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Research Article
Impact of Proper Sanitation, Hygiene Practices, Environmental Condition and Water Quality on Disease Incidence in Poultry, Bangladesh

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Abstract

Background and Objective: Poultry farming can provide gainful employment to poultry workers throughout the year in Bangladesh. To run successful poultry production, sanitation and waste management practices should be deliberately practiced to avoid a high rate of disease incidence. This study was conducted to assess disease incidence, the sanitation condition of the farms, personal awareness of workers and waste management practices in small scale commercial poultry farms in Mithapukur Upazila, Rangpur. **Materials and Methods:** The current study was conducted on twenty poultry farms in Mithapukur Upazila, Rangpur, Bangladesh from January-December 2019 to determine disease incidence in poultry, to monitor environmental conditions and to assess the water quality along with sanitation condition of small scale commercial poultry farms by structured questionnaire survey through personal interview. **Results:** The maximum disease incidence (DI) was recorded 18.23% in January while the minimum DI was recorded 7.22% in May. Minimum DI was found in those farms where workers used deep tube-well water whereas municipal supply water and tube-well water user had higher DI in poultry. Out of 20 poultry farms, 85% farms did not meet the required level of hygienic condition where DI was found to be in maximum level, however, 15% farms were found to follow the proper sanitation protocols where DI were in a minimal level. **Conclusion:** It could be concluded that the sanitation condition of the farms, water quality and personal awareness of workers along with their hygiene practices reduce disease incidence of poultry flocks and improve poultry production husbandry practices.

Key words: Disease incidence, poultry farms, sanitation and hygiene practices, water quality, environmental condition, biosecurity, poultry flocks

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The poultry sector is an important avenue in promoting agricultural growth in Bangladesh that can reduce the problem of malnourishment in the people of this country[1]. This sector is a requisite part of farming systems and has given the employment opportunity to about 6 million people either directly or indirectly[2], improved food security and enhanced supply of quality protein, minerals and vitamins to people's meals, contributing country's economic growth and reducing the poverty level in rural and urban areas of Bangladesh[2]. Though the growth of the poultry industry has emerged and intensified around the world, with China, Russia and India ranked among the top poultry-producing countries[3], the bright prospect of Bangladesh's poultry sector growth has also been reflected nowadays[4]. Bangladesh's poultry sector is gearing up to export eggs and poultry meat by 2024 to the big market especially the Middle East. The sector has nearly closed the gap between the domestic demand with a growing supply of both eggs and meat as the country's poultry farms are growing at a faster rate of 15% a year[2]. The total investment in this poultry sector was only BDT 15 thousand million in the 90s whereas this sector having Tk 35,000 core investments is expected to double in the next decade[2]. Bangladesh's poultry sector commercially produces 10.22 billion eggs and 1.46 million tons of poultry meat annually where 1 million entrepreneurs and 8 million people involved, however, 17 billion eggs, 2 million tons of poultry meat, 85.8 million day-old chicks and 7.9 million MT of feed will be required to meet the demand of the people of this country by 2021[2]. Recent data showed that 15.52 billion eggs have already been produced against the current annual demand of 17.13 billion in Bangladesh. Bangladesh's poultry sector meets the demand of 36% of total protein intake through meat and egg consumption and provides about 22-27% of the total animal protein supply in this region[1].

Poultry farming can be the main source of family income and can provide gainful employment to smallholder poultry workers throughout the year[2]. To run successful poultry production in small scale commercial farms, sanitation and waste management practices should be deliberately practiced in day to day activities[5]. Poor sanitation standards are considered as a risk factor for professional poultry operations[3]. Proper measures need to be put into place to avoid disease occurrence in poultry. Following a disease outbreak or the emergence of a more pathogenic form of a given disease can cause severe economic losses in large farms of higher bird density[6]. Contaminated water source serving thousands of chicken in poultry farms can contribute to disease occurrence that would certainly result in great economical losses[7]. Biosecurity measures must be the first line of defense to fight against these disease-causing agents. The knowledge and proper maintenance of biosecurity are essential for ensuring the health and productivity of livestock within an enterprise, region and country[8]. Biosecurity measures are implemented in poultry farms to avoid the risk of human health and economic losses[9]. Moreover, biosecurity measures are administered in farms to prevent the initiation, persistence or spreading of pathogenic agents, through isolation and sanitation measures[9]. Lack of proper biosecurity measures is responsible for the occurrence of infectious diseases, such as Newcastle disease or zoonosis such as Highly Pathogenic Avian Influenza (HPAI) in poultry farms[10].

