Explor Anim Med Res,
Vol.10, Issue - 2, 2020, p. 100-111

ISSN 2277- 470X (Print), ISSN 2319-247X (Online)
Website: www.animalmedicalresearch.org

Review Article

IMPACTS OF INTENSIVE POULTRY FARMING ON 'ONE HEALTH' IN DEVELOPING COUNTRIES: CHALLENGES AND REMEDIES

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Received 23 September 2020, revised 20 October 2020

ABSTRACT: During the recent past, poultry sector has shown immense adaptations to meet the ever-increasing demand for safe meat and eggs. However, this growth has been accompanied by structural changes within the industry which has led to emergence of various environmental and public health concerns ranging from water, air and soil pollution to ecological imbalances, biodiversity losses and occupational health and safety hazards. This paper analyses the environmental and human health impacts of intensive poultry production and various technical strategies to mitigate these issues.

Key words: Intensive poultry production, Environmental impacts, Occupational health risks, One health, Mitigation strategies.

INTRODUCTION

Globally, in particular, in the Asian sub-continent poultry farms are located in densely populated areas. In such regions, majority of poultry are kept by smallholders in less intensive systems. For these households, poultry has served as both a safe guard and a mean to acquire assets and alleviate poverty. Developing countries are now pouring in heavily in intensive poultry production through commercial chains to supply quality meat and eggs for increasing urban and peri-urban populations. Moreover, increasing external pressures on the poultry sector arising from social, economic and environmental factors are also strengthening the trend towards intensification (Mcleod *et al.* 2009). Intensification refers to the various processes by which livestock production and trade systems can improve the overall outputs such as the quantity of meat, eggs, or milk produced per unit of animals (Steinfeld 2004). This intensification could primarily be attributed to increase in the popularity of poultry products in daily food basket. India is second most densely populated country in the world with more than 450 inhabitants per km^2 land area (UN 2019). The country is also known for its high concentration of poultry farms in rural as well as in urban areas. However, the intensification and expansion of poultry farming is a relatively recent phenomenon. Poultry meat and eggs are rapidly becoming major sources of animal proteins in the diets of Indian consumers which is evident from the fact that per capita consumption of poultry meat in India estimated to be 2.2 kg/person/year in 2014 which has shown a steady increase over the years (Devi *et al.* 2014). In 2020, the consumption of poultry meat in India was found to be over 3.9 million metric tons (Keelery 2020). Currently poultry meat consumption is considered to be about 3 kg per person, and the poultry industry considers that this will get tripled to 9 kg by the year 2030. To meet this escalating demand of inexpensive and quality poultry meat and eggs, the Indian poultry industry has shown tremendous growth during the recent past. Ever increasing population, more purchasing power, rapid urbanization and industrialization have become strong drivers behind the growth in poultry industry. To meet the growing demand of poultry meat, its production has increased from 9 to 122 million tonnes between 1961 and 2017. Globally its share in the world meat production has also increased up to 37% (FAO 2020). At present, India ranks 3rd in

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egg production (with the egg production of 103318 millions), 4th in broiler production (with 4.9 million MT meat production) in the world, with the overall poultry products export of around Rs. 515.90 crores (BAHS 2019). During 2011 – 2015, Indian processed meat and poultry were the second fastest growing markets with a Compound Annual Growth Rate (CAGR) of 22%. Indonesia, however topped the list with CAGR of 26.7% followed by Vietnam (15.5%), China (13.9%) and Brazil (10.9%) (ICFA 2016).

However, this growth in poultry sector has been accompanied by various structural changes within the sector, characterized by the emergence and growth of intensive farming establishments i.e. land independent system (Gerber *et al*. 2007). Almost 30 years back, 70% of poultry population was contributed by native chicken which were reared under foraging system. But today, about 80% of this sector is occupied by exotic birds which are reared under intensive system especially in high-income countries such as Belgium, Netherlands and in much of Southeast Asia (Gilbert *et al.* 2015). However, this industrialization of poultry sector and disposal of unprecedented amounts of generated poultry waste poses some significant detrimental effects on different compartments of environment i.e. air, soil and water. The increase in waste management problems can be considered as one of the major factor responsible for such harmful effects on environmental health.

'One health' is an integrative approach of multiple disciplines working locally, nationally and globally to attain optimal health for humans, animals and environment. Since, intensification necessitates increase in livestock numbers and densities, the use of particular feed to increase conversion ratios, faster production cycles and synchronous all-in/all-out policies (Gilbert *et al*. 2017). Therefore, such changes may potentially change transmission patterns and the evolutionary conditions of prevailing pathogens leading to emergence of zoonotic diseases (Alizon *et al*. 2009). Hence, intensive poultry farming not only poses a significant risk to people who are working indoor but can also acts as a potential source of outdoor pollution for the general public. Moreover, to begin by understanding how intensification affects animals and their welfare, and how it relates to ethical beliefs about the care and use of animals is of great concern in current scenario (Fraser 2008). A One Health perspective intrinsically holds reflections on human and animal well-being. Animal diseases threaten human health and food security, for example by the transmission of zoonotic diseases or by the loss of animal productivity. Consequently, we can no longer turn away from the close linkage, interrelations and interdependencies of human and animal health without considering at the same time maintenance of stable ecosystem services, some of which are seriously threatened by livestock rearing methods and/or excessive, exploitative human activities (Rabinowitz *et al*. 2008). Therefore, understanding the impact of poultry production on human and environmental health will help to find suitable remedial measures for sustainable poultry production. In this context, the present article focuses on various issues occurring at farm and regional levels and various managemental strategies to counter 'One Health' issues.

