J I T A A
Journal of the Indonesian Tropical Animal Agriculture
Accredited by Ditjen Penguatan Risbang No. 60/E/KPT/2016

J. Indonesian Trop. Anim. Agric.
pISSN 2087-8273 eISSN 2460-6278
http://ejournal.undip.ac.id/index.php/jitaa
44(1):56-64, March 2019
DOI: 10.14710/jitaa.44.1.56-64

Cross-sectional survey on environmental pollution surrounding poultry production cluster area

E. Martindah[1] and N. Ilham[2]
[1]Indonesian Research Centre for Veterinary Science (IRCVS), Jl. RE. Martdinata No. 30, Bogor - Indonesia.
[2]Indonesian Center for Agriculture Socio Economic and Policy Studies (ICASEPS), Jl. Tentara Pelajar Cimanggu Blok Kompleks Pertanian No. 3. Bogor - Indonesia
Corresponding E-mail: emartindah@gmail.com

Received October 24, 2018; Accepted November 29, 2018

ABSTRAK

Penelitian ini dilakukan untuk mengetahui pencemaran lingkungan sekitar kluster produksi unggas/ *poultry production cluster* (PPC). Survei *cross-sectional* terkait pencemaran lingkungan di sekitar PPC telah dilakukan di Kabupaten Subang dan Ciamis, Provinsi Jawa Barat, Indonesia. Aspirasi peternak tentang pencemaran lingkungan dan masalah sanitasi terkait dengan keberadaan PPC diperoleh melalui kuesioner semi-terstruktur. Gas amonia (NH_3) dalam feses diuji secara kualitatif, dan air di sekitar kandang dianalisis guna melihat kemungkinan adanya pencemaran bakteri Coliform dan Salmonella sp. Hasil studi menunjukkan bahwa debu dan gas amonia yang berasal dari feses (Subang 300-450 ppm, Ciamis 25-525 ppm) telah mencemari lingkungan dan menimbulkan bau tidak sedap di sekitar PPC. Selain itu, populasi lalat juga meningkat ketika panen ayam, sehingga kehidupan masyarakat tidak nyaman. Kualitas air di sekitar PPC menunjukkan bahwa kontaminasi Salmonella sp. dapat diabaikan, akan tetapi sebagian besar sampel dari Subang dan Ciamis terkontaminasi dengan bakteri coliform pada kisaran <3 MPN/ml-27 MPN/ml. Kebijakan perbaikan manajemen untuk mengurangi pencemaran lingkungan masih diperlukan dalam mengembangkan daerah PPC.

Kata kunci: ammonia, Coliform, lingkungan, pencemaran, kluster produksi unggas

ABSTRACT

This study was carried out to determine the environmental pollution surrounding poultry production cluster (PPC). A cross-sectional survey on environmental pollution surrounding PPC was conducted in the districts of Subang and Ciamis, West Java Province, Indonesia. Information of farmers aspiration on environmental pollution and sanitation issues related to the existence of PPC was collected by semi-structured questionnaires. Ammonia gas (NH_3) in feces was tested qualitatively, and ground water was analyzed for Coliform and Salmonella sp. contamination. The result showed that dust and ammonia gases from feces (Subang 300-450 ppm, Ciamis 25-525 ppm) pollute the environment and caused an unpleasant odor surrounding the pens. Fly population was increasing during the harvest time of chickens, causing community daily lives were not comfortable. Water quality surrounding PPC indicated that Salmonella sp. contamination was negligible however most samples from Subang and Ciamis were contaminated with coliform bacteria (<3 MPN/ml–27 MPN/ml). Improvement on management policy to reduce the environmental pollution is thus still needed to develop surrounding the PPC areas.

Keywords: ammonia, Coliform, environment, pollution, poultry production cluster

INTRODUCTION

Poultry production clusters (PPC) compose of small-scale farmers and it is defined as "areas of concentrated poultry production in rural areas usually separated from residential areas" where farmers operate certain economies of scale (Aengwanich *et al.*, 2012). The government of Indonesia has established various policies to encourage the growth of poultry production cluster (PPC) in rural areas (Ilham, 2015). This PPC has been developed through a partnership with large-scale business, which is accompanied by the intensification and concentration of poultry operations.

