:60 Mixture of compost soil, peat and Oak	88.4	(Lawniczek-Walczyk <i>et al.</i> , 2013)
40:40:60 Mixture of compost soil, peat and Coconut fiber	89.7	
20:80 Mixture of manure fertilizer and rick husk	99-100	(Jinanan & Leungprasert 2015)

\*RE% Reduction of Ammonia Gas (Biofilter efficiency).

$$UAR = Q \div A \dots (5)$$

$$UPD = 8.82 \times 10^{11} \times (\text{percent voids})^{-8.6} \times UAR^{1.27} \dots (3)$$

Where, UAR= Unit Air Flow Ratio (m<sup>3</sup>/m<sup>2</sup>)

Percent voids of media Biofilter= (porosity %).

The bucket method was used (Schmid *et al.*, 2004), where a bucket was filled with a sample of media up to 1/3 bucket and the bucket was dropped ten times from a height of 15 cm to the ground, then complete the bucket by 2/3 size of the sample media and dropped for ten times as the first time, after that add the bucket completely and then dropped for ten times until the media filled the size of the bucket completely, finally add the water leisurely above the media in the bucket until the water reached the edge of the upper bucket and with the measuring of the amount of water added and then calculated the porosity % by the following equation:

$$\text{Percent voids} = \frac{\text{Volume of water added}}{20 \text{ liters}} \times 100 \dots (4)$$

Percent voids = porosity %; volume of water added (litter); 20 litres = pile size

Where, A = Area of media Biofilter

$$A = V \div D \dots (6)$$

Results of design calculations:

$$V = 0.09 \text{ m}^3, A = 0.36 \text{ m}^2, \text{TPD} = 2.7 \text{ mmH}_2\text{O}$$

Using the opposite wood and wire mesh with circular channel section to move the air from the ventilator fan to the position under the media, the medium height from the ground surface was 30 cm. The biofilter media were wet during the experiment period by a bucket.

### Conducting experiments

Two field experiments were conducted in the poultry field of the Agricultural Research Station, College of Agriculture, University of Basrah. The first experiment aimed to evaluate the efficiency of the biofilter with different concentrations of ammonia gas using different densities of birds, lasted 35 days from 20<sup>th</sup> November 2017.

The experiment plan included the use of three densities of birds (14, 16, 18) birds /m<sup>2</sup>

and three replicates where each was allocated to dimensions of 1.2 x 1.5 x 2.5 length, width, height and all were connected with a biofilter from the outside by air transport channel. A total of 234 chickens (Ross 308, weigh 44.5 g) were raised 35 days. The floor was sprinkled with wood shavings 7 cm thick until the age of the birds were 21 days and then completed to 10 cm thickness for the rest of the breeding period. The electric heater (1200 W) was used in the hall to heat the furnace and control the temperature and humidity (Electronical devices) during the last week of experiment and used lighting 24 hours a day.

The second experiment lasted 35 days from 18/3/2018 to 21/4/2018. In order to evaluate the biofilter performance in reducing the emission of ammonia to the environment using different types of filter media mixture. The mix. is a mixture of biomaterial material as a percentage of the total media volume, Mix1 mixture of 0.25 Conocarpus leaves to 0.75 rice straw, a Mix2 mixture of 0.50 Conocarpus leaves to 0.50 straws of rice, Mix3 mixture of 0.75 Conocarpus leaves to 0.25 straws of rice.

Distributed 207 birds by 23 birds (14 birds /m<sup>2</sup>) in each of the nine places. Measurements studied in the first and second experiment:

The efficiency of the biofilter in the treatment of ammonia gas at week 2, 3, 4 and 5 of bird life, using the following equation (Jinanan & Leungprasert, 2015; Seedorf & Hartung, 2002).

Where,

$$RE\% = \frac{C_i - C_o}{C_i} \times 100 \dots \dots (7)$$

Where,

RE% = The efficiency of the biofilter in reducing the emission of ammonia

C<sub>i</sub> = concentration of ammonia gas under the biofilter media (ppm)

C<sub>o</sub> = Concentration of ammonia gas out of biofilter media (ppm)

The concentration of ammonia gas was measured in the polluted air collected under the biofilter media using the Gas Detection Tube with pump (rang 1-30 pmm , time of one measure is 1-2 minute) made in Drager.com, USA.