It is quite difficult to keep a commercial poultry facility completely disease-free though all prevention and control measures are taken. Sanitation of equipment, housing, protective clothing for poultry workers and sustaining personal hygiene is used for the destruction of disease agents[5]. Though different disinfectants can be used to sanitize the poultry house, it must be chosen cautiously to avoid problems with newly introduced flocks[11]. Confined poultry housing can produce large amounts of waste, which may contain substantial quantities of pathogens. Much of this waste is being disposed of in the environment untreated and which may pose an infection risk for both domestic and wild animals and birds[12]. Poultry wastes have been associated with environmental pollution and threat to human health[12] also stated that, the nutrients and organisms in poultry wastes pose little environmental threat when proper land application conditions are implemented[5].

There are some small-scale commercial poultry farms in and around Rangpur city, Bangladesh. There is no well-documented information about disease incidence of poultry and the sanitation and waste disposal practices undertaken in these farms. However, the availability of information is very crucial for better poultry production. Therefore, this study was conducted to assess disease incidence, the sanitation condition of the farms, personal awareness of workers and waste management practices in small scale commercial poultry farms in Mithapukur Upazila, Rangpur.

MATERIALS AND METHODS

Study design: This study was conducted in different poultry farms of Mithapukur Upazila in Rangpur surveyed from January-December, 2019. The survey was conducted to ascertain the sanitation condition of the farms and personal awareness of workers as well as their waste management

system to reduce the contamination of the environment and public health. This study also explained the relationship between hygiene and sanitation condition along with environmental conditions with a disease incidence of poultry. This structured questionnaire-based survey was conducted in poultry farms that were selected purposively, based on the objectives of the study. The study considered all types of poultry farms like a broiler, layer and cock. Data were collected from primary sources and accomplished by direct interviews with the respondent once per month. The survey was conducted based on the following questionnaires:

- Working condition in poultry farms
- Sources of water
- Hygienic and sanitation conditions of the poultry farms
- Types of sanitizer used
- Room condition
- Disease occurrence
- Hygienic status of workers
- Poultry litter management system. This study was conducted by the Bangladesh Council of Scientific and Industrial Research (BCSIR)

Study area: This prospective cohort study was conducted in twenty poultry farms (n = 20) of Mithapukur Upazila in Rangpur (Fig. 1)[13]. This study area was selected as this type of study was not conducted previously here.

Eligibility and enrollment of poultry farms: The poultry farms were surveyed those met the following study eligibility criteria:

- Selected poultry farms covered the area of Mithapukur Upazila, Rangpur

Fig. 1: Location of poultry farms in Mithapukur Upazila, Rangpur, Bangladesh[13]

- A large number of poultry flocks were nourished in these farms
- One type of poultry flocks were raised in each farm
- Cooperation of the poultry farm owner
- Well-communication system of the poultry farms. The poultry farms that raised different types of poultry altogether were excluded from the study. These farms were enrolled for twelve months

Data collection: All poultry farms enrolled were followed prospectively from January-December, 2019. The poultry farm owners and workers were interviewed personally and data were collected using an interview schedule and collected data were on water sources, used sanitizer, hygiene protocol and type of poultry in those farms. These questions were all asked as open-ended questions with multiple responses allowed.

Statistical analysis: Data were compiled, tabulated and analyzed by the objectives of the research. Descriptive statistics were reported as mean, standard deviation along with percentage and were determined using Microsoft Excel (Version 14.0, Microsoft, Corp, Redmond, WA). For the testing association between categorical data, Pearson's chi-square test was used. Pearson's chi-square test was performed using Microsoft Excel. A two-tailed p-value $p<0.05$ was considered statistically significant.

