EREM 78/3
Journal of Environmental Research, Engineering and Management
Vol. 78 / No. 3 / 2022
pp. 119–128
DOI 10.5755/j01.erem.78.3.31010

Effect of Drinking Magnetized Water on Offensive Odour from Poultry Droppings of Broiler Chicken

Received 2022/03 | Accepted after revision 2022/07

http://dx.doi.org/10.5755/j01.erem.78.3.31010

Effect of Drinking Magnetized Water on Offensive Odour from Poultry Droppings of Broiler Chicken

Kamorudeen Olaniyi Yusuf*
Department of Agricultural and Biosystems Engineering, University of Ilorin, Ilorin, Nigeria

Oluwatobi Sunday Akande
Agricultural and Rural Management Training Institute, Ilorin, Kwara State, Nigeria

Modupe Ruth Baiyeri
Department Agricultural and Bio-environmental Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin, Nigeria

***Corresponding author:** yusuf.ok@unilorin.edu.ng or kamaru.yusuf@yahoo.com
oluwatobibi@gmail.com,
baiyerimodupe@gmail.com

The study was conducted to assess the effect of drinking magnetized water (MW) on the offensive odour by the poultry droppings from the broiler chicken (BC). Poultry droppings in poultry farm normally give offensive odour around the area where poultry farm is sited. Drinking MW could improve the digestibility of feed and dryness of the poultry droppings thereby reducing the ammonia (NH_3), hydrogen sulphide (H_2S) and offensive odour. BCs (Arbor Acres breed) were given MW. The magnetic water treatment unit comprises a 20 by 60 mm rectangular plastic pipe and 960 mm long surrounded with 12 pieces of a 10 × 25 × 50 mm neodymium magnet rated 1.5T. The treatments were MW treated for 33 s (MW_1), MW treated for 66 s (MW_2), MW_3 was treated for 99 s and the control (non-magnetized water, NMW). A total of 80 BCs (day old) with 20 for each treatment were given MW_1, MW_2, MW_3 or NMW and monitored for 7 weeks. Samples of poultry droppings were randomly collected at 4, 5, 6 and 7 weeks. NH_3 and H_2S were analyzed using standard methods. The mean concentration of NH_3 for MW_1 varied from 13.10×10^{-3} to 49.85×10^{-3}, MW_2 varied from 12.50×10^{-3} to 42.64×10^{-3}, MW_3 varied from 12.43×10^{-3} to 41.32×10^{-3} while the corresponding values for NMW varied from 20.30×10^{-3} to 65.13×10^{-3} mg/L. MW_1, MW_2 and MW_3 reduced the odour by 30.65–55.73%, 52.74–62.40% and 33.42–63.31%, respectively.

The effect of drinking MW was significant on the reduction of NH_3 at $\alpha \leq 0.025$. MW also reduced the concentration of H_2S in the poultry droppings. MW is recommended for producing broiler chicken to reduce offensive odour from the poultry farms.

Keywords: air pollution, broiler chicken, magnetized water, odour, paired t-test, poultry droppings.

Introduction

Production of broiler chicken is essential for economic development of a country and provides animal protein for healthy growth, development and high demand of animal protein especially in Nigeria (Oloso et al., 2020). Air pollution (offensive odour) is one the problems of a poultry farm in the area where it is sited. Ammonia (NH_3) and hydrogen sulphide (H_2S) are the two main odour pollutants in a poultry farm. Ammonia is an invisible and water-soluble alkaline gas that could cause respiratory disease and heart disease (Maliselo and Nkonde, 2015). Hydrogen sulphide normally gives the smelling of rotten egg which is an offensive odour. The rate of production of air pollution (gases) is influenced by some factors such as diet composition and conversion efficiencies of the feed, the manure handling practices and environmental conditions (Smith et al., 2000; Broucek and Cermak, 2015). Casey et al. (2017) have also pointed out that the rate of generation of odour, gases, manure, microorganisms, particulates and other waste product depends on weather conditions, time, species of the poultry, the manure handling system, the housing, the feed type and the management system. When broiler chickens are given feed that is rich in protein, the broiler would produce uric acid which is converted to ammonia under favourable conditions. Concentration of ammonia above 25 ppm could adversely affect the poultry broiler chickens (Sheikh et al., 2018). Maliselo and Nkonde (2015) have stated that unused nitrogen is excreted as uric acid (80%), ammonia (10%), and urea (5%). When ammonia gas is exposed to moisture, it reacts and forms aqueous ammonium which could adversely affect the broiler chicken on nasal cavity and eyes (Maliselo and Nkonde, 2015). Ullman et al. (2004) have reported on some methods such scrubbers, biofilter, oxidants (such as ozone, potassium permanganate) for reduction of odour in broiler chicken housing. Wysocka and Boguszewicz (2019) indicated that the simple method of odour removal is done by sorption of odourants in water scrubbers.