Wang *et al*. (2015) noted that in many Asian countries PPC is key strategies to engage small commercial poultry producers in high-value production chains and to control infectious poultry diseases. Consequently, the existence of PPC has a great impact on the welfare of farmers (Ilham *et al*., 2013; Ilham, 2015). In contrast, the use of large facilities associated with PPC, has given rise to not only limited to the local production settings, but extend to environmental concerns. Poultry farm often considered as a business which contributes to polluting the environment, so that chicken density in PPC can cause many pollution problems.

Studies related to environmental pollution by livestock waste have been reported (Charles and Hariono 1991; Harper *et al*. (2010) and reviewed by Rahmawati (2000). Animal production tends to be concentrated in relatively small geographical areas and may increase localized ammonia (HN_3) (Harper *et al.*, 2010). The environmental impacts are highly dependent on poultry production, especially on manure management practices. Poultry waste may lead to reduced air quality with high concentrations of organic and inorganic dust, microorganism as well as harmful gases such as ammonia, hydrogen sulfide and methane (Gates *et al*., 2008). However, the consequence of the change from a single small-farm to poultry production clusters on environmental pollution is not well understood. The objective of this study was to determine the environmental pollution surrounding poultry production cluster (PPC).

MATERIALS AND METHODS

Study Design

A cross-sectional study was designed in the district of Subang and Ciamis West Java, Indonesia. The study was conducted coincide with dry season. Two PPC in each district were selected as a study site, they were 53 broiler farmers in PPC Subang and 63 male-layers farmers (PPC Ciamis). Both locations were using open litter pen type farming system. Poultry pens size in PPC Subang is greater than in PPC Ciamis, which are correlated linearly with poultry ownership. Average poultry ownership in Subang was 4,600 to 5,000 birds per production cycle, while in PPC Ciamis was 2,200 to 2,900 birds. Information of farmers aspiration on environmental pollution and sanitation issues related to the existence of PPC was collected by semi-structured questionnaires.

Ammonia Level Measurement

Sample feces were taken from the inside of pen in PPC Subang (n=8 farmers) and PPC Ciamis (n=17 farmers) when the the poultry were between 3-4 weeks of age. Each sample site was collected from 12 pick-up points, mixed homogeneously, so that the collected samples were representing fresh and dried manure. Ammonia level in manure is determined indirectly using *Nessler's method* (Bartik and Piskac, 1991) and compared against the standard colour indicator, from yellow, orange, redness to yellow rusty (Stair and Whaley 1990).

Examination of Water

A total of 18 samples of ground water was collected from various sources and tested for microbes of Salmonella sp. and Colliform. Samples of water in PPC Subang were collected from dug wells (6 samples), artesian wells (2 samples), ditches (1 sample) and pond (1 sample) with distance from the pen were 200 m, 200-300 m and 1-2 m, respectively. Samples of water in PPC Ciamis was collected from dug well (8 samples), with distance from the pen was about 100-150 m. Water from dug wells and artesian wells are used for human consumption and chickens drinks. Laboratory test for water pollution, was done at Diagnostic Laboratory Unit, in Indonesian Research Centre for Veterinary Science (IRCVS/BBLitvet), Bogor.

RESULTS AND DISCUSSIONS

Environmental Problem Surrounding PPC

Concentrations of poultry operations under PPC scheme increased in operation size. Consequently, environmental pollution problems have occurred. Access to the farm disposal facilities to accommodate manure is limited. As a result, the poultry farm is a source of the smell and attracts flies, rats and other pests that create local disturbances. However, Rodić *et al.* (2011) pointed out that poultry industry will not threaten the environment only if both economically and environmentally acceptable management practices are applied. Gerber *et al*. (2007) stated that the development of PPC would increase waste, especially from poultry pen, which cannot be managed by land disposal and cause environmental problems

Control of Fly Population

The results of the survey based on farmers' perceptions (Table 1) showed that most farmers in PPC Subang (70%) admit their difficulties in eradicating flies populations. While in PPC Ciamis the proportion between farmers experiencing difficulties and farmers have no problems to control flies were almost similar, being 49 and 51%, respectively. People in the study sites complaint frequently of discomfort due to the increased of flies population, especially at harvest time of poultry. Flies are considered environmental pollutants just by their presence. The population of flies may cause a public health problem. It is known that flies could act as a disease vector and can spread various pathogen agents of the diseases such as *typhoid fever, salmonellosis,* diarrhea, cholera, and another parasite. The shift from small farm flocks to poultry production cluster (PPC) operations had greatly increased people concerns of the fly population. Flies could breed prolifically in moist, litters, spoiled feed and plant material as well as all kinds of manure including poultry manure (Kalu, 2015). Manure moisture of 70 to 80% is most suitable for fly breeding; and fly breeding usually less occur in manure with moisture below 60% (Robertson, *et al.* 2015).