Ethical approval: Informed consent was obtained from all study respondents.

RESULTS

A total of 20 poultry farms were followed prospectively for 12 months. The main source of water for sixty percent of poultry farms were tube-well (n = 12/20, 60%), however rest of the farms used municipal supply water (n = 4/20, 20%) and water from deep tube-well (n = 4/20, 20%). The maximum DI was recorded 18.23% at 14°C where RH was recorded 77.9% in January while the minimum DI was recorded 7.22% at 35°C where RH was 80.9% in May. 45% (n = 9/20) of the poultry farms raised the Sonali, where the layer and cock raising farms were in equal percentage (n = 4/20, 20%) however the least percentage (n = 3/20, 15%) was found for the broiler. Of 20 farms, 85% (n = 17/20) of poultry farms did not meet the required level of the proper hygiene and sanitation condition along with waste management system where DI of poultry chicks were found to be in maximum level. However, 15% (n = 3/20) farms were found to follow the proper hygiene and sanitation protocols along with proper waste (litter) management system where DI was found to be in minimal level.

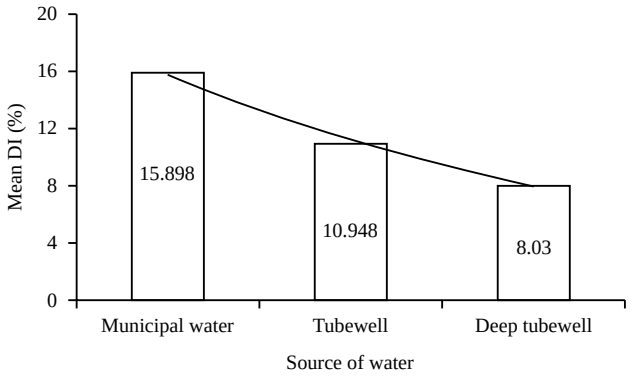


Fig. 2: Correlation of DI (%) in poultry flocks and source of water
Minimum DI was found in those poultry farms where deep tube-well water (8.03%) was used rather than tube-well water (10.948%). However, maximum DI was found in municipal water user (15.898%)

Types of poultry in poultry farms: Survey data showed that different types of poultry (broiler, Sonali, layer and cock) were raised for meat and egg production (Table 1). One type of poultry flocks was raised on each different farm.

Hygiene and sanitation status of the poultry farms: The status of the cleanliness of the yard of all poultry farms was good. Sanitizers (timsen, glutex, lifeline, etc) were used for sanitary practices. Municipal supply water, tube-well water or deep tube-well water was directly used as water sources. None of the water purification methods was followed in any farms. The maximum mean DI (27.46%) was recorded in poultry farm 7 and the minimum mean DI (3.96%) was in poultry farm 6 and farm 20 where hygiene and sanitation condition were relevant to disease incidence. The ranges of DI (%) were recorded as 3.96-27.46% for tube-well water, 9.12-23.33% for municipal supply water and 3.96-12.71% for deep tube-well water (Table 2). Minimum DI was found in those poultry farms where workers used deep tube-well water (8.03%) whereas tube-well water and municipal water user had higher DI in poultry (DI = 10.948% and 15.898% respectively) (Fig. 2).

Room condition of the farms: Room conditions of the farms were satisfactory. Rooms were made of brick and well ventilated where sufficient aeration and sunlight prevailed. The rooms were cleaned regularly. In January, the ranges of temperature were recorded 10.9-15.2°C and relative humidity

Table 1: Types of poultry flocks in study areas of Rangpur

Poultry farms	Location	Types of flocks	Aim of nourished
1	Ranipukur	Sonali	Meat
2	Khoragachh	Sonali	Meat
3	Kafrikhal	Sonali	Meat
4	Moyenpur	Sonali	Meat
5	Emadpur	Sonali	Meat
6	Mirzapur	Layer	Egg and meat
7	Mirzapur	Sonali	Meat
8	Bera Hazratpur	Cock	Meat
9	Durgapur	Layer	Egg and meat
10	Gopalpur	Cock	Meat
11	Palipara	Sonali	Meat
12	Barabala	Layer	Egg and meat
13	Milonpur	Sonali	Meat
14	Baluamasimpur	Sonali	Meat
15	Daulat Nupur	Broiler	Meat
16	Pairaband	Cock	Meat
17	Bhangni	Cock	Meat
18	Chengmari	Layer	Egg and meat
19	Latifpur	Sonali	Meat
20	Balarhat	Sonali	Meat