Measure the concentration of ammonia gas for air out of the filter (at a height of 50 cm above the media surface) and by the same device.

Mass mean diameter (mm): where eight sieves with different diameters (75, 50, 25, 9.5, 4, 3.17, 1.7, 1.18) were used after drying the air fill sample, record the total weight and then drain for 5 minutes and then measure the weight of the parts above each sieve using the following equation (Schmid *et al.*, 2004):

$$dmm = \frac{\sum m_i \times d_i}{M} \dots \dots \dots (8)$$

Where,

dmm = mass mean diameter (mm)

m<sub>i</sub> = weight of the parts at each sieve

d<sub>i</sub> = Midpoint The average between two successive diameters of sieve openings

M = total weight of the sample

The measurements also included: density of biofilter media, temperature, moisture content, microbial preparation (total bacteria, total fungi (cfu\gm)) at 2 and 5 weeks as Harrigan & McCance (1998).

### Statistical Analysis

The data were analysed for the traits studied using the Completely Randomized Design (CRD) to determine the effect of the different treatments. The differences (P<0.05) were tested by Duncan (1955). The statistical program SPSS.22 was used for this purpose.

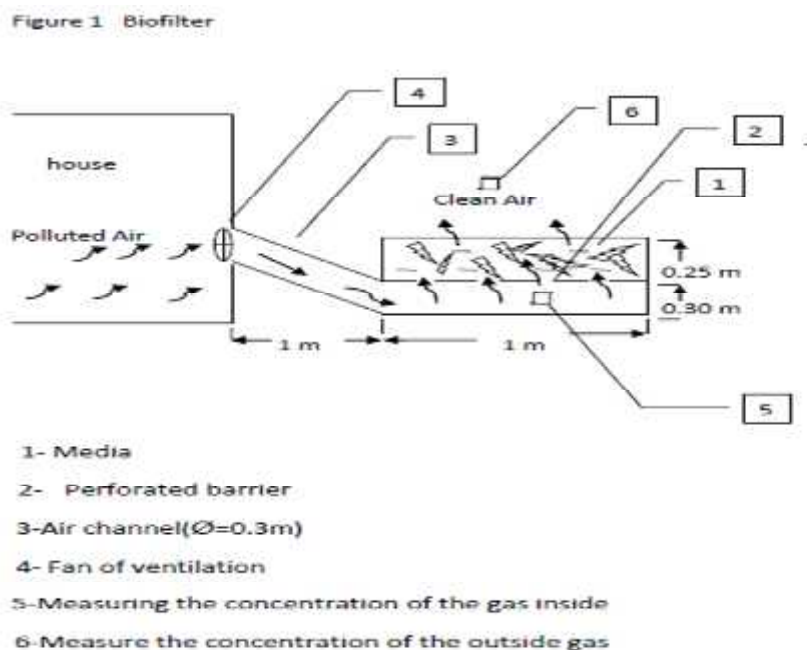


Fig. (1): Parts of Biofilter and the way insulation with the broiler house.

## Result and Discussion

### The first experiment:

To evaluate the performance of the media of biofilter consisting of a mixture of 30% Conocarpus leaves to 70% of the rice straw in the treatment of different concentrations of ammonia gas in the air. Therefore, different densities of birds, 14, 16, 18 (bird / m<sup>2</sup>) were used during the five-week breeding period. The concentration of ammonia under the filter

(Ci) increases with the stocking density, and the statistical analysis showed significant differences between the concentration values of the gas and the effect of bird density. Starting from the second week of the experiment at the age of 14 days for birds and ended at the age of 35 days and this is consistent with Abouelenien *et al.* (2016) respectively after 45-days of storage.

Table (2): Effect of the stock density on the concentration of ammonia gas outside the bird house, at different ages of birds (average ± standard deviation).