Farmers in PPC Subang (34%) and PPC Ciamis (17%) had applied flies control in a combination of mechanical (by using nets and insect glue) and chemical (spraying and put larvadex in the feed) (Table 1). This showed that farmers had a positive effort to control flies not depends only on chemical control.

According to Roberstson *et al*. (2015), four basic management strategies such as barn management, biological control, mechanical control and chemical control make up a successful integrated fly control program. Some control methods can be applied simultaneously. In the study sites, 60-65% of farmers used insecticide (chemical) by spraying to control the adult flies (Table 1). They found that spraying was the most effective and economical method to control heavy populations of adult flies. Even though chemical control methods have shown a reduction in fly density, its control for routine long-term use can lead to the development of insecticide resistance (Dogra and Aggarwal, 2010). Robertson *et al.*

Table 1. Farmers' Perception and Effort to Control Flies Population

Perception and effort to control flies	PPC Subang (n= 53)	PPC Ciamis (n=63)
Difficulty of controlling flies in the poultry sheds (%):		
a. Yes	70	49
b. No	30	51
Effort to control flies (%):		
a. Spray	60	65
b. Insect Net	0	2
c. Mechanical control by Insect glue	2	2
d. Larvadex in the feed	4	0
e. No action	0	14
f. Others / Combination as mentions above	34	17

(2015) noted that insecticides only control the adult flies, as any pupae in manure will still emerge as adults, moreover, it harm the environment and affect birds, if applied improperly.

Ammonia and Odour

About 81% of farmers in Subang and 43% in Ciamis recognized that chicken manure caused a very disturbing stinging smell (Tabel 2). Odour issues are serious in the residential area that is close to PPC facility especially in Subang. Some people complained about the hostile smell of ammonia from the poultry pens, especially in Subang as the poultry density per production cycle is higher than in Ciamis. This was also reflected from the aspiration of 87% farmers in PPC Ciamis that said easy to overcome odour. Similar situation was also occurred in Nigeria, about 63 % of the residents near by the poultry farms either resolved to permanently shut their doors and windows or make verbal complaints against the foul odours to the headship of the farms (Akanni and Benson, 2014). Odour may arise from improper disposal of poultry waste. These odours are from gases that arise as a result of uncontrolled decomposition of manure (Kalu, 2015). In all excreted animal manures, nitrogen in the form of ammonia (NH_3) is potential to create odours and negatively impact on air quality as well as animal and human health. Kalu *et al.* (2016) stated that odour from animal feeding operations is caused of a large number of contributing compounds including ammonia (NH_3), volatile organic compounds (VOCs), and hydrogen sulfide (H2S).

Table 2 shows that 53% of farmers in Subang and 87% in Ciamis did not have any problem in reducing the odour in their farm, however, in general, did not provide any particular space to collect the feces (>80%). This result was in line with studied carried out by Kalu *et al.* (2016), that 73.1% of the farmers were not aware that improper disposal of their waste affects the environment and human health. Moreover, most of the farmers do not know how to handle their waste efficiently.

Farmers in Ciamis fed their layers with broilers feed. Their effort to reduce bad odour was by adding rice-bran (48%) for covering the surface of manure and replace the litter more often, or combination of both. Methods of odour handling using a compound containing a microorganism (probiotic) into the feed was practiced by 10% of farmers in Ciamis. By adding probiotic into feed would improve feed efficiency, reduces protein which is not digested, and expected lessen the formation of gas that causes

Table 2. Farmer Perception and Practice to Reduce the Odour

Perception and Farmers' Effort in Overcoming Odour	PPC Subang (n= 53)	PPC Ciamis (n= 63)
Farmers' Perception of odour		
1. Feces generates strong odour (%)		
- Yes	81	43
- No	19	57
2. Coping with odour (%):		
- Difficult	47	13
- Easy to overcome odour	53	87
3. A place to collect feces (%)		
- Available	15	14
- Not available	85	86
Effort to reduce odour (%)		
1. Adding rice bran in litter	40	48
2. Providing starbio/probiotic into the feed	0	10
3. Replacing bran more often/once a week	15	21
4. Combination	45	21

smells in manure (Rahmawati, 2000). Furthermore, the used of 1-3% lime and 0.025-0.05% starbio-probiotics appears to be a good choice compared to zeolites and EM4®.