Table 2: Correlation of DI (%) in poultry flocks and hygiene status of farms and poultry workers

Poultry farms	Cleanliness of yard	Used sanitizer	Water sources	Personnel hygiene	Toilet facilities	Waste management (L)	Satisfactory scale	Mean disease incidence (%)
1	+	+ +	Municipal Water	+	++	-	NS	15.63
2	+	+ +	Municipal Water	++	+++	+	NS	9.12
3	+	+ +	Municipal Water	-	+	-	NS	23.33
4	+	+ +	Municipal Water	++	+++	++	NS	15.51
5	+	+ +	Tubewell	+	++	+	NS	7.54
6	+	+ + +	Tubewell	+++	+++	++	S	3.96
7	-	-	Tubewell	-	+	-	NS	27.46
8	+	+ +	Tubewell	+	++	++	NS	10.42
9	+	+ + +	Tubewell	+++	+++	++	S	5.8
10	+	+ +	Tubewell	+	++	+	NS	10.83
11	+	+ +	Tubewell	++	++	-	NS	8.11
12	+	+ +	Tubewell	+	++	+	NS	6.67
13	+	+ +	Tubewell	+	++	+	NS	7.92
14	+	+ +	Tubewell	+	+++	+	NS	8.33
15	+	+ +	Tubewell	+	++	+	NS	24.34
16	+	+ +	Tubewell	-	++	+	NS	10.0
17	+	+ +	Deep Tubewell	+	++	+	NS	12.71
18	+	+ + +	Deep Tubewell	+++	+++	++	S	5.8
19	+	+ + +	Deep Tubewell	+	++	+	NS	9.65
20	+	+ +	Deep Tubewell	+	++	+	NS	3.96

Good = +++: Moderate = ++: Poor = +: None = –: S = Satisfactory, NS: Not satisfactory

was 76-79.2% and DI was 5-47.5% in poultry farms (Table 3, 4 and Fig. 3). In February the ranges of temperature were 16.0-20°C and RH was 72.0-76.9% and DI was 4.56-26.36% (Table 3, 4 and Fig. 3). In March the ranges of temperature were 27.0-29.5°C and RH was 64.0-68.2% and DI was 0-39.47% (Table 3, 4 and Fig. 3). In April the range of temperature were 32.0-35.0°C and RH was 65.0-68.2% and DI was 0-28.95%. In May the ranges of temperature were 34.0-36.9°C and RH was 79.0-82.5% and DI was 0-18.18%. In June the ranges of temperature were 35.0-36.2°C and RH was 82.0-84.2% and DI was 0-21.05% (Table 3, 4 and Fig. 3). In July the range of temperature were 27.8-31.2°C and RH was 82-88.1% and DI was 2.5-20.45%. In August the ranges of temperature were 28.32 °C and RH was 86-88.9% and DI was 2.5-34.10%. In September the range of temperature were 27.0-37.1°C and RH was 84.0-87.3% and DI was 2.27-22.34%. In October the range of temperature were 26.0-28.9 °C and RH was 75.4-79.1% and DI was 5-34.1%. In December the ranges of temperature were 18.0-20.1°C and RH was 75.6-86.3% and DI was 7.14-38.64%. A higher rate of DI had been found at lower ambient temperature and a lower rate of DI was in relative higher temperature though RH had been no profound effect on DI.