Water is a compound that is essentially needed by animals because it supports life and is required for all the metabolic processes for normal functioning of poultry broilers. Magnetized water, also called magnetically treated water, could be used to reduce the offensive odour (air pollution) in the farm and the surrounding areas. Magnetized water is produced when water is allowed to pass through the magnetic field through a hose or a pipe. For the water to be magnetically treated, the flow of water must cut the magnetic field at right angle based on the Fleming's right-hand rule, otherwise, the water would not be magnetically treated. The technology of giving broiler chickens magnetized water is to increase the growth rate, boost the immunity of the broiler chicken and reduce the offensive odour from poultry droppings. Yacout et al. (2015) have concluded that magnetized water improves the nutrient digestibility of goat. Therefore, magnetized water could also be given to broiler chickens to improve the nutrient digestibility which could reduce the concentration of ammonia, hydrogen sulphide and other gases that produce odour from poultry droppings. El-katch et al. (2017) have stated that magnetized water improves the growth rate, feed efficiency, immunity and well-developed intestine and better healthy growth of Pekin ducklings.

Magnet has been used for about four decades in engineering, agriculture, health, wastewater treatment and some other areas for the benefits of mankind

(Yusuf and Ogunlela, 2015). The technology of application of a magnetic field for better performance of crop, animal and other areas for the benefits of man are not known in some areas or countries. Magnet produces a magnetic field which could be used for treating drinking water for broiler chickens and for other purposes. The properties of magnetized water are modified by reducing the bonding angle from 104° to 103°, reducing the surface tension, increasing its solubility and reducing the rate of carbonate deposition in the pipe (Babu, 2010). Magnetized water is a non-chemical method and a simple technology that could be used for high crop yield, for improving animal production and increasing the lactation of a dairy farm (Mohamed and Ebead, 2013; Yusuf and Ogunlela, 2015; Yusuf et al., 2020). Radha and AL-Sardary (2021) have pointed out that magnetized water has a positive effect on the quality of egg and biochemical processes of the poultry. Podlesny et al. (2004) have stated that 15 s is effective time for producing magnetized water, but Aladjadjiyan (2007) has pointed out that 1–10 min is adequate time for production of magnetized water using the circulation flow method. The circulation flow method works by allowing water to flow through a pipe surrounded by pieces of permanent magnets. The objective of this study was to determine the effect of drinking magnetized water on ammonia, hydrogen sulphide and offensive odour from poultry droppings of broiler chickens.

Materials and Methods

Magnetic treatment unit and production of the magnetized water

The magnetic treatment unit was fabricated using a 10 × 25 ×50 mm neodymium magnet. The neodymium magnet is a permanent magnet that is produced from neodymium (Nd), iron (Fe) and boron (B) to form NdFeB magnet which is the strongest magnet available globally with high magnetic flux density ranging from 1.0–1.5 Tesla (1 T = 10,000 G) and above. The neodymium magnet is a strong rare magnet which can work effectively at room temperature and at high temperature up to 80°C without demagnetization. Other permanent magnets with magnetic flux density ranging within 2000–5500G could also be used to produce magnetized water but the time of passing through the magnetic field would be increased from 55 s to 120 s. The magnetic treatment unit in this study consists of a pipe (a 20 mm by 60 mm rectangular transparent pipe 960 mm long constructed using Perspex glass) surrounded with 12 pieces of the neodymium magnet.

Three (3) pieces of the neodymium magnet were arranged on the sides of a 320 mm long rectangular plastic pipe (transparent made of Perspex glass) which is the treatment unit. The 3 layers of the rectangular plastic pipe are connected together using a 12.7 mm (0.5 inch) elbow pipe. This principle was adopted to maximize the available pieces of 12 neodymium magnets, and to make it compact. The magnetic treatment unit is connected to a 50-litre bucket with a 25.4 mm pipe and a control tap for regulating the flow of the water. The isometric view and the pictorial view of the magnetic treatment unit are shown in *Figs. 1* and *2*.