The frequency relative of ammonia level more than 300 ppm in PPC Subang and Ciamis was 75% and 47.6% respectively (Table 3). This indicted that in those two sites the level of ammonia is relatively high, even though in a cluster of Broiler (Subang) was slightly higher than male-layers cluster (Ciamis). This result was in line with the farmer effort in reducing odour as reflected in Table 2, in which farmers in Ciamis (48%) adding rice bran and 10% of farmers added probiotic in the chicken feed. The emission rates of the pollutants depend on many factors including temperature, humidity, wind speed and weather conditions, ventilation, housing type, and manure properties and characteristics – for example, dryer manure and litters result in more particulate emission, while moist conditions are likely to result in increased emission of ammonia (Williams, 2013). Aerosol contamination from poultry production can generally be characterized as pollutants, including gases (such as ammonia), particulates (dust) and microbial pathogens. Kalu (2015) noted that environmental problems such as odor nuisance and land pollution resulting from improperly discharged manure.

The workers in PPC and people who live nearby the PPC are potentially exposed to ammonia if feces (litter) are not handled properly. Maguire *et al.* (2006) stated that if manure left unattended to for more than 72 hours, the rate of ammonia volatilization would be higher, thereby creating environmental pollution for the birds, worker in the farm and people living close to the poultry farms. Ammonia emission from poultry manure can cause several problems such as poor poultry performance, reduce the poultry's immunity, and damage the bird's respiratory systems (Aziz and Barnes, 2009). In addition, they stated that at high concentrations, ammonia is irritating the conjunctivae of the eyes and damage the mucous membranes of the respiratory system which increases the susceptibility of birds to bacterial infection, especially *E. coli* infection. Broilers reared in an environment with ammonia concentration over 25 ppm showed a reduction in antioxidant capacity (Wei *et al.*, 2012), and reduce carcass traits and immune organ indices and increased the kidney and hepatic indices (Xing *et al.,* 2016). Hutabarat (2007) summarized that in a range of 200-400 ppm, ammonia could cause *nasopharyngeal* irritation, while the level of >400 – 500 ppm causes direct hazardous impact to the human health.

The ammonia level needs to be controlled, not only for the animal health but also for the public health. According to Harper *et al.* (2010), the ammonia emission will increase steadily after the third week of poultry growth. The emission rate of ammonia increase in a linear relationship with age from chick placement to the end of the flock (Gates *et al.,* 2008). Choi *et al.* (2011) indicated that adding liquid aluminum chloride to rice husk would be a useful in reducing the negative environmental impact of litter. The decreased volatile fatty acids (VFA) production and (NH_3) volatilization was associated with reduction in litter pH. To achieve efficient farming and to maintain good environmental quality, attention has to be given to farm management, housing and waste handling. The heat produced

Table 3. The Ammonia Level in PPC Subang and Ciamis

Location and Ammonia Level	Frequency	Frequency relative (%)
PCC Subang (n = 8)		
• 250 - 300 ppm	2	25.00
• > 300 ppm	6	75.00
PCC Ciamis (n = 17)		
• 250 - 300 ppm	9	52. 94
• > 300 ppm	8	47. 06
TOTAL (n = 25)		
• 250 - 300 ppm	11	44.00
• > 300 pp m	14	56.00

during composting completely reduces the pathogenic organisms in the waste (Adeoye *et al*., 2014). In this regards, the government of Indonesia has issued decree No. 31/Permentan/OT.140/2/2014 through Minister of Agriculture. The decree state about guidelines of good management for broilers and layers in which a farm of broilers and layers needs to be equipped with good management and environmentally friendly (Kementerian Pertanian, 2014). Sartika *et al*. (2015) stated that the development of PPC triggers another serious problem, not only to animal diseases that threaten the production, but also impact on public health. Aerosol emissions from poultry production can transmit communicable diseases to nearby poultry flocks; scientific evidence shows that some pathogenic microorganisms can remain viable and able to be transported for considerable distances (from 50 to more than 500 m) in ambient air (Williams, 2013).