Table 3: Disease incidence (%) in different poultry farms of Mithapukur Upazila, Rangpur from January-December, 2019

Poultry farms	Number of chicks examined	Number of diseased chicks (%)													
		January	February	March	April	May	June	July	August	September	October	November	December	Mean DI (%)	SD
1	32	8 (25)	5 (15.62)	3 (9.37)	3 (9.37)	4 (12.5)	3 (9.37)	4 (12.5)	3 (9.37)	5(15.62)	5 (15.62)	8 (25)	9 (28.13)	15.63	7.46038
2	30	5(16.67)	4 (13.33)	2 (6.67)	2 (6.67)	3 (10)	3 (10)	3 (10)	2 (6.67)	2 (6.67)	1 (3.33)	2 (6.67)	4 (13.33)	9.12	3.79394
3	40	19 (47.5)	12 (30)	8 (20)	9 (22.5)	5 (12.5)	5 (12.5)	7 (17.5)	6 (15)	6 (15)	8 (20)	10 (25)	17 (22.5)	23.33	11.3984
4	36	10 (27.78)	5 (13.89)	7 (19.44)	3 (8.33)	4 (11.11)	3 (8.33)	4 (11.11)	3 (8.33)	6 (16.67)	5 (13.89)	8 (22.22)	9 (25)	15.51	6.74807
5	42	5 (11.90)	3 (7.14)	5 (9.52)	2 (4.76)	2 (4.76)	2 (4.76)	3 (7.14)	3 (7.14)	2 (4.76)	3 (7.14)	5 (11.90)	3 (7.14)	7.54	2.58006
6	40	3 (7.5)	3 (7.5)	1 (2.5)	1 (2.5)	0	0	1 (2.5)	1 (2.5)	2 (5)	2 (5)	2 (5)	3 (7.5)	3.96	2.70906
7	44	20 (45.45)	16 (26.36)	7 (15.91)	10 (22.73)	8 (18.18)	11 (25)	9 (20.45)	15 (34.10)	7 (15.91)	10 (22.73)	15 (34.10)	17 (38.64)	27.46	9.85709
8	32	6 (18.75)	4 (12.5)	5 (15.63)	2 (6.25)	3 (9.38)	2 (6.25)	3 (9.38)	3 (9.38)	2 (6.25)	3 (9.38)	3 (9.38)	4 (12.5)	10.42	3.84661
9	44	5 (11.36)	2 (4.56)	0	3 (6.82)	0	2 (4.56)	2 (4.56)	3 (6.82)	1 (2.27)	2 (4.56)	4 (9.09)	4 (9.09)	5.8	3.53863
10	30	5 (16.67)	4 (13.33)	5 (16.67)	2 (6.67)	2 (6.67)	3 (10)	3 (10)	3 (10)	2 (6.67)	3 (10)	4 (13.33)	3 (10)	10.83	3.51763
11	38	5 (13.16)	3 (7.89)	5 (13.16)	2 (5.26)	2 (5.26)	2 (5.26)	3 (7.89)	3 (7.89)	2 (5.26)	3 (7.89)	3 (7.89)	4 (10.53)	8.11	2.85164
12	40	3 (7.5)	4 (10)	2 (5)	0	3 (7.5)	2 (5)	2 (5)	2 (5)	4 (10)	3 (7.5)	3 (7.5)	4 (10)	6.67	2.88675
13	40	5 (12.5)	3 (7.5)	5 (12.5)	3 (7.5)	2 (5)	2 (5)	3 (7.5)	3 (7.5)	2 (5)	2 (5)	4 (10)	4 (10)	7.92	2.7866
14	40	5 (12.5)	3 (7.5)	5 (12.5)	4 (10)	2 (5)	2 (5)	3 (7.5)	3 (7.5)	2 (5)	3 (7.5)	5 (12.5)	3 (7.5)	8.33	2.88675
15	38	12 (31.58)	10 (22.32)	15 (39.47)	11 (28.95)	5 (13.16)	8(21.05)	5 (13.16)	7 (18.42)	10 (22.32)	8 (21.05)	10 (22.32)	10 (22.32)	24.34	7.53778
16	35	5 (14.29)	3 (8.57)	5 (14.29)	4 (11.43)	2 (5.71)	2 (5.71)	3 (8.57)	3 (8.57)	2 (5.71)	4 (11.43)	4 (11.43)	5 (14.29)	10.00	3.33642
17	40	8 (20)	5 (12.5)	7 (17.5)	5 (12.5)	4 (10)	6 (15)	4 (10)	4 (10)	3 (7.5)	5 (12.5)	4 (10)	6 (15)	12.71	3.60844
18	46	3 (6.52)	4 (8.70)	2 (4.35)	0	3 (6.52)	2 (4.35)	2 (4.35)	2 (4.35)	4 (8.70)	3 (6.52)	3 (6.52)	4 (8.70)	5.8	2.51022
19	38	8 (21.05)	4 (10.53)	3 (7.89)	2 (5.26)	3 (7.89)	2 (5.26)	3 (7.89)	3 (7.89)	4 (10.53)	3 (7.89)	4 (10.53)	5 (13.16)	9.65	4.24824
20	40	2 (5)	4 (10)	1 (2.5)	1 (2.5)	0	0	1 (2.5)	1 (2.5)	2 (5)	2 (5)	2 (5)	3 (7.5)	3.96	2.91125
Mean DI (%)	-	18.63	12.49	12.24	9	7.22	8.12	8.98	9.45	9	10.2	13.27	14.64	-	-
SD	-	4.2740151	2.8654025	2.8080486	2.0647416	1.65638	1.862856	2.060153	2.167979	2.0647416	2.34004	3.0443468	3.3586463	-	-