Podlesny et al. (2004) have reported that 15 s was effective time for producing magnetized water but Aladjadjiyan (2007) have stated that 60–600 s was adequate time for production magnetized water. The times used in this study for treating the water through the magnetic field were 33 s, 66 s and 99 s. The water given to broiler chickens was obtained from a borehole in the poultry farm and allowed to pass through the magnetic treatment unit one (1) time for 33 s (1 single flow) and denoted by MW_1, MW_2 for 66 s when the water was allowed to flow through the magnetic treatment unit two (2) times, and MW_3 for 99 s when the water was allowed to flow through the magnetic treatment unit three (3) times. NMW (non-magnetized water) is the control. The magnetized water was poured into the black plastic bowl (*Fig. 3*) from which broiler chickens drink water. *Fig. 4* shows the scanned electronics microscope (SEM) of the molecular structure of magnetized and non-magnetized water.

Fig. 1. *Isometric view of the magnetic treatment device for producing magnetized water*

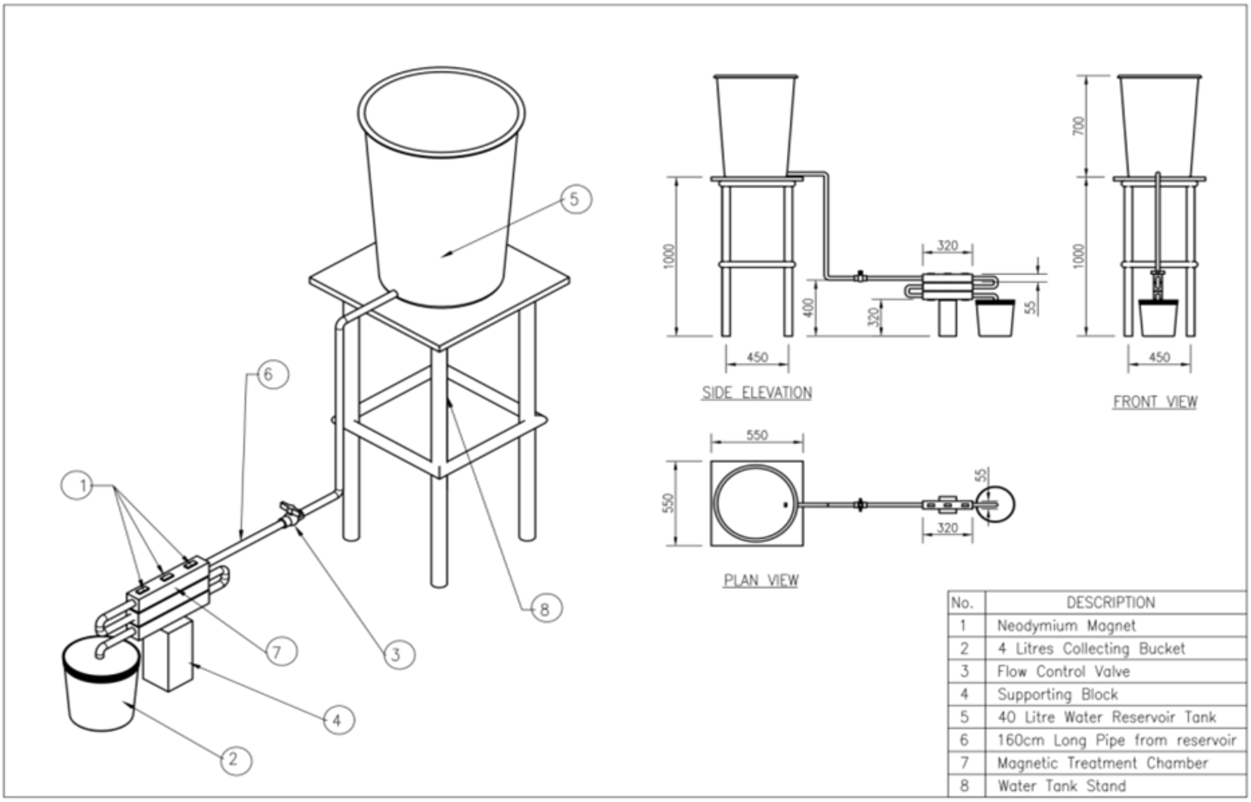
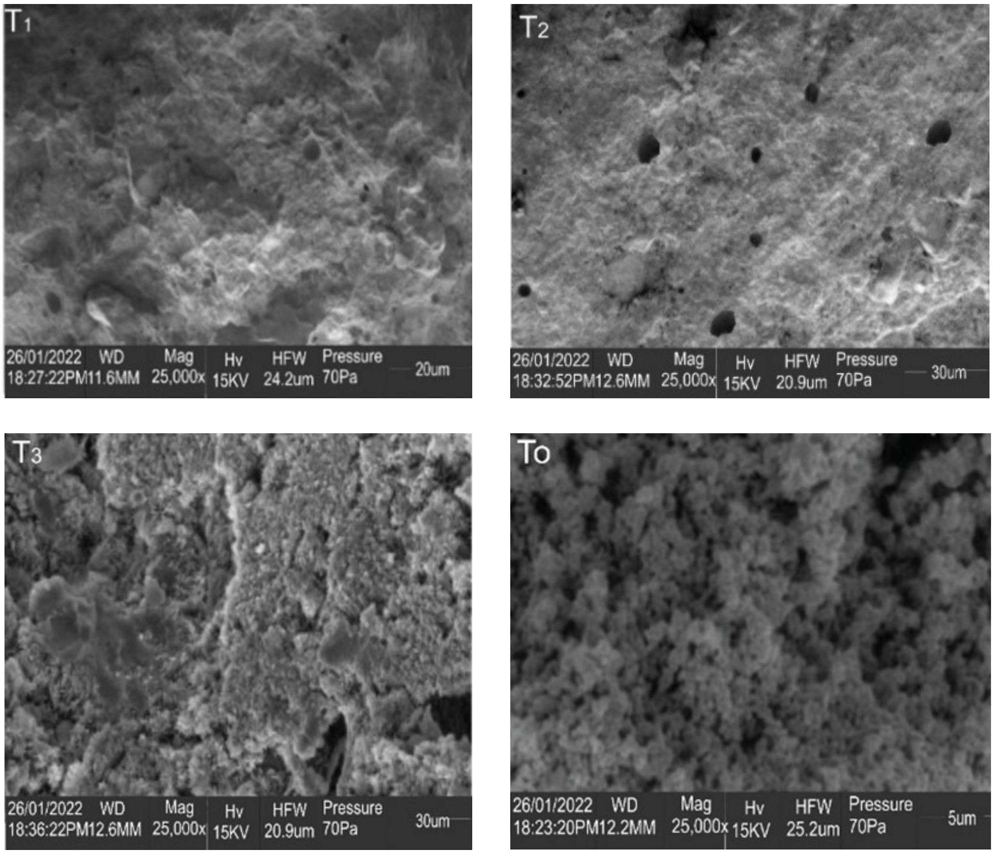