ENVIRONMENTAL POLLUTION

The livestock and poultry farming is responsible for almost 18% of the global emission of greenhouse gases and therefore the environmental impact of livestock and poultry farming has received much attention during the past few years (Steinfeld *et al.* 2006). However, very little attention has been given to the potential risks associated with poultry waste constituents, including pathogenic microorganisms, antibiotic-resistant bacteria, and residues of the drugs added to poultry feeds. The intensive poultry production to meet the rising demands of people has given rise to various environmental concerns that are not only limited to the local production settings, but have been extended to environmental problems at regional and global scales. The various environmental components get polluted due to improper managemental practices as discussed below:

Air pollution

Poultry facilities acts as source of foul odor and attract flies, rodents and other pests that create local nuisances and a source of infectious diseases (Kolominskas *et al.* 2002). Odor emissions, caused by a large number of contributing compounds including ammonia, hydrogen sulphide and volatile organic compounds from poultry farms adversely affect the life of people living in the vicinity (IEEP 2005). The emission of odors mostly depends on frequency of manure removal and cleaning, temperature and humidity of the manure, type of manure storage, and prevailing air movements. Although, odor does not generally cause any public-health concern but it can represent a strong local problem especially when high number of poultry are reared in confinement areas. This have been linked with frequent complaints of odor nuisance, and other health symptoms, including headache, irritation of eyes, nose and throat, and drowsiness in

poultry farm workers and people living in close proximity to these establishments (Hamid *et al*. 2018).

When birds are reared in cages, there is no contact between birds and droppings that facilitates breeding and multiplication of flies without any hindrance. Therefore, flies are an additional concern for residents living near poultry facilities. According to a research conducted by the Ohio Department of Health, residences that were located in close proximity to poultry facilities (within half a mile square area) had 83 times the average number of flies and mosquitoes. In addition to the nuisance, flies can also serve as vectors for transmission of various diseases such as cholera, dysentery, typhoid, malaria, filaria, dengue fever and even anthrax. The presence of flies is mainly related to poor feed management and especially to filth created during storage and losses from feeding systems.

Dust generated from poultry farm is a combination of manure solids, feathers, dander, hair, and feed. It is commonly encountered problem in those which have concrete/solid floors. Dust is generally generated through feed mills, vehicular movements, piled up manure, and routine farm operations. The severity of dust is more from feed mills than the rearing area. However, it is very difficult to eliminate from animal production units.

Water pollution

Poultry fecal material contains reasonable quantity of nitrogen, phosphorus, and other excreted substances such as antibiotics, pathogens and heavy metals. The leaching and runoff of these undesirable substances could probably result in contamination of nearby surface water and groundwater resources. Such high levels of nutrients may cause eutrophication of the affected water bodies. The effluents generated from poultry farms are usually rich in organic material. Hence, a high concentration of nutrients, total suspended solids (TSS) results in elevated biochemical oxygen demand (BOD), chemical oxygen demand (COD). Further, usage of pesticides to control pests and predators has also been reported to cause ground and surface water pollution (Kumar *et al.* 2019).

Since, poultry carcasses act as significant source of disease and odors, and can attract numerous vectors. Therefore, the carcasses and cadavers of poultry needs immediate attention and should be properly managed. Improper disposal of poultry carcasses can also contribute to water pollution especially in flood prone areas or in locations having shallow water table. The most common methods used for the disposal of poultry carcasses include burial, incineration, composting and rendering but during poultry disease epidemics as in the case of highly pathogenic avian influenza (HPAI) outbreaks in different parts of the world, the improper disposal of large numbers of infected birds has created new problems associated with environmental contamination. During such poultry disease outbreaks in many countries especially developing countries including India, dead birds are usually thrown out on the roads, farm lands and rivers, thus creating different types of environmental hazards (Ahuja 2011). Following burial of dead birds, carcass undergoes a decomposition process resulting in release of nutrients, pathogens and other components into the environment. These substances may enter into surrounding water sources eventually contaminating groundwater and surface water (Ritter *et al*. 1988, Freedman and Fleming 2003).

One of the most striking environmental issues resulting from knackeries or slaughterhouse operations is the uncontrolled discharge of wastewater into the environment. Similar to many other food-processing industries, the requirement for sanitation, hygiene and quality control in chicken processing also results in high water usage resulting in high levels of wastewater generation with high BOD and COD levels. Large quantities of high-quality water are consumed in poultry slaughterhouses for different purposes such as evisceration, cleaning, washing operations etc. (EU 2003). The high BOD and COD of waste water discharged from the poultry slaughter houses are attributed to the presence of organic materials such as flesh, fat, blood, and excreta which in turn may lead to reduced levels of activity or even death of vulnerable aquatic life. Residues of disinfectant and chemicals used in washing and maintaining hygiene in slaughter houses such as chlorine, as well as various pathogens including species of Salmonella and Campylobacter may also be discharged out with the water thus contaminating environment.

There are corroborations that chronic exposure to some chemical pollutants adversely affects the health of some fish species. The correlation between water pollution by organic material, hydrocarbons, nitrogenous compounds (ammonia and nitrites), heavy metals etc. from various sources including poultry feces and the incidence fish disease has been earlier made (Austin 1999). For instance, winter stress syndrome, which is characterized by greatly reduced levels of lipid in fish, seems likely to result from stresses, including the presence of pollutants in the aquatic environment (Lemly 1997). The stress caused by the excessive pollutants in water may results in epidermal papilloma, lymphocystis, skin ulcers and septicemia in fish (Mellergaard and Nielsen 1995). The heavy metals also have role in exacerbating microbial fish diseases e.g.,

copper increases the susceptibility of fish to *Vibrio anguillarum* and *Edwardsiella tarda.* Similarly, there are evidences that nitrites at a concentration of 6 mg/L in water increased the susceptibility of channel catfish (*Ictalurus punctatus*) to infection by *Aeromonas hydrophila* (Hanson and Grizzle 1985).