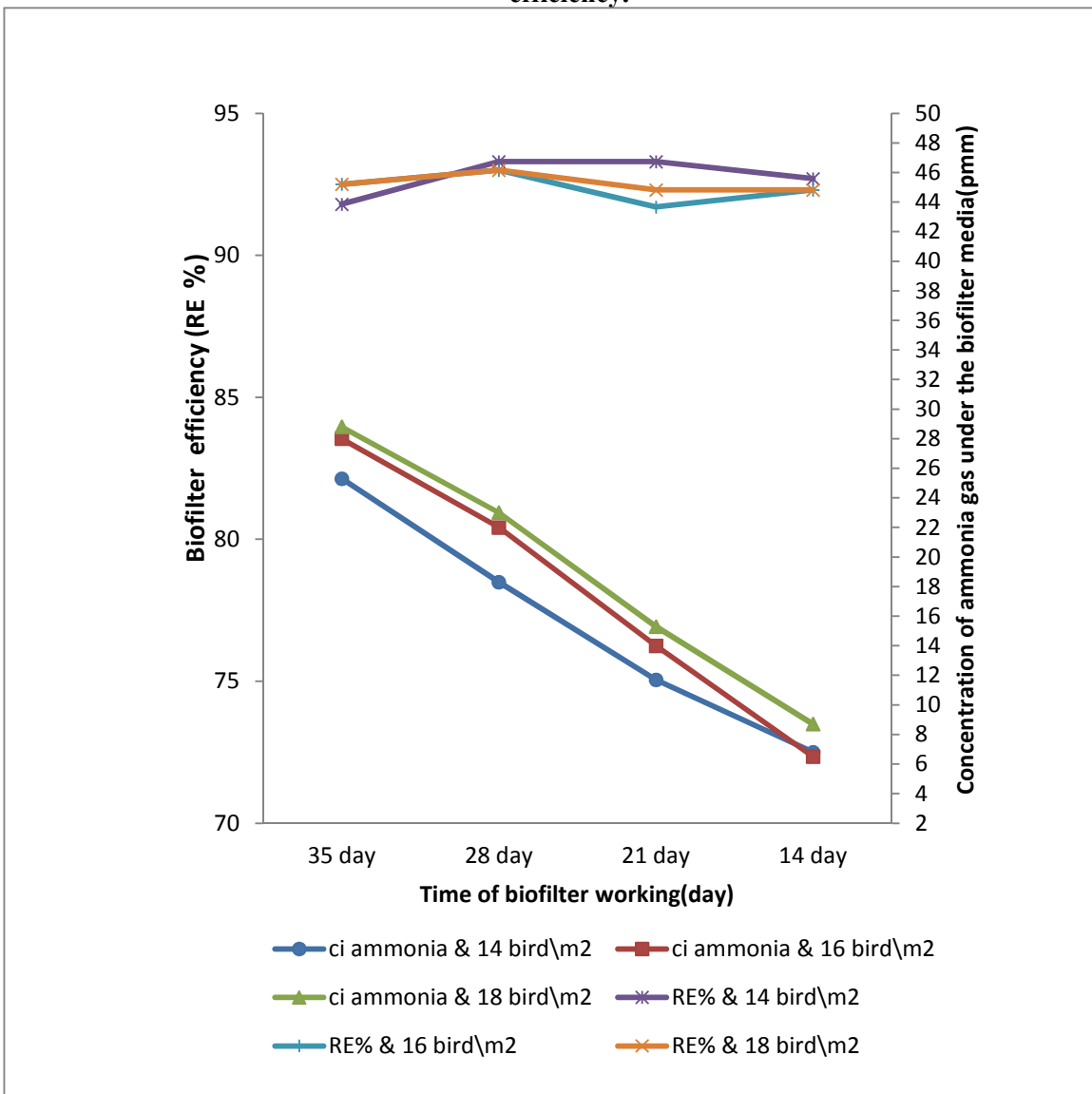
Stocki density bird/m <sup>2</sup>	Concentration of ammonia gas under of biofilter media ( ppm)			
	35 days	28 days	21 days	14 days
14	25.3±0.29 <sup>a</sup>	18.3±0.29 <sup>a</sup>	11.7±0.29 <sup>a</sup>	6.8±0.29 <sup>a</sup>
16	28.0±0.00 <sup>b</sup>	22.0±1.00 <sup>b</sup>	14.0±0.00 <sup>b</sup>	6.5±0.50 <sup>a</sup>
18	28.8±0.76 <sup>b</sup>	23.0±0.29 <sup>c</sup>	15.3±0.29 <sup>c</sup>	8.7±0.29 <sup>b</sup>

Similar letters mean no significant difference between them (p< 0.05).