Table 4: Room temperature (Temperature °C), relative humidity (RH%) and Disease Incidence (DI %) in different poultry farms of Mithapukur Upazila, Rangpur from January-December, 2019

Name of farms	January		February		March		April		May		June		July		August		September		October		November		December	
	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)	Tem. (°C)	R.H (%)
1	15.0	77.0	16	72.0	27.5	64	32.0	65.0	34	79.0	35.2	82.0	29.8	84.0	30	87.8	31.0	85.2	28	88.2	23	78.2	19.8	82.1
2	14.8	79.0	16.7	74.0	29.5	68.2	35.0	68.7	37	82.5	36.3	84.2	30.5	82.3	30	87.0	29.2	84.0	26.5	87.0	23	77.0	18.1	81.0
3	13.0	76.9	19	76.9	28.0	65.3	32.1	65.3	33	79.2	35.0	85.0	30.0	84.8	31	88.0	31.2	85.3	28.2	87.2	29	78.1	20.1	80.5
4	15.2	77.5	18	73.0	27.3	65.0	32.0	66.7	34	80.0	35.2	86.0	29.4	88.1	29	86.5	29.8	84.5	28.9	88.4	22	76.1	18.0	86.3
5	13.9	78.3	20	75.0	28.3	66.4	34.2	65.9	36	81.4	36.0	84.3	28.5	83.5	32	88.8	31.5	85.4	27.1	86.1	23	75.4	18.2	78.9
6	15.0	79.2	18	74.1	27.0	66.0	34.0	66.4	36	80.0	35.3	83.4	28.9	84.9	31	87.5	30.4	85.0	27.0	87.2	23	76.4	19.0	79.5
7	11.2	77.4	18	73.2	28.1	67.1	34.5	65.9	36	80.2	35.1	84.0	29.5	85.6	32	88.9	32.3	87.3	28.8	88.8	24	79.1	17.8	82.5
8	15.1	76.8	19	72.9	28.3	66.5	32.3	65.4	35	81.9	36.2	85.1	30.0	84.5	31	88.1	31.1	85.7	27.7	86.7	22	77.5	18.5	78.2
9	14.6	78.4	19	74.4	27.6	64.5	32.6	67.0	35	82.0	35.8	89.0	30.1	82.3	30	87.1	30.2	84.8	26.0	85.0	21	76.1	18.7	79.5
10	13.3	76.0	19	72.9	28.6	64.4	32.8	67.0	37	80.1	35.9	82.5	30.8	83.0	31	87.5	31.0	85.3	27.6	86.8	22	76.7	19.1	78.6
11	12.2	78.5	19	72.5	28.0	64.3	34.6	65.2	37	81.4	35.0	83.1	31.0	84.7	29	87.8	31.8	86.1	26.2	86.5	23	75.8	18.2	80.5
12	12.0	77.9	19	73.4	28.4	65.3	32.1	64.9	34	82.0	36.1	84.0	29.8	85.1	31	88.7	32.1	85.9	27.1	85.5	22	76.5	18.7	78.6
13	15.1	77.8	17	73.4	28.5	67.0	34.1	67.8	34	83.0	35.7	83.2	28.6	84.5	28	88.0	37.1	86.2	27.8	87.1	23	76.8	19.4	77.9
14	14.0	77.4	19	74.0	27.3	65.5	32.7	68.2	36	82.4	35.9	83.9	29.4	82.7	28	88.1	28.1	85.8	26.7	86.3	22	75.2	18.4	77.8
15	10.9	78.9	19	73.3	27.1	65.3	34.9	68.0	35	80.0	35.4	84.1	30.8	85.0	28	87.4	32.2	87.1	27.9	87.2	23	77.1	17.8	81.5
16	13.5	76.7	19	74.2	28.8	64.9	32.4	67.3	37	79.9	35.6	83.8	31.2	84.6	30	86.2	31.4	86.5	28.0	85.8	21	75.6	19.5	77.5
17	12.9	78.7	19	72.9	27.2	65.8	32.0	67.0	36	81.0	36.2	83.1	30.8	83.9	30	86.7	27.0	84.2	27.1	86.5	22	75.4	18.7	80.4
18	11.4	76.7	17	74.1	28.0	64.7	34.8	67.2	35	80.1	36.0	83.7	29.1	84.4	30	86.0	29.8	86.1	26.5	85.7	21	76.1	18.4	79.4
19	14.8	79.1	19	73.4	27.6	65.0	32.2	68.0	36	81.0	35.2	82.7	28.9	85.1	31	87.0	30.0	84.7	26.7	85.6	22	75.8	18.6	77.8
20	13.2	78.9	18	73.7	27.5	65.3	34.0	67.5	36	79.8	36.0	83.1	27.8	84.6	28	87.8	27.2	84.8	26.1	85.4	22	76.7	18.4	78.7
Mean	14.0	77.9	18	73.7	28.0	65.5	33.0	66.7	35	80.9	36.0	84.0	30.0	84.4	30	87.5	31.0	85.5	27.0	86.7	23	76.6	19.0	79.9
SD	1.43	0.97	1.02	1.04	0.65	1.07	1.15	1.16	1.2	1.17	0.44	1.5	0.94	1.3	1.3	0.82	2.15	0.9	0.86	1.03	1.7	1.03	0.64	2.16