Fig. 2. *Pictorial view of the magnetic treatment unit for producing magnetized water*

Fig. 3. *Magnetized water in two plastic black bowls from where broilers would drink water*

Fig. 4. *Scanned electronics microscope (SEM) of the molecular structure of water (magnification = 25000×)*



$T_1 = MW_1$ = *Magnetized water treated for 33 s (water flows once through the magnetic treatment unit)*
$T_2 = MW_2$ = *Magnetized water treated for 66 s (water flows twice through the magnetic treatment unit)*
$T_3 = MW_3$ = *Magnetized water treated for 99 s (water flows 3 times through the magnetic treatment)*
$T_0 = NMW$ = *Non-Magnetized Water (Control)*

Magnetized water for broiler chickens

A total of 5 litres per 24 hours of magnetized water was made available for each treatment and given to 20 broiler chickens. The water was poured in a black plastic bowl, and 5 litres of freshly treated magnetized water was poured in the bowl every 24 hours. Two stones (3 kg each) were put inside the plastic bowl to hold the plastic bowl firmly on the ground and to prevent broiler chickens from pouring the water down, and the stone would not react with the water. The water was changed every 24 hours to have quality magnetized water and to ensure that the water is used within 24 hours after treatment with a magnetic field because the memory of magnetized water decreases after 24 hours (Ogunlela and Yusuf, 2016).

Determination of ammonia and hydrogen sulphide

The samples (50 g for each treatment) of poultry dropping (faeces) were collected from the broiler chickens. The sample was put in a polythene bag and taken to the Central Research Laboratory of the University of Ilorin, Nigeria, for the determination of the concentrations of ammonia (NH_3) and hydrogen sulphide (H_2S). Standard methods of UV spectrophotometer were used as given by AOAC (2000) and APHA (2005).

Rating of odour by sensing

The rating of the odour from the poultry droppings (faeces) was assessed by 2 men and 1 woman (a total of 3 assessors for sensing the odour) that have a very sensible olfactory lobe (sensitive nose) for detecting odour by smelling. The samples from the broiler chickens given MW_1, MW_2, MW_3 and NMW (control) were collected at 3, 4, 5, 6 and 7 weeks after the broiler chickens were given magnetized water to drink. The 3 assessors were given 50 g of the poultry droppings from each treatment one after the other to sense the odour (by smelling) and rate it using the rating assessment in *Table 1*. Each assessor recorded the rating value of the odour and the mean ratings of the odour were determined as given in *Table 2*. An olfactometer could also be used for detecting and rating the odour to compliment the sense of smelling by human assessors.