Water Quality Surrounding PPC

In the poultry farm, the source and quality of water are important. The source of drinking water must be free from contamination of microbial pathogens. A study in Thailand found where egg-laying chickens are raised over fish ponds, resulted in water both in the fish ponds and the public water sources (Aengwanich *et al*., 2014). Mostly the water source in the study sites comes from dug wells and is distributed through pipes with the electric water pump. A sample of water is collected and tested for microbes of Salmonella sp. and Coliform. The laboratory test result (Tables 4 and 5) shows that all samples from water sources are negative of Salmonella sp. However, for Coliform mostly present at <3 MPN/ml – 27 MPN/ml. There were two samples with a high level of *coliform* contamination, i.e a sample from PPC Subang with 290 MPN/ml of the *coliform* level, and a sample from Ciamis with 160 MPN/ml of *coliform*. Water with this level of coliform must be boiled for human consumption, considers the coliform level is already on the verge (PP No. 20/1990). Those two samples were collected from the buckets where the source is artesian well and dug well respectively. Although the water appearance looks clear, there is a possibility the water is contaminated from septic tank seep or is contaminated when in the water container.

The water source in the study sites might be contaminated by absorption or seepage of pen waste-water (pen washed activity). *Coliform* is a family of bacteria made up of several groups, one of which is the fecal *coliform* group, which is found in the intestinal tracts of warm-blooded animals including humans. The presence of coliform bacteria is typically an indication of fecal contamination. When water has a high bacterial count, the best option is to eliminate the source of the contamination or to locate an alternative water source. Study conducted by Onu *et al.* (2015) indicated that the effects of poultry production activities include the degradation of

Table 4. Water Analysis Result (Salmonella sp. and Coliform) in PPC Subang

Water Source	Distance from Poultry Pens (m)	Usage	Physic, pH	Salmonella sp.	Coliform MPN/mL
Artesian l	5	poultry	clear, 5.5	negative	290
Dug Well	1	poultry	clear, 6.5	negative	< 3
Dug Well	400	human	clear, 5.5	negative	14
Ditch	400	-	turbid, 7.5	negative	< 3
Artesian	1	poultry, human	clear, 6	negative	< 3
Pond	0.5	pen wash, fish pond	turbid, 7.5	negative	4
Dug Well	400	human	clear, 5.5	negative	< 3
Dug Well	50	human	clear, 6	negative	27
Spring	200	poultry, human	turbid, 6.5	negative	< 3
Dug Well	200	poultry, human	clear, 6.5	negative	< 3

Table 5. Water Analysis Result (Salmonella sp. and Coliform) in PPC Ciamis

Source	Distance from Poultry pens (m)	Usage	Physic, pH	Salmonella sp.	Coliform MPN/mL
Dug Well	1	poultry, human	clear, 5.5	negative	4
Dug Well	50	poultry, human	clear, 7	negative	15
Dug Well	200	poultry, human	clear, 5.5	negative	7
Dug Well	1	poultry	clear, 5.5	negative	< 3
Dug Well	150	poultry, human	clear, 6	negative	4
Dug Well	70	poultry, human	clear, 5.5	negative	39
Dug Well	10	poultry, human	clear, 5.5	negative	160
Dug Well	10	poultry, human	clear, 6	negative	< 3

nearby surface and /or underground water, as well as pollution of the environment through the emission of foul odour; thus causing discomfort to both the human and animal lives. Environmental hygiene control is not prioritized by the local government in study the sites. Such a situation is common in developing countries however, there is a need for collateral personal hygiene and sanitary education to achieve improved outcome (Mara *et al.,* 2010; Jenkins *et al.,* 2014). However, Elsaidy *et al.* (2015) stated that different water sources is safe as drinking water for poultry; as long as it is acceptable within the range of drinking water quality for chickens, he suggested of maintaining the hygienic quality of stored water.

Acidity and alkalinity of water are one that indicates the quality of drinking water. The pH, hardness, and total dissolved solids (TDS) can all affect consumption patterns. Water with a pH of 7 is neutral; a pH greater than 7 indicates alkalinity, while a pH less than 7 indicates acidity. Good water/normal water has a pH around 6.5 – 7.2. The resulting test of water sample in study sites show the water pH used for poultry drink is about 5.5 – 7, and physically the water is clear. When the water pH is lower or higher in the normal range, it can affect the medicine solubility, especially for medicine that difficult to dissolve homogenously in water. Water with a low pH can be unpalatable, while high pH water can clog watering systems because of excessive mineral levels, especially calcium and magnesium. Water outside maximum acceptable levels for both high and low pH can negatively impact performance (Tabler *et al.,* 2013). It can affect chickens drinking consumption which also affect the growth and productivity of the chickens. Moreover, he suggested that regular water sanitation program on the farm will assist farmers in preventing unhealthy environments. Providing a clean and safe water supply is critical to ensuring that poultry performs at their best.