Soil pollution

Poultry droppings containing excessive nutrients and trace elements can contaminate soil and affect plants growth. Other indirect impacts include ecosystem destruction and biodiversity crisis associated with the expansion of feed crop production into natural habitats. For increasing production of poultry and other livestock feed stuffs there has to be expansion of crop land into natural habitats e.g. by deforestation. As per National Institute of Space Research, Brazil, in 2002 about 2.5 million hectares Amazon forest disappeared and about 0.77-million-hectare expansion was alone attributed to soybean cultivation (Bickel and Dros 2003). To meet the increasing demand of poultry feed, there has been triggered intensification of feed production. Maintaining high crop yields through feed production intensification require excessive usage of chemical pesticides and fertilizers, which in turn pollute the land and water resources leading to ecosystem destruction and biodiversity erosions. Poor manure-management and improper burial of dead bird can also result in pollution of soil with nutrients, pathogens and heavy metals. The use of fertilizers and manure has both positive and negative effects on soil chemistry and on plant growth (Han *et al.* 2016). However, accumulation of nutrients in soil due to continuous long-term excessive usage of manure may result into changes in soil pH and buildup of high metal concentration. The poultry manure has relatively high concentrations of ammoniacal nitrogen. Therefore, when poultry manure is applied to soil, nitrification (conversion of NH4 into NO3 with release of H^+ ions) and further decomposition by soil microorganisms produce various organic acids and carbonic acid into the soil (Chang *et al.* 1990). This leads to reduction in soil pH, which may result in crop losses and health risks to people living in and around those areas (Manitoba 2013).

Poultry waste is also a source of arsenic, a potential human carcinogen. There are evidences that organic arsenicals used in poultry feed for growth promotion and prevention of parasitic infections, are transformed into inorganic arsenicals in poultry waste (Nachman *et al.* 2005). There are reports of elevated soil arsenic levels in places where poultry wastes have been applied (Gupta and Charles 1999). This inorganic arsenic is quite leachable and can therefore find its way into groundwater and finally to humans (Rutherford *et al.* 2003).

Noise pollution

Poultry birds, like all other vertebrate organisms, have circadian rhythm which is controlled by natural light/dark cycle of day and night. The activity of birds is quite low during the night hours or especially when there is insufficient light. Most of their activities and feeding are during the daytime when there is abundant exposure of light. Although they do take some rest during the day. However, fans, feeders and birds together contribute to a large extent to the noise inside the farm. The arrival, operation and departure of feed trucks, loading trucks, and clean out equipment contribute to noise levels outside the farm which could act as a source of annoyance to the neighbors. Unfortunately, India has not yet established noise limits w.r.t intensive poultry farming. According to Central Pollution Control Board's (CPCB) commercial poultry farms were exempted from the provisions of the acts for prevention and control of pollution. Although, in 2015 CPCB issued some of the general environmental guidelines for poultry farms but they lacked comprehensive quantitative limits. Therefore, in September 2020, National Green Tribunal (NGT) of India directed the CPCB to revisit the guidelines for classifying poultry farms as green category industry and exempting their regulation under various laws (Anonymous 2020).

Ecological disturbances and biodiversity losses

Apart from environmental pollution, intensive poultry production can significantly affect the ecological climax. Large amount of wastewater with high BOD and COD is discharged from poultry slaughterhouses into the environment, polluting surface water sources as well as posing a serious risk for the environmental health. The discharge of different biodegradable organic compounds containing wastewater may cause reduction of dissolved oxygen content in surface waters, which may lead to death of aquatic life. Macronutrients (*e.g.*, nitrogen, phosphorus) may cause eutrophication of the affected water sources which leads to excessive algal growth, reducing the sun light penetration and cutting the oxygen supply to underwater plants. The subsequent dying off and mineralization of these algae may lead to the death of aquatic life because of oxygen depletion (Verheijen *et al.* 1996).

The insecticides used for controlling various parasites and disease vectors can find their way into ground and surface water, thus contaminating otherwise usable water

sources. The insecticides or their active metabolites can persist in the environment for considerable period of time thereby affecting ecological balances. The use and eventually excretion of hormones from poultry has been linked with endocrine disruption in the wildlife. Endocrine disrupting chemicals (EDCs) are various xenobiotic chemicals like pesticides that interfere with endocrine systems of the body. In poultry production, EDCs can both enter and leave the production cycle. Several researchers have shown that poultry litter contains EDCs such as estrogen (17-ß-estradiol), estrone and testosterone (Nichols *et al.* 1997, Shore and Shemesh 2003). These EDCs has been found to cause endocrine disruption resulting in reproductive disorders in a variety of wildlife such as mollusks, seals, eagles, alligators, turtles and fish (Fisher *et al.* 2005, Street *et al.* 2018).

The intensive poultry production has driven high demand for feed, fish meal etc. Intensive feed production contributes to biodiversity loss through land use, changes in land-use pattern, and modification of natural ecosystems and habitats. This has been explained by the fact that to meet the demands of poultry feed, several million square biodiversity rich zones have been cleared to cultivate maize and soya throughout the world (Wassenaar *et al.* 2007, Dei 2017). The requirement of fishmeal by the poultry is also an important determinant accounted for overexploitation of fisheries. According to one of the estimates, about 40% of global fishmeal production is used alone in the livestock sector of which 13% is exclusively used by the poultry sector (Jackson 2007). This overexploitation has threatened the biodiversity of aquaculture sector.

The intensive poultry production is also contributing towards global climate change in way that can be mitigated if taken care of properly. The poultry housing facilities, feed preparation units, transportation services used for national and international trade, slaughtering, waste burning etc. are potential sources of greenhouse gases such as carbon dioxide, N_2O emissions (EU 2003, Ramirez *et al.* 2004).

HUMAN HEALTH HAZARDS

Workers involved in poultry operations and communities residing nearby are in constantly subjected to various hazards and safety issues. Occupational health and safety hazards related to the daily operations of the poultry sector can be physical, chemical, biological hazards. People involved in poultry production facilities may be exposed to various physical hazards related to equipment and vehicle operation and repair, trip and fall hazards and lifting heavy weights etc. Among chemical hazards, substances used in poultry production activities include pesticides, disinfecting agents, minerals, antibiotic and hormonal products. Workers may be exposed to pesticides through dermal contact and inhalation during their preparation and application as well as ingestion due to consumption of contaminated water (Damalas and Koutroubas 2016).