Table 1. *Rating of the odour of poultry droppings by sensing*

Rating code	Full meaning of the rating code	Rating score
VOO	Very offensive odour	5
OO	Offensive odour	4
VSO	Very strong odour	3
SO	Strong odour	2
NO	No odour	1

Paired t-test statistical analysis for the ammonia concentration

The statistical analysis adopted was the paired t-test to know if the effect of MW was significant on the air pollution by the broiler chicken or not. The mean difference between the results of magnetized water and that of NMW was determined. The mean, the standard deviation, the standard error and the t-test values were calculated using Equations (1), (2), (3) and (4), respectively as given by Montgomery (1998). The data used for the computation of the paired t-test as an illustration was obtained from *Table 4* and presented in *Table 3*.

Table 2. *Determination of rating values of the odour from poultry droppings by sensing*

Week	MW_1	MW_2	MW_3	NMW
3	2.00	2.00	2.00	5.00
	3.00	2.00	5.00	4.00
	2.00	2.00	4.00	5.00
Mean	2.33	2.00	3.67	4.67
4	4.00	4.00	4.00	5.00
	2.00	3.00	3.00	5.00
	2.00	2.00	3.00	4.00
Mean	2.67	3.00	3.33	4.67
5	3.00	3.00	3.00	5.00
	2.00	2.00	2.00	4.00
	2.00	2.00	3.00	5.00
Mean	2.33	2.33	2.67	4.67
6	4.00	4.00	4.00	5.00
	3.00	4.00	3.00	5.00
	2.00	3.00	3.00	4.00
Mean	3.00	3.67	3.33	4.67
7	3.00	4.00	4.00	5.00
	2.00	3.00	3.00	5.00
	3.00	3.00	3.00	5.00
Mean	2.67	3.33	3.33	5.00

MW_1, MW_2, MW_3 and NMW were as defined in Figure 4.

Table 3. *Data of ammonia extracted from Table 4 for calculating the paired t-test*

Conc. NH_3 NMW	Conc. NH_3 MW_1	$d = NMW - MW_1$	d^2
0.06513	0.04985	0.01528	0.00023350
0.02200	0.01310	0.00890	0.00007921
0.04945	0.04275	0.00670	0.00004489
0.02030	0.01390	0.00640	0.00004096
n = 4		$\sum d = 0.03728$	$\sum d^2 = 0.00039856$

$$\overline{d} = \frac{\sum d}{n} \quad (1)$$

$$\delta = \sqrt{\frac{\sum d^2 - n(\overline{d})^2}{n-1}} \quad (2)$$

$$\delta_{Er} = \frac{\delta}{\sqrt{n}} \quad (3)$$

$$t_{cal} = \frac{\overline{d}}{\delta_{Er}} \quad (4)$$

Where: $\overline{d}$ – mean of the difference from x_1 and x_2;
Σd – summation of d;
n – number of the observations;
δ – standard deviation;
δ_{Er} – standard error;
t_{cal} – calculated value of the t-test.

$$\overline{d} = \frac{0.03728}{4} = 0.00932 \quad (1)$$

$$\delta = \sqrt{\frac{0.00039856 - 4(0.00932)^2}{4-1}} = 0.0041275658 \quad (2)$$

$$\delta_{Er} = \frac{0.0041275658}{\sqrt{4}} = 0.0020637829 \quad (3)$$

$$t_{cal} = \frac{0.00932}{0.0020637829} = 4.516 \quad (4)$$

Similarly, NMW versus MW_2: t-test = 3.245, for NMW versus MW_3: t-test = 3.500

The table values of t-test at $\alpha \leq 0.025 = 4.176$ and t-test at $\alpha \leq 0.05 = 3.183$ when the number of degrees of freedom is 3.