CONCLUSION

The direct consequences of PPC development are the increase of waste from the poultry pens which cause environment problem, such as odour issues in residential surrounding PPC, increasing fly population, as well as water and air contamination. The shift from small farm flocks to PPC had greatly increased farmers' concerns of a fly population that was difficult to be eradicated especially during the harvest time of chickens. A combination of mechanical and chemical for fly control is a positive effort in managing pesticide resistance.

ACKNOWLEDGMENTS

This study is funded through a capacity-building initiative for Ecohealth Research on Emerging Infectious Disease in Southeast Asia supported by the International Development Research Centre (IDRC), the Canadian International Development ment Agency (CIDA) and the Australian Agency for International Development (AusAID) in partnership with the Global Health Research Initiative.

REFERENCES

Adeoye, P.A., C.M. Hasfalina, M.S.M. Amin, A.M. Thamer and C.O. Akinbile. 2014. Environmental implication of poultry waste generation and management techniques in Minna, Semi-arid Region of Nigeria. Annual Res. Rev. Biol. (ARRB). 4(10):1669-1681

Aengwanich, W., M. Intarakhamhaeng, J. Wandee, T. Nongbua, S. Chaiyasak, P. Srikot, K. Thammasar, N. Junsanitsri, K.Sritongtuam and T. Tawinwaang. 2012. Poultry Production Clusters (PPCs) after AI outbreaks in Thailand: Past, present and future direction. Int. J. Poultry Sci.11: 541–550

Aengwanich, W., T. Boonsorn and K. Thammasar. 2014. Mathematical equations for reducing water pollution problems among Poultry Production Clusters in Nong Khai Province, Thailand. J. Geosci. Environ. Protection *(*GEP*)*. 2:48-51

Akanni, K.A and O.B. Benson. 2014. Poultry wastes management strategies and environmental implications on human health in Ogun State of Nigeria. Advances in Econ. Business 2(4):164-171.

Aziz, T. and H.J. Barnes. 2009. Harmful effect of ammonia on birds. World Poult. 26(3):28-30.

Bartik, M. and A. Piskac. 1991. The Main Chemical and Toxicological Method of Examination in Farm Animal Poisoning Veterinary Toxicology. Eksebisi Suci. Pub. Co. New York. 298-319.

Charles, R.T. and B. Hariono. 1991. Pencemaran lingkungan oleh limbah peternakan dan pengelolaannya. Bull. FKH-UGM. X(2): 71-75.

Choi, I.H., J.H. Choi, S.H. Ko and P.A. Jr. Moore. 2011. Reducing ammonia emissions and volatile fatty acids in poultry litter with liquid aluminum chloride. J. Environ. Sci. Health. B. 46(5):432-435.

Dogra, V. and A.K. Aggarwal. 2010. Association of poultry farms with housefly and morbidity: A comparative study from Raipur Rani, Haryana. IJCM. 35(4):473-477.

Elsaidy, N., Mohamed R.A. And F. Abouelenien. 2015. Assessment of variable drinking water sources used in Egypt on broiler health and welfare. Vet. World 8(7):855-864.

Gates, R.S., K.D. Casey, E.F. Wheeler, H. Xin and A.J. Pescatore. 2008. U.S. broiler ammonia emissions inventory model. Atmos. Environ. 42:3342-3350.

Gerber, P., C. Opio and H. Steinfeld. 2007. Poultry production and the environment – a review. Poultry in the 21st Century. Animal Production and Health Division, FAO, Rome.

Harper, L.A., T.K. Flesch, and J.D. Wilson. 2010. Ammonia emmisions from broiler production in the San Joaquin Valley. Poult. Sci. 89:1802-1814.

Hutabarat, I.O. 2007. Analisis dampak gas ammonia dan khlorin pada faal paru pekerja pabrik sarung tangan karet "X" Medan. Thesis. Universitas Sumatra Utara, Medan.