Workers may be exposed to a range of pathogens such as bacteria, fungi, mites and viruses secreted and excreted by live birds or transmitted through excreta, carcasses and parasites and ticks. Fortunately, most of the poultry diseases are not zoonotic in nature. However, few diseases, especially avian influenza is a consistent threat to those living along with poultry (Kumar *et al.* 2018b). The origin of avian influenza and the reasons for the evolution of highly pathogenic avian influenza virus (H5N1) are still uncertain (Peiris *et al.* 2007), although some evidence indicates that the enormous growth in intensive poultry production with relatively low bio-security has provided favorable environment for the virus to evolve (Gilbert e*t al.* 2017). Other parasites such as *Cryptosporidium* and *Giardia* spp. can also easily spread from poultry manure to water supplies and can remain viable in the environment for long periods of time thus affecting human health (Kyakuwaire *et al.* 2019). Poultry farms also acts as hiding places for rodents. Apart from direct detrimental effects of rodents, they can also act as potent source of various bacterial (*e.g.*, *Campylobacter jejuni*, *Salmonella typhimurium*, *Salmonella enteritidis*, *Leptospira* spp.) and viral (e.g., Hantavirus, Rotavirus F) zoonotic pathogens transmissible to the persons working in poultry farms and also to the neighbors (Backhans and Fellstrom 2012, Gravinatti *et al.* 2020). The major poultry borne zoonotic agents are their transmission dynamics are presented in Table 1.

Antibiotic are used therapeutically for treatment of disease and prophylactically as antibiotic growth promoters (*e.g.*, Avilamycin, **B**ambermycin, Efrotomycin and Ionophores) to boost feed efficiency and increase weight gain. If antibiotics are used indiscriminately in feed, antibiotic resistant micro-organisms might develop in the gastrointestinal tract of birds. Such resistant bacteria can potentially infect humans on or in the vicinity of the farm (Kumar *et al.* 2018a, Thakur *et al.* 2019). For example, colistin is widely used as a growth promoter in Indian poultry sector and after carbapenem-resistant cases, colistin-resistant cases among Gram-negative bacteria are also being reported from hospitals across India (Davies and Walsh 2018, Walia *et al.* 2019). It was found that poultry house workers were 32 times more likely to carry gentamicin-resistant *E. coli* as compared

Table 1. The zoonotic pathogens associated with poultry and their mode of transmission.

Agents	Diseases/Infections	Transmission mode (from infected birds to humans)
Bacteria	Avian Tuberculosis	Direct contact with infected birds, contact with a contaminated fomite or by ingestion of contaminated raw chicken
	Campylobacteriosis	Contaminated meat and water
	Colibacillosis	Contaminated poultry meat, eggs and water
	Salmonellosis	Contaminated poultry meat, eggs and water
Viruses	Avian Influenza	Contact with live infected birds and their secretions and excretions
	West Nile Virus infection	Bites from infected mosquitoes
	New Castle Disease	Contact with live infected birds and their secretions and excretions
Protozoan	Toxoplasmosis	Contaminated poultry meat
Fungi	Aspergillosis	Inhalation of spores present in soil, water and feed
	Cryptococcosis	Inhaling dust contaminated with bird droppings
	Histoplasmosis	Contact with soil contaminated by bird or bat droppings
Chlamydia	Ornithosis	Inhalation of organism shed by infected birds, handing of dead infected birds, nasal discharge, bite and person to person contact

(Source: Kumar *et al.* 2018b)

with community referents. Therefore, based on a risk assessment studies, in 2005 the US Food and Drug Administration banned use of all the fluoroquinolone in poultry production to reduce the prevalence of fluoroquinolone-resistant Campylobacter infection in humans (Price *et al.* 2007, Silbergeld *et al.* 2008).

Rearing poultry in a confined cage environment also leads to stress in birds and they become more susceptible to infection especially bacterial infections like *Campylobacter, Salmonella* and *Escherichia coli*. All these causes serious illnesses among humans (Fouad *et al.* 2008, Shields and Greger 2013). Therefore, intensive poultry farming practices are increasing the risk of introducing these pathogens in our food through multidirectional food webs (Singer *et al*. 2007). Overcrowded and unhygienic confinement of birds under intensive poultry farming facilitate the immune suppression in birds, providing more opportunities for viruses like avian influenza for their rapid spread, amplification and mutation (Gimeno and Schat 2018). Rearing poultry under these types of unhygienic environmental conditions with inadequate ventilation is thought to act as a perfect breeding ground for the emergence and spread of virulent avian influenza like diseases in near future which have major public health implications.

Open wet markets are the perfect place to spread diseases. Live-poultry markets were the source of the H5N1 bird-influenza virus that transmitted to and killed six of 18 people in Hong Kong (Mounts *et al.* 1999). Likewise, live-poultry markets in the USA have been associated with the emergence of H5 and H7 influenza viruses, which are a threat to commercial poultry (Webster 2004). The recent COVID-19 pandemic sweeping through China is believed to have started at a wet market, where fish, poultry and other animals are slaughtered on the premises. Live-poultry markets (chicken, pigeon, quail, ducks, geese, and other farm-raised fowls) are generally separated from markets dealing with red-meat or sea foods but the retail stalls can be found near to each other with practically no physical separations in between. Despite the widespread availability of affordable refrigeration, many people still prefer live animals for fresh produce. Hence, the close contacts between humans and food animals in wet markets have resulted in the transmission of many microbes from animals to humans (Woo *et al.* 2006).

Biofilm are collection of bacterial population that are firmly adhered to any surface through a self-produced matrix of extracellular polymeric substances. Biofilms survive for long and show resistance to various antibiotics and disinfectants. Poultry is a major reservoir of various pathogen such as *Salmonella* spp. and *Campylobacter* spp. These microorganisms are capable of forming biofilms thereby acting as major contaminants in the poultry industry and represents a threat to human health

too (Pometto and Demirci 2015). The poultry packing plant generates surface contaminating residue which are rich in lipids and protein. These contaminated surfaces favor the formation of biofilms of many pathogens of public health significance. The economic losses could be attributed to the food spoilage and damage caused to poultry equipment by the biofilms, and also for the damages caused in humans arising from foodborne infections (Jass *et al.* 2000).