Results and Discussion

Concentrations of ammonia and hydrogen sulphide in poultry droppings

The results of the concentration of ammonia gas (NH_3) from the faeces (poultry droppings) of broiler chickens that were given magnetized water and non-magnetized water are presented in *Table 4*. The mean concentrations of NH_3 for MW_1 were 49.85 × 10^{-3}, 13.10 × 10^{-3}, 42.75 × 10^{-3} and 13.90 × 10^{-3}, MW_2 were 42.64 × 10^{-3}, 15.40 × 10^{-3}, 24.95 × 10^{-3} and 12.50 × 10^{-3}, MW_3 were 41.32 × 10^{-3}, 12.43 × 10^{-3}, 32.55 × 10^{-3} and 14.75 × 10^{-3} while the corresponding values of NMW (control) were 65.13 × 10^{-3}, 22.00 × 10^{-3}, 49.45 × 10^{-3} and 20.30 × 10^{-3} mg/kg. The broiler chickens that were given magnetized water had lower concentrations of ammonia gas for all the 4 periods of sample collection for the analysis. This means that magnetized water enhanced the rate of digestion of the feed and better digestibility of the feed given to broiler chickens which eventually reduced the concentration of NH_3 compared with broiler chickens given non-magnetized water.

Table 4. *Concentration of ammonia in poultry droppings*

Week	Concentration of NH_3 in poultry droppings (mg/kg)			
	$MW_1 \times 10^{-3}$	$MW_2 \times 10^{-3}$	$MW_3 \times 10^{-3}$	$NMW \times 10^{-3}$
4	49.85	42.64	41.32	65.13
5	13.10	15.40	12.43	22.00
6	42.75	24.95	32.55	49.45
7	13.90	12.50	14.75	20.30

MW_1, MW_2, MW_3 and NMW were as defined in Figs. 4, 2.

The result was in agreement with the study of Maliselo and Nkonde (2015) who reported that unused nitrogen was excreted as uric acid and ammonia but any method that improved the rate of digestion and digestibility of the feed rich in protein would reduce the concentration and emission of the ammonia gas which normally pollute the environment. The results of this study correlated with those obtained in the study of El-Deeb et al. (2020) that water was one of the main factors that are essential and necessary for the completion of physiological processes inside the tissues of the poultry. The result of hydrogen sulphide is presented in *Table 5*. From *Table 5*, the results of H_2S from broiler chickens that were given magnetized water were not different from the values obtained for non-magnetized water. The results were not consistent like the results of ammonia. This means that ammonia was the main gas given out the difference in the odour from the broiler chicken.

The effect of magnetized water on the broiler chicken was statistically significant on the reduction of emission of ammonia at $\alpha \leq 0.025$ with calculated values of paired t-test for NMW versus MW_1 equal to 4.516 as presented in *Table 6*. The effects of magnetized water for NMW versus MW_2 (treated for 66 s) and NMW versus MW_3 (treated 99 s) were significant at $\alpha \leq 0.05$ as shown in *Table 6*.

Table 5. *Concentration of hydrogen sulphide in poultry droppings*

Week	Concentration of H_2S in poultry droppings (mg/kg)			
	$MW_1 \times 10^{-2}$	$MW_2 \times 10^{-2}$	$MW_3 \times 10^{-2}$	$NMW \times 10^{-2}$
4	107.86	107.79	107.64	108.03
5	107.56	107.46	107.28	106.91
6	106.40	106.59	106.46	106.60
7	107.32	106.80	106.90	107.10

MW_1, MW_2, MW_3 and NMW were as defined in Figure 4.

Table 6. *Result of paired t-test on reduction of concentration of ammonia from poultry droppings*

Treatment	DF	Calculated value of t	Table value of t at $\alpha \leq 0.025$	Table value of t at $\alpha \leq 0.05$
NMW vs MW_1	3	4.516*	4.176	3.183
NMW vs MW_2	3	3.245**	4.176	3.183
NMW vs MW_3	3	3.500**	4.176	3.183

*DF = degree of freedom, MW_1, MW_2, MW_3 and NMW were as defined in Fig. 4, * = significant at $\alpha \leq 0.025$, ** = significant at $\alpha \leq 0.05$*

Rating of the odour by smelling

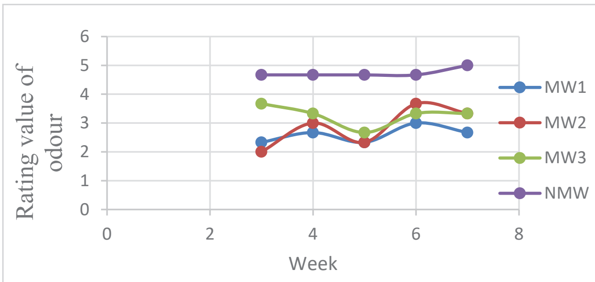
The mean rating of odour by smelling is presented in *Table 7*. The results obtained by 3 assessors using smelling indicated that broiler chickens that were given non-magnetized water produced more concentrated odour that is very offensive odour to the environment and they were all higher than the rating values of magnetized water. All broiler chickens given magnetized water produced odour that was not offensive. This means that magnetized water removed offensive odour that is normally associated with broiler chickens housing. This removal of offensive odour would reduce the air pollution from the broiler chicken by using magnetized water as drinking water, and this could indirectly encourage more production of broiler chicken farms in some areas which would increase animal protein in the country. Magnetized water is a non-chemical method and could be a simple alternative method for the removal or reduction of odour in poultry farms. The trend of the mean results of odour by smelling for clarity is shown in *Fig. 5*.