Ilham, N., Y. Yusdja, E. Basuno, E. Martindah, and R.A.D. Sartika. 2013. Ecohealth assesment on poultry production clusters for the livelihood of improvement small producers. Final Report (Indonesia). Indonesia Center for Sosio-Economic and Agriculture Policies. Indonesian Agency for Agricultural Reserch and Development. Ministry of Agriculture – Republic of Indonesia collaboration with International Development Research Centre (IDRC) – Canada.

Ilham, N. 2015. Kebijakan pemerintah terhadap usaha unggas skala kecil dan kesehatan lingkungan di Indonesia. Wartazoa. 25(2): 95-105.

Jenkins, M.W, M.C. Freeman and P. Routry. 2014. Measuring the safety of excreta disposal behaviour in India with the new Safe San Index: Reliability, validity and utility. Int. J. Environ. Res. Public Health. 11:8319-46.

Kalu, E. 2015. Poultry litter/manure management practices in intensively managed poultry farms in Portharcourt. IOSR J. Agric. Vet. Sci. 8(3):53-58.

Kalu E., A.N. Ajaruonye, and N. Okwara. 2016. Waste management practices in selected poultry farms in Umuahia, Abia State. J. Vet Adv. 6(9):1310-1316.

Kementerian Pertanian. 2014. Peraturan Menteri Pertanian Republik Indonesia Nomor 31/Permentan/OT.140/2/2014, tentang Pedoman budi daya ayam pedaging dan ayam petelur yang baik. Kementerian Pertanian, Jakarta Indonesia.

Mara D., J. Lane, B. Scott and D. Trouba. 2010.

Sanitation and health. PloS Med 7:e1000363
Maguire R.O., D. Hesterberg, A. Gernat, K. Anderson, M. Wineland, and J. Grimes. 2006. Liming poultry manures to decrease soluble phosphorus and suppress the bacterial population. J. Environm Qual. 35: 849-857.
Onu, D.O., E.I. Offor and B.O. Okpara. 2015. Poultry wastes management strategies and environmental implications in Abia State. Int. Res. J. Agric. Sci. Soil Sci. 5(6):159-164.
Peraturan Pemerintah. 1990. Peraturan Pemerintah No. 20 Tahun 1990 Tentang: Pengendalian Pencemaran Air. Jakarta.
Rahmawati, S. 2000. Upaya pengelolaan lingkungan usaha peternakan ayam. Wartazoa. 9(2):73-80.
Robertson, A., D. Ward and S. Lachance. 2015. House Fly Control in Poultry Barns. Publication 849. Queen's Printer for Ontario. Toronto. Canada.
Rodić, V., L. Perić, M. Đukić-Stojčić and N. Vukelić. 2011. The environmental impact of poultry Production. Biotechnol. Anim. Husbandry. 27(4):1673-1679.
Sartika, R.A.D., N. Ilham and R.A. Wulandari. 2015. The impact of poultry production cluster (PPC) and Non PPC on child health in Indonesia (A qualitative research). J. Advanced Studies in Agric. Biol. Environ. Sci. 2(4):15-23
Stair, E.L. and M. Whaley. 1990. Rapid screening and spot tests for the presence of common poisons. Vet. Hum. Toxicol. 32(6): 564-566
Tabler T., J. Wells and W. Zhai. 2013.Water Quality Critical to Broiler Performance. Extension Service of Mississippi State University, cooperating with U.S. Department of Agriculture. Publication 2754.
Wang, L, E. Basuno, T. Nguyen, W. Aengwanich, N. Ilham and X. Li. 2015. An ecohealth assessment of poultry production clusters (PPCs) for the livelihood and biosecurity improvement of small poultry producers in Asia. Infectious Diseases of Poverty. 4:6.
Williams, C.M. 2013. Poultry waste management in developing countries: Aerosol contamination. Poultry Development Review. Food and Agriculture Organization (FAO) of the United Nations.
Wei F.X., B. Xu, R.N. Sa, S.Y. Li , F.Z. Liu and Q.Y. Sun. 2012. The effect of ambient relative humidity and ammonia on antioxidant capacity and meat quality of broiler chickens. Acta Vet Zootech Sin. 43(10):1573-1581
Xing, H., S. Luan, Y. Sun, R. Sa and H. Zhang. 2016. Effects of ammonia exposure on carcass traits and fatty acid composition of broiler meat. Animal Nutrition. 2(2016): 282-287.