RECOMMENDED MEASURES TO COMBAT 'ONE HEALTH' PROBLEMS

In India, the magnitude of environmental impacts of intensive poultry production (water pollution, air pollution, soil pollution etc.) can be efficiently reduced by following the national regulations and standards prescribed in the different acts such as Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Protection of Pollution) Act 1981 and Environment (Protection) Act 1986. In the year 2015, Central Pollution Control Board (CPCB) of India formulated the guidelines to address the environmental issues related with poultry farms in the country. Subsequently State Pollution Control Boards (SPCB) has implemented these guidelines in different states. These national environmental guidelines include standards and practices related to the minimization of the odour gaseous pollution problem, proper solid waste (dead birds, manure, hatchery debris) management, waste water/effluent treatment and disposal, and good housekeeping practices at poultry farms etc. According to CPCB guidelines 2015, the poultry farms which are having capacity to handle 1 lakh or more birds at a time in a single location need to approach SPCB of respective state to obtain necessary consent under Water Act, 1974 and Air Act, 1981. The commercial poultry farms which are handling more than 5,000 birds at a given time on any single location should be registered with local bodies (CPCB 2015).

A number of techniques and different management practices such as on farm management, animal waste management, nutrition management; efficient feed production, integrated pest management etc. are available to control the previously mentioned detrimental effects on environment, biodiversity and human health. The waste management practices that can and will surely take care of poultry industry waste product includes sanitary landfills, rendering facilities, extrusion machinery, compost plants, lagoons or holding tanks, and land application techniques etc. Other issues wise technical strategies may include:

1. For control of air pollution, foul odor and flies, minimize the surface of manure in contact with air *i.e.*, frequently collect litter. Dense vegetation buffer screens disperse odour from poultry farms. Ammonia gas generated during de-nitrification of manure and can be released directly into the atmosphere at any stage of the manure handling process. This gas has a sharp and pungent odor, can act as an irritant when present in elevated concentrations and can also contribute to eutrophication in surface water when gets deposited. Therefore, composting manure not only significantly reduces emissions but also eliminates certain pathogens and flies larvae, and improves the handling characteristics of manure and other residues by reducing their volume, weight and moisture content. The moisture content of composting pile should not be more than 60%, otherwise it may result in odour. Drying minimizes the moisture content of manure, inhibits chemical reactions, and thus reduces gaseous emissions too. Therefore, ensuring free flow of air over manure collection points helps to keep it dry. If necessary, certain chemicals (*e.g.*, urinase inhibitors) can also be applied to reduce conversion of nitrogen to ammonia. Lowering of moisture content in litter can also be achieved by the incorporation of hydrophilic products such as hashes, rice husk, peanut husk, dust or sawdust etc.

2. Dust can cause respiratory problems, reduce visibility and facilitate transmission of odors and diseases. For controlling dust, proper road facilities for the movement of vehicles in and around production facilities are required. Further, to minimize dust generation, dust collection systems especially in feed grinding areas should be installed, wetting of vehicle parking lots and frequently traveled unpaved roads can be another option to minimize dust generation.

3. Water and air pollution can also be prevented by storing manure in closed buildings or bags *i.e.*, holding of manure until a convenient and optimum time. Storing of poultry manure in closed buildings reduces the emissions of gaseous compounds in the air and also reduces the risk of environmental contamination as compared to the risk associated with leaving manure exposed. Proper timing and rate of manure application are the critical management factors. Manure should be applied at a particular time during the year in such a way that losses to surface water, groundwater and the atmosphere is prevented, and there is optimal utilization of manure nutrients by growing plants. Moreover, owing to its low water and high nutrient content, poultry litter makes valuable manure to agriculture and as animal feed especially for poultry.

4. Minimum sound production from poultry farm in unavoidable due to normal physiological activities of the birds. However careful site selection and farm design with adequate buffer distances to sensitive environments will minimize noise pollution.

5. Environmentally controlled poultry house is the housing system in which all the conditions are maintained as near as to the bird's optimum requirements. For instance, poor ventilation leading to accumulation of ammonia, methane, hydrogen sulphide, carbon dioxide not only affects the performance of poultry but also has detrimental health effects on workers (Verma *et al*. 2014). Therefore, the concept of environmentally controlled poultry house may prove very good opportunity to address the issues of one health.

6. Dead-bird management and disposal: There are generally some methods of dead bird disposal currently in practice *i.e.*, rendering, composing, incineration and burial. The odorless compost is very good organic manure to crops. Offsite disposal using rendering or burial is usually required during mass mortality events. Onsite disposal involving burial or incineration has implications for the management of environmentally sensitive factors including leaching of nutrients into surface or ground water, air pollution and odour generation. Therefore, off-site disposal is the best available practice along with composting.

7. Poultry feed can become unusable waste material if spilled during storage, loading, and unloading or during animal feeding. Waste feed owing to its organic content may sometime lead to contamination of rainwater runoff. Therefore, to minimize wasted feed, it is advisable to protect feed from exposure to rain and wind during processing, storage, transport and feeding. Maintaining all the operations *i.e.*, feed storage, transport and feeding systems in good working condition is very essential. Since, poultry feed primarily consists of grains, fish meal, meat and bone meal, supplements *e.g.*, amino acids, enzymes, vitamins, mineral etc. Therefore, it is better to consider mixing of waste feed with other recyclable materials destined for use as fertilizer.

8. The decrease in nutrient uptake by the poultry without affecting their growth and production can be achieved by efficient nutrition management. It can be achieved by formulating feed as per age, growth and production stage of reared poultry stock. Improvement in feed digestibility and bioavailability of nutrients can be attained through the use of uncontaminated feed and dietary supplementary enzymes *e.g.*, phytases, highly digestible genetically modified feedstuffs e.g. low-phytate maize, highly digestible synthetic amino acids and trace minerals.