The Fig. (1) of the time series for each stock density shows the results of the efficiency of the biofilter during the time period for running the biofilter and with different densities of birds. Note that the efficiency of the biofilter did not register a significant difference between the values during the period of operation, has maintained an efficiency not less than 91%. Jinanan & Leungprasert (2015) that there was no effect on the different concentrations of ammonia

gas, which ranged from 0.25-3 to 20-42 ppm. The efficiency of the biofilter reached 99%. We believe that the reason for the improving filter efficiency is due to the increased absorption surface of the polluted and moisture retention where the biofilter media was characterized by an average diameter of 32mm parts (Table 3), and consequently the total static pressure was reduced and easy to pass the polluted air through the media for treatment.

**Fig. (1): Time series of the relationship between different concentrations of ammonia with biofilter efficiency.**



**Table (3): Physical properties of bio-filter media (mean ± standard deviation).**

Mix. of Biofilter media	Stock density (Kg)m <sup>3</sup>	Mass mean diameter (mm)	Porosity %
Mix	47±4.2	32±0.3	44±1.6

Mix of 30 : 0.70 Conocarpus & rice straw.

**The second experiment**

To evaluate the effect of different mixture ratios for the biofilter media (Conocarpus and rice straw) on the efficiency of the biofilter in reducing ammonia emissions to the environment. The results showed in Table (4) that there is a significant effect of the mixing ratios on the efficiency of the biofilter. Mix1

and Mix2 recorded a better reduction in ammonia emission compared to Mix3 after 35 days. The efficiency of the filter with Mix1 was 91.7% and 91.2% with Mix2 compared to the efficiency of the filter with Mix3 which reached 77.5%.

**Table (4): Effect of different mixing ratios on the efficiency of the bio filter in ammonia emission reduction and at different operating intervals (mean ± standard deviation).**

Mix	Efficiency of the bio filter in ammonia emission reduction (RE%)				
	Avg.	35 days	28 days	21 days	14 days
Mix1	91.7 <sup>a</sup> ±0.6	94.3 <sup>a</sup> ±0.58	94.3 <sup>a</sup> ±0.58	92.3 <sup>a</sup> ±0.58	85.67 <sup>a</sup> ±2.5
Mix2	91.2 <sup>a</sup> ±0.6	93.0 <sup>b</sup> ±0.0	94.0 <sup>a</sup> ±0.0	92.7 <sup>a</sup> ±2.5	85.0 <sup>a</sup> ±0.0
Mix3	77.5 <sup>b</sup> ±0.6	77.0 <sup>c</sup> ±0.0	75.0 <sup>b</sup> ±6.0	81.0 <sup>b</sup> ±0.0	77.0 <sup>b</sup> ±2.0

We believe that the reason for the disparity in the efficiency of a bio filter in reducing ammonia emissions is due to the effect of mixing ratios on the content of microorganisms growing in the media (bacteria and total fungi) in the second and fifth weeks respectively. Mix1 recorded an increase in the fungus content of  $3.03 \times 10^6$  and  $2.85 \times 10^6$  CFU/gm compared with Mix2 which recorded  $1.93 \times 10^6$ ,  $1.89 \times 10^6$  CFU/gm and Mix3 which recorded  $2.77 \times 10^6$ ,  $2.70 \times 10^6$  CFU/gm; Oliver (2015) has found an important role for biofilter media in reducing odors and gaseous pollutants. While Mix3 recorded an increase in bacterial content compared with Mix1 and Mix2 as shown in the table (5).

There are no significant differences between the values of the characteristics (temperature °C, moisture content M.C% and pH) according to the mixture ratios of Mix1, Mix2 and Mix3 during the periods of 14, 21, 28 and 35 days (Table 6).