Temp: Temperature (°C), RH: Relative humidity (%)

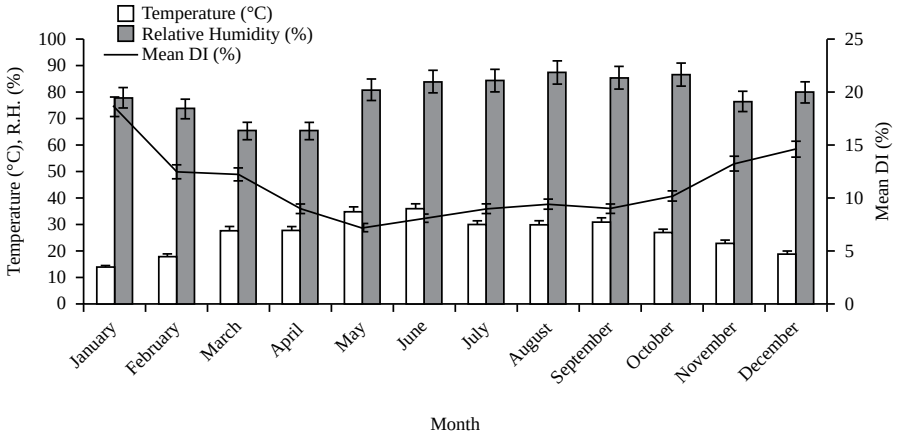


Fig. 3: Relationship of DI (%) in poultry flocks with temperature

Temperature (°C) and RH (%) from January-December, 2019. The maximum DI was 18.23% at 14°C where RH was recorded 77.9% in January while the minimum DI was recorded 7.22% at 35°C where RH was 80.9% in May