9. To minimize, prevent or control the various occupational health and safety hazards, different agencies have suggested various guidelines. Some of such recommendations include proper training of personnel involved in poultry operations, use of personnel protective equipment (PPEs), ensuring implementation of hygienic practices and routine medical checkup etc.

10. Intensive poultry production units in high-income countries have approached risk management by focusing on risk characterization and using Hazard Analysis Critical Control Points (HACCP) procedures for risk management (Ventura da Silva 2013). This approach is now adopted by producers in low- and middle-income countries. The Codex Alimentarius Commission of WHO and FAO provide regulatory advice on the application of such procedures. Based on risk assessment, critical control points are identified in the poultry production chain, and adjustments in the chain will ensure the quality of final products. For instance, potential risks such as pathogenic microorganisms, their toxins, chemical residues are first identified in production chain and then their probable entry portals such as feed and feed ingredients, and environmental sources are identified as critical points at which these hazards may be controlled during poultry production.

11. Control of flies and rodents are essential component of good housekeeping practices in poultry farm. An integrated approach that ensures proper disposal of waste, correct ventilation of shed, controlled temperature, good sanitation, avoidance of fed spills, immediate repair of leakages, prompt removal of broke eggs and dead birds etc. will help to control flies in poultry farm (CPCB 2015). Further, the methods to control rodents includes exclusion, trapping, glue boards, slow/rapid killing toxic baits, tracking powder etc.

CHALLENGES

There have been various media reports on animal waste littered around poultry farms as threat to water resources, aquaculture, crops and human/animal health. But the comprehensive statistical data on such evidences is still lacking. Therefore, there is an urgent need to conduct epidemiological studies and address the issues of different pollutant generated from intensive poultry production and their effect on human/ animal population, agricultural/ aquaculture economy in India.

The One Health approach requires rigorous evidences around its practical execution. Then only it can become a way booster for addressing common health issues at

the human, animal and ecological interface. The inter-sectoral collaborations, significant resource mobilization and political co-operation required to realize this approach needs to get translated from theoretical to practical application. In most of developing countries, including India, human, animal and environmental health issues are taken up by separate sectors (Govt., NGOs, Private) with limited communications and collaborations. The concept of One Health was in its infancy in India during last decade but is increasingly growing. The Indian Government has taken some initiatives to tackle expanding problems such as emergence of zoonotic diseases, antimicrobial resistance, highly pathogenic avian influenza, vaccines for preventable diseases in poultry sector using 'One Health' initiative but still there are several challenges at the level of its implementation. Multisectoral approach involving government poultry organizations, private entrepreneurs, food safety regulatory authorities, feed manufacturers, economists, researchers, policy makers etc. is required to achieve objectives of One Health in poultry farming. Hence, to address One Health there is a need to have a collaborative, trans disciplinary approach for designing and implementing programmes, policies and legislation supported by basic and applied research.

CONCLUSION

The presence of large numbers of poultry farms in densely populated areas of developing countries of the world raises questions about the possible impact on 'One Health' *i.e.*, the health risks for neighboring residents and environment in totality. Poultry farming is by far, most profitable business especially when it comes to feed conversion efficiency and net profits. But, the intensification of this sector also simultaneously demands various associated problems of environmental pollution and zoonotic disease transmission to be taken care of with top-most priority. Generally, the impacts on different compartments of environmental due to this sector are substantial. Intensive poultry production is associated with release of variety of pollutants such as greenhouse gases, ammonia, organic materials, oxygen-demanding substances, nutrients, heavy metals, and persistent pesticides, disease causing pathogens, veterinary drug residues like antibiotics, hormones, and odor along with other airborne emissions. These pollutants have been shown to produce impacts across multiple media. Therefore, allocating considerable amount of funds for creating awareness among producers and consumers, establishing waste disposal systems and preventing environmental pollution will surely reap benefits in coming years.

REFERENCES

Anonymous (2020) Outlook India news report. Available at: https://www.outlookindia.com/newsscroll/poultry-farms-cause-pollution-cant-be-exempted-from-regulation-ngt/1938819 Accessed on 18.10.2020.

Ahuja SM (2011) Cost effective solution for carcass disposal in India. Int J Environ Sci 1(6): 1-6.

Alizon S, Hurford A, Mideo N, Van Baalen M (2009) Virulence evolution and the trade-off hypothesis: history, current state of affairs and the future. J Evol Biol 22: 245-259.

Austin B (1999) The effects of pollution on fish health. J Applied Microbiol Sympos, Supplement 85: 2348-2428.

Backhans A, Fellström C (2012) Rodents on pig and chicken farms - a potential threat to human and animal health. Infect Ecol Epidemiol 2:10.3402/iee.v2i0.17093.

BAHS (2019) Basic Animal Husbandry Statistics-2019, Government of India, Ministry of Fisheries, Animal Husbandry and Dairying, Department of Animal Husbandry and Dairying, Krishi Bhawan, New Delhi. Available at: http://dadf.gov.in/sites/default/filess/BAHS%20%28Basic% 20Animal% 20Husbandry%20Statistics-2019%29_0.pdf. Accessed on 10.09.2020.

Bickel U, Dros JM (2003) The impacts of soybean cultivation on Brazilian ecosystems –three case studies. Study commissioned by WWF Forest Conversion Initiative. Gland, Switzerland, WWF.

CPCB (2015) Central Pollution Control Board: Environmental guidelines for poultry farms. B-4032/PCI-SSI/poultry/2015. Available at: http://www.ppcb.gov.in/Attachments/Siting%20Criteria%20of%20Industries/guidelines%20poultry%20farm.pdf Accessed on 20.10.2020.

Chang C, Sommerfeldt TG, Entz T (1990) Rates of soil chemical changes with eleven annual applications of cattle feedlot manure. Can J Soil Sci 70: 673-681.