Table 7. *Rating values of odour of poultry droppings by smelling*

Week	Rating value for the odour of poultry droppings			
	MW_1	MW_2	MW_3	NMW
3	2.33	2.00	2.00	4.67
4	2.67	3.00	3.00	4.67
5	2.33	2.33	2.00	4.67
6	3.00	3.67	3.67	4.67
7	2.67	3.33	3.33	5.00

MW_1, MW_2, MW_3 and NMW were as defined in Figure 4.

Fig. 5. *Mean rating of odour of poultry droppings by smelling*



MW_1, MW_2, MW_3 and NMW were as defined in Table 2.

Conclusion

Magnetized water is a non-chemical method and a simple technology which could be used for improving production broiler chickens. Magnetized water should be allowed to flow once through the magnetic treatment unit for about 33 s for effective treatment. Magnetized water reduced the concentration of ammonia gas and also reduced the offensive odour from poultry droppings. Magnetized water that was treated for 33 s and passed through the magnetic field one time reduced the odour by 30.65–55.73%, magnetized water that was treated for 66 s and passed through the magnetic field two times reduced the odour by 52.74–62.40%, and magnetized water that was treated for 99 s and passed through the magnetic field three times reduced the odour by 33.42–63.31%. The effect of magnetized water was statistically significant on the removal of offensive odour that is normally caused by ammonia at $\alpha \leq 0.025$ for magnetized water treated for 33 s, but the effect of magnetized water that was allowed to flow twice (66 s) and three times (99 s) was significant at $\alpha \leq 0.05$. Magnetized water is recommended for broiler chicken production in Nigeria to control offensive odour in poultry farms.

References

Aladjadjiyan, A. (2000) The use of physical methods for plant growing stimulation in Bulgaria. Journal of Central European Agriculture, 8 (3): 369-380. https://hrcak.srce.hr/file/30699

AOAC. (2000) Official Methods of Analysis of the Association of Official Analytical Chemists. 15th Ed. Arlington, Virginia, USA: AOAC.

APHA (2005) Standard methods for the examination of water and waste water, 21st Edition. American Public Health Association, Washington.

Babu, C. (2010) Use of magnetic water and polymer in agriculture. TropicalResearch, ID 08-806-001. https://www.gmxinternational.com/applications/agriculture/GMX-on-agriculture.pdf

Broucek, J. and Cermak, B. (2015) Emission of harmful gases from poultry farm and possibilities of their reduction. Journal of Ekologia (Bratislava), 34 (1): 89-100. https://doi.org/10.1515/eko-2015-0010

Casey, K. D, Bicudo, J. R, Schmidt, D. R, Singh, A, Gay, S. W, Gates, R. S, Jacobson, L. D and Hoff, S. J. (2015) Air quality and emissions from livestock and poultry production/waste management systems. Animal Agriculture and the Environment: National Centre for manure and animal waste management. White Paper, Rose, J. M, Caldwell, D. F, Humenik, F. J (Eds), St. Joseph, Michigan, ASABE publication number 9/3C0306: 1-40. https://dr.lib.iastate.edu/handle/20.500.12876/1119

El-Deeb, A. M. A, Abdel-Hmid, A. F and Mikhail, W. Z. A. (2020) Effect of water treatments on the productive performance of domestic, Egyptian fayoumi chickens. Journal of Plant Archives, 20 (2): 8103-8110.

El-katcha, M. I, Soltan, M. A. Naggar, K. E. I and Farfour, H. T, (2017) Effect of magnetic water treatment and some additives on growth performance, some blood biochemical parameters and intestinal health of growing pekin ducklings, Alexandria Journal of Veterinary Sciences, 53 (1): 143-156. https://doi.org/10.5455/ajvs.249419

Maliselo, P. S and Nkonde, G. K. (2015) Ammonia production in poultry houses and its effect on the growth of gallus gallus domestica (broiler chickens): A case study of a small-scale poultry house in Riverside, Kitwe, Zambia, International Journal of Scientific and Technology Research, 4 (4): 141-145. https://www.ijstr.org/final-print/apr2015/Ammonia-Production-In-Poultry-Houses-And-Its-Effect-On-The-Growth-Of-Gallus-Gallus-Domestica-broiler-Chickens-A-Case-Study-Of-A-Small-Scale-Poultry-House-In-Riverside-Kitwe-Zambia.pdf

Mohamed, A .I. and Ebead, B. M. (2013) Effect of irrigation with magnetically treated water on faba bean growth and composition. International Journal of Agricultural Policy and Research, 1 (2):24-40. https://journalissues.org/wp-content/uploads/2014/07/IJAPR-Ahmed-and-Ebead.pdf

Montgomery, D. C., Runger, G. C., Hubele, N. F. (1998) Engineering statistics. John Wiley and Sons, Inc, New York: 135-248.