The statistical analysis did not show any significant differences between the values of the physical properties of the three biofilter media (porosity%, mass mean diameter, stock density) (Table 7).

**Table (5): Bacterial and fungi content in biofilter media mixtures (CFU\gm).**

Mix	Fungi CFU\gm		Bacteria CFU\gm	
	14 days	35 days	14 days	35 days
Mix1	2.85±6.3 <sup>c</sup>	3.03±3.06 <sup>c</sup>	1.95±4.2 <sup>b</sup>	2.45±5.7 <sup>b</sup>
Mix2	1.89±5.0 <sup>a</sup>	1.93±2.52 <sup>a</sup>	1.41±1.0 <sup>a</sup>	1.84±4.0 <sup>a</sup>
Mix3	2.70±4.73 <sup>b</sup>	2.77±3.51 <sup>b</sup>	3.46±2.65 <sup>c</sup>	4.95±5.51 <sup>c</sup>

The same letters mean that there is no significant difference (P<0.05).

**Table (6): Operation condition of three mixture ratios at 14-35 days (T= temperature of media biofilter, M.C = Moisture content of media biofilter, pH value of media biofilter).**

Mix		Mix <sub>1</sub>	Mix <sub>2</sub>	Mix <sub>3</sub>	
Operating Condition	14 day	T	24.±0. 10a	24.±0. 06a	24.±0. 06a
		M.C	60.3±0.60a	62.7±0. 58a	51.0±1. 00a
		pH	6.4±0. 00 a	7.7±0. 06 a	7.4±0. 01a
	21 day	T	26.2±0. 10a	26.7±0. 58a	25.9±0. 15a
		M.C	50.0±0. 57a	51.7±2. 00a	54.3±0. 58a
		pH	8.1±0. 01a	8.3±0. 01a	8.1±0. 01a
	28 day	T	30.5±0. 50a	32.3±0. 30a	31.7±0. 30a
		M.C	50.8±0. 61a	51.5±0. 87a	52.3±0. 29a
		pH	8.1±0. 01a	8.3±0. 01a	8.2±0. 02a
	35 day	T	36.2±0. 12a	36.9±0. 06a	35.3±0. 58a
		M.C	51.3±0. 61a	51.7±0. 58a	50.5±0. 44a
		pH	8.2±0. 01a	8.3±0. 06a	8.2±0. 01a

Similar letters mean no significant difference between them (p< 0.05).

**Table (7): The effect of mixing ratios on the physical properties of the media (mean ± standard deviation).**

Mix	Stock density (Kg\m <sup>3</sup> )	Mass mean diameter (mm)	Porosity %
Mix1	50.5±0.5 <sup>a</sup>	32.3±0.3 <sup>a</sup>	42.7±2.5 <sup>a</sup>
Mix2	53.7±0.3 <sup>a</sup>	28.9±0.1 <sup>a</sup>	37.3±1.5 <sup>a</sup>
Mix3	72.1±0.2 <sup>a</sup>	25.2±0.3 <sup>a</sup>	28.7±1.1 <sup>a</sup>

### Conclusions

**The first experiment:** The efficiency of the biofilter, a mixture of 0.30 Conocarpus Erectus trees, leaves with 0.70 rice straw, was not affected by the concentration of the ammonia gas resulting from differences in bird density. The efficiency of the Biofilter was 91% during the testing period (14-35) days.

**The second experiment:** The effect of the difference in the ratio of the mixture of the biofilter materials (the Conocarpus leaves with the rice straw) to the efficiency of the biofilter in reducing the emission of ammonia gas to the external environment. The media were topped with a mixture of 0.25 Conocarpus leaves with 0.75 rice straws on the sides 0.50 Conocarpus leaves with rice



straw 0.50 and 0.75 Conocarpus leaves with 0.25 straws of rice. The efficiency of the Biofilter was about 91.7% when media 0.25 leaves of Conocarpus with 0.75 straw, rice during the test period of 14 - 35 days, and characterized by a high content of total fungi compared to the other two.

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