Damalas CA, Koutroubas SD (2016) Farmers' exposure to pesticides: toxicity types and ways of prevention. Toxics 4(1): 1.

Davies M, Walsh TR (2018) A colistin crisis in India. Lancet Infect Dis 18(3): 256-257.

Dei HK (2017) Assessment of maize (*Zea mays*) as feed resource for poultry. Poultry Science. Available at: https://www.intechopen.com/books/poultry-science/assessment-of-maize-zea-mays-as-feed-resource-for-poultry. Accessed on 15.10.2020.

Devi SM, Balachandar V, Lee SI, Kim IH (2014) An outline of meat consumption in the Indian population - a pilot review. Korean J Food Sci Anim Resour 4(4): 507-515.

EU (2003) Integrated pollution prevention and control: reference document on best available techniques for intensive rearing of poultry and pigs. Brussels, European Commission.

FAO (2020) Gateway to poultry production and products. Available at: http://www.fao.org/poultry-production-products/production/en/. Accessed on 15.09.2020.

Fisher DJ, Staver KW, Yonkos LT, Ottinger MA, Pollack S (2005) Poultry litter-associated contaminants: environmental fate and effects on fish. Report to Maryland Centre for Agro-Ecology Inc, Queenstown, USA. Available at: http://www.agroecol.umd.edu/files/D.%20Fisher%20Poultry%20Litter%20Effects%20on%20Fish.pdf. Accessed on 07.08.2020.

Fouad MA, Razek AHA, Badawy SM (2008) Broilers welfare and economics under two management alternatives on commercial scale. Int J Poul Sci 7: 1167-1173.

Fraser D (2008) Animal welfare and the intensification of animal production. In: Thompson PB (Eds.) The ethics of intensification. The international library of environmental, agricultural and food ethics, vol 16. Springer, Dordrecht.

Freedman R, Fleming R (2003) Water quality impacts of burying livestock mortalities. Paper presented to the Livestock mortality recycling project steering committee. Ridgetown, Canada, Ridgetown college/University of Guelph. Available at: http://www.ridgetownc.on.ca/research/documents/fleming_carcassburial.pdf. Accessed on 26.08.2020.

Gerber P, Opio C, Steinfeld H (2007) Poultry production and the environment—a review. Animal production and health division, Food and Agriculture Organization of the United Nations; Rome, Italy.

FAO publishing Web. Available at: http://www.fao.org/ag/againfo/home/events/bangkok2007/docs/part2/2_2.pdf. Accessed on 26.08.2020.

Gilbert M, Conchedda G, Van Boeckel TP, Cinardi G, Linard C *et al.* (2015) Income disparities and the global distribution of intensively farmed chicken and pigs. PLoS One 10(7): e0133381.

Gilbert M, Xiao X, Robinson TP (2017) Intensifying poultry production systems and the emergence of avian influenza in China: a 'One Health/Ecohealth' epitome. Arch Public Health 75: 48.

Gimeno IM, Schat KA (2018) Virus-induced immunosuppression in chickens. Avian Dis 62(3): 272-285.

Gravinatti ML, Barbosa CM, Soares RM, Gregori F (2020) Synanthropic rodents as virus reservoirs and transmitters. Rev Soc Bras Med Trop 53: e20190486.

Gupta G, Charles S (1999) Trace elements in soils fertilized with poultry litter. Poult Sci 78: 1695-1698.

Hamid A, Ahmad AS, Khan N (2018) Respiratory and other health risks among poultry-farm workers and evaluation of management practices in poultry farms. Brazilian J Poultry Sci 20(1): 111-118.

Han SH, An JY, Hwang J, Kim SB, Park BB (2016) The effects of organic manure and chemical fertilizer on the growth and nutrient concentrations of yellow poplar (*Liriodendron tulipifera* Lin.) in a nursery system. Forest Sci Technol 12(3): 137-143.

Hanson LA, Grizzle JM (1985) Nitrite-induced predisposition of channel catfish to bacterial diseases. Progressive Fish Culturist 47: 98-101.

ICFA (2016) Indian meat market, Indian Council of Food and Agriculture. Available at: https://www.icfa.org.in/assets/doc/reports/Indian_Meat_Market.pdf. Accessed on 10.09.2020.

IEEP (2005) The environmental impacts of trade liberalization and potential flanking measures. Stage 1 of a report to DEFRA. Institute for European Environmental Policy, London.

Jackson A (2007) Challenges and opportunities for the fishmeal and fish oil industry. Feed Technology Update 2(1): 01-09,

Jass J, Walker J (2000) Biofilms and biofouling. In: Walker J, Surmanand S, Jass J (Eds.) Industrial biofouling: detection, prevention and control. New Jersey: John Wiley & Sons. 1–12.

Keelery S (2020) Consumption volume of poultry meat in India from 2013 to 2020. Available at: https://www.statista.com/statistics/826711/india-poultry-meat-consumption/. Accessed on 15.10.2020.

Kolominskas C, Bawden K, Ormerod R (2002) Strategies to reduce odour emissions from meat chicken farms. In Proceedings 2002 Poultry Information Exchange 27–39. Available at: http://www.fsaconsulting.net/pdfs/PIX%20Odour.PDF. Accessed on 07.08.2020.

Kumar A, Patyal A, Panda AK (2018a) Sub-therapeutic use of antibiotics in animal feed and their potential impact on environmental and human health: a comprehensive review. J Anim Feed Sci Technol 6(1): 15-25.

Kumar A, Sharma D, Kumar R (2018b) Zoonoses at the human-avian interface: a review. BAOJ Vet Sci 2: 005.

Kumar A, Thakur A, Sharma V, Koundal S (2019) Pesticide residues in animal feed: status, safety and scope. J Anim Feed Sci Technol 7(2): 73-80.

Kyakuwaire M, Olupot G, Amoding A, Nkedi-Kizza P, Basamba TA (2019) How safe is chicken litter for land application as an organic fertilizer?A review. Int J Environ Res Public Health 16(19): 3521.