Ogunlela, A. O. and Yusuf, K. O. (2016) Effect of magnetic treatment of water on chemical properties of Water and sodium adsorption ratio, Journal of Research in Forestry, Wildlife and environment, 8 (4): 73-79. https://doi.org/10.5755/j01.erem.73.1.18760

Oloso, N. O, Smith, P. W, Adeyemo, I. A, Odeokun, I. A, Isola, T. O, Fasanmi, O. G and Folorunso Oludayo Fasina, F. O. (2020) The broiler chicken production value chain in Nigeria between needs and policy: situation analysis, action plan for development, and lessons for other developing countries, CAB Reviews, 15 (20): 1-12. https://doi.org/10.1079/PAVSNNR202015020

Podlesny, J., Pietruszewski, S. and Podleoena, A. (2004). Efficiency of the magnetic treatment of broad bean seeds cultivated under experimental plot conditions, International Agrophysics, 18 (1): 65-71. http://www.internationalagrophysics.org/pdf-106680-37522?filename=Efficiency%20of%20the.pdf

Radha, G. H and AL-Sardary, S. Y. T. (2021) Effects of using magnetic mater on egg quality and biochemical composition in commercial layers. IOP Conference Series: Earth and Environmental Science, 761: 1 - 9. https://doi.org/10.1088/1755-1315/761/1/012106

Sheikh, I. U, Nissa, S. S, Zaffer, B, Bulbul, K. H, Akand, A. H, Ahmed, H. A, Dilruba Hasin, D, Hussain, I and SA Hussain, S. A. (2018) Ammonia production in the poultry houses and its harmful effects, International Journal of Veterinary Sciences and Animal Husbandry, 3 (4) Part A: 30-33. https://www.veterinarypaper.com/pdf/2018/vol3issue4/PartA/3-4-14-175.pdf

Smith, K. A., Jackson, D. R., Misselbrook, T. H., Pain, B. F. and Johnson, R. A. (2000) Reduction of ammonia emission by slurry application techniques, Journal of Agricultural Engineering Research, 77 (3): 277-287. https://doi.org/10.1006/jaer.2000.0604

Ullman, J. L, Mukhtar, S, Lacey, R. E and Carey, J. B. (2004) A review of literature concerning odors, ammonia, and dust from broiler production facilities: 4. remedial management practices. The Journal of Applied Poultry Research, 13 (3) : 521-531. https://doi.org/10.1093/japr/13.3.521

Wysocka, I. and Boguszewicz, A. (2019) Effectiveness of removal of odorous compounds from a poultry farm in a water scrubber with sand filling, Journal of Ecological Engineering, 20 (2): 141-145. https://doi.org/10.12911/22998993/97243

Yacout, M. H, Hassan A. A, Khalel, M. S, Shwerab A. M, Abdel-Gawad E. I and Abdel-kader Y. I. (2015) Effect of magnetic water on the performance of lactating goats, Journal of Dairy, Veterinary and Animal Research, 2 (5): 3-14. https://doi.org/10.15406/jdvar.2015.02.00048

Yusuf, K. O. and Ogunlela, A. O. (2015) Impact of magnetic treatment of water on growth and yield of tomato. Journal of Notulae Scientia Biologicae, 7 (3): 345-348. https://doi.org/10.15835/nsb.7.3.9532

Yusuf, K. O. and Ogunlela, A. O. (2016) Effect of magnetically treated water on the quality of tomato. Kathmandu University Journal of Science, Engineering and Technology, 12 (2): 29-33. https://doi.org/10.3126/kuset.v12i2.21519

Yusuf, K. O, Ogunbamowo, T. R and Obalowu, R. O. (2020) Effect of magnetized water on water use efficiency, yield and nutritional qualities of watermelon under deficit irrigation. Agricultural Engineering International (CIGR) Journal, 22 (3); 51-60. https://cigrjournal.org/index.php/Ejounral/article/view/5833/3363