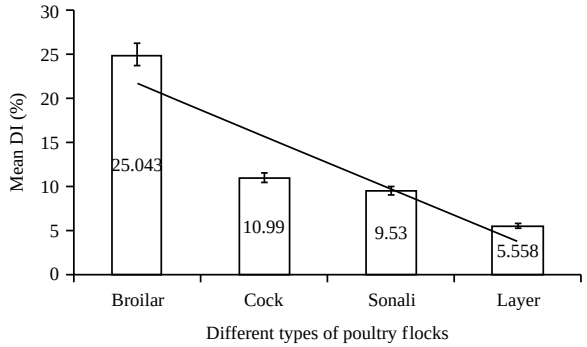


Fig. 4: DI in different poultry flocks

Broiler was more prone to be infected by disease agent (25.043%) rather than cock (10.99%), Sonali (9.53%) and layer (5.558%)

The maximum DI recorded was 18.23% at 14°C where RH was recorded 77.9% in January while the minimum DI was recorded 7.22% at 35°C where RH was 80.9% in May (Table 3, 4 and Fig. 3).

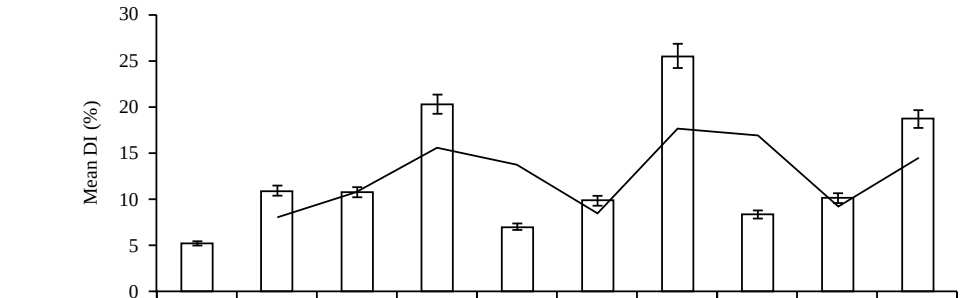
Occurrence of disease in poultry chicks in farms: For identifying the diseased poultry flocks, clinical symptoms were considered as a parameter for diseased chicks. Decreasing feed intake, growth rate, weight gain, survival rate, egg production (impairment in nutrition digestion and absorption), paleness, ruffled feathers, depression, huddling, watery or bloody diarrhea, paralysis and prostration of the head and the neck were considered as clinical signs of occurrence of diseases in this study. It was found that DI was higher in the broiler (25.043%) rather than cock (10.99%) and Sonali (9.53%), however, the layer was less susceptible to be infected (DI = 5.558%) (Fig. 4).

Hygiene practices of the poultry workers: It was observed that the poultry workers were not aware of their hygiene. They did not use footbaths, gloves, hairnets and boots while coming into and out of the toilets. Hand-washing facilities were not available on-site in some farms and toilets were not well equipped with basins with adequate facility to wash, disinfect, dry or sanitize hands. No separate staff room and storeroom were located nearby the farms.

In the case of personal hygiene of poultry workers, 55% (n = 11/20) of poultry farms had poor conditions whereas 15% (n = 3/20) of poultry farms workers did not follow any hygiene protocols. However, 15% (n = 3/20) of poultry farm workers (Farm 6, 9, 18) had a satisfactory level of personal hygiene where workers used sanitizer spraying on their feet while they entered the toilet and they also washed their hand after coming from the toilets. 60% (n = 12/20) of poultry farms followed hygiene protocols in case of using toilets whereas 20% (n = 2/20) farms were in poor condition and 60% (n = 12/20) farms were in the moderate state in the scale of sanitary condition (Table 2, Fig. 5).

Low DI (5.20%) had been found in poultry chicks in those farms where poultry farm workers maintained proper personal hygiene status, however, poor personnel hygiene practice was found to be responsible for higher DI (20.26%) in other poultry farms. Proper use of toilets had a profound effect on lower DI in poultry flocks (7.02%) whereas higher DI (25.40%) had been documented when sanitation condition was in a poor state (Table 2, Fig. 