Lemly AD (1997) Role of season in aquatic hazard assessment. Environ Monit Assess 45: 89-98.

Manitoba (2013) Manitoba government policy document, effects of manure and fertilizer on soil fertility and soil quality. Available at: https://www.gov.mb.ca/agriculture/environment/nutrient-management/pubs/effects-of-manure%20-fertilizer-on%20soil%20fertility-quality.pdf. Accessed on 17.10.2020.

Mcleod A, Thieme O, Mack SD (2009) Structural changes in the poultry sector: will there be smallholder poultry development in 2030? World Poultry Sci J 65: 191-200.

Mellergaard S, Nielsen E (1995) Impact of oxygen deficiency on the disease status of common dab *Limanda limanda*. Diseases Aquatic Organisms 22(2): 101-114.

Mounts AW, Kwong H, Izurieta HS (1999) Case-control study of risk factors for avian influenza A (H5N1) disease, Hong Kong. J Infect Dis 180: 505-508.

Nachman KE, Graham JP, Price LB, Silbergeld EK (2005) Arsenic: a roadblock to potential animal waste management solutions. Environ Health Perspect 113(9): 1123-1124.

Nichols DJ, Daniel TC, Moore PA Jr, Edwards DR, Pote DH (1997) Runoff of estrogen hormone 17β estradiol from poultry litter applied to pasture. J Environ Qual 26 (4): 1002–1006.

Peiris JSM, de Jong MD, Guan Y (2007) Avian influenza virus (H5N1): a threat to human health. Clin Microbiol Rev 20: 243-267.

Pometto AL, Demirci A (2015) Biofilms in the food environment. 2 nd edn. New Jersey: John Wiley & Sons 320.

Price LB, Lackey LG, Vailes R, Silbergeld E (2007) The persistence of fluoroquinolone-resistant Campylobacter in poultry production. Environ Health Perspect 115(7): 1035-1039.

Rabinowitz PM, Odofin L, Dein FJ (2008) From “us vs. them” to “shared risk”: can animals help link environmental factors to human health? EcoHealth 5(2): 224-229.

Ramirez CA, Patel M, Blok K (2004) How much energy to process one pound of meat? A comparison of energy use and specific energy consumption in the meat industry of four European countries. Energy 31: 2047-2063.

Ritter WF, Chirnside AEM, Harris JR (1988) Impact of dead bird disposal on groundwater quality. Paper presented at the International winter meeting of the American society of agricultural engineers, Chicago, USA, Dec. 3–16. St. Joseph, USA.

Rutherford DW, Bednar AJ, Garbarino JR, Needham R, Staver KW *et al.* (2003) Environmental fate of roxarsone in poultry litter. Part II. Mobility of arsenic in soils amended with poultry litter. Environ Sci Technol 37: 1515-1520.

Shields S, Greger M (2013) Animal welfare and food safety aspects of confining broiler chickens to cages. Animals (Basel) 3(2): 386-400.

Shore LS, Shemesh M (2003) Naturally produced steroid hormones and their release into the environment. Pure Appl Chem 75(11-12): 1859-1871.

Silbergeld EK, Graham J, Price LB (2008) Industrial food animal production, antimicrobial resistance, and human health. Annu Rev Public Health 29(1): 151-169.

Singer RS, Cox LA, Dickson JS, Hurd HS, Phillips I *et al.* (2007) Modelling the relationship between food animal health and foodborne illnesses. Preventive Veterinary Medicine 79: 186-203.

Steinfeld H (2004) The livestock revolution–a global Veterinary mission. Vet Parasitology 125(1-2): 19-41.

Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M *et al.* (2006) Livestock’s long shadow: environmental issues and options. FAO, Rome.

Street ME, Angelini S, Bernasconi S, Burgio E, Cassio A *et al.* (2018) Current knowledge on endocrine disrupting chemicals (EDCs) from animal biology to humans, from pregnancy to adulthood: highlights from a national Italian meeting. Int J Mol Sci 19(6):1647.

Thakur A, Kumar A, Sharma M, Kumar R, Vanita B (2019) Strategies to minimize the impact of antibiotic resistance in livestock production system. Int J Curr Microbiol App Sci 8(3): 2293-2310.

United Nation (2019) Elaboration of data by United Nations, department of economic and social affairs, population division. World population prospects: the 2019 revision. (Medium-fertility variant). Available at: https://www.worldometers.info/world-population/india-population/. Accessed on 15.10.2020.

Ventura da Silva M (2013) Poultry and poultry products—risks for human health. Poultry development review, FAO. Available at: http://www.fao.org/docrep/013/al742e/al742e00.pdf. Accessed on 12.07.2020.

Verheijen LAHM, Wiersema D, Hulshoff PLW, De Wit J (1996) Management of waste from animal product processing. Working document livestock and the environment: finding a balance. FAO/World Bank/USAID, Rome.

Verma KK, Singh V, Gupta SL, Yadav J, Verma AK (2014) Environmentally controlled house – in poultry production. Poultry Line 1: 29-32.

Walia K, Sharma M, Vijay S, Shome BR (2019) Understanding policy dilemmas around antibiotic use in food animals and offering potential solutions. Indian J Med Res 149(2): 107-118.

Wassenaar T, Gerber P, Verburg PH, Rosales M, Ibrahim M *et al.* (2007) Projecting land use changes in the neotropics: the geography of pasture expansion into forest. Global Environmental Change 17(2): 86-104.

Webster RG (2004) Wet markets - a continuing source of severe acute respiratory syndrome and influenza? Lancet 363(9404): 234-236.

Woo PC, Lau SK, Yuen KY (2006) Infectious diseases emerging from Chinese wet-markets: zoonotic origins of severe respiratory viral infections. Curr Opin Infect Dis 19(5): 401-407.

***Cite this article as:** Kumar A, Patyal A (2020) Impacts of intensive poultry farming on 'One Health' in developing countries: challenges and remedies. Explor Anim Med Res 10(2): 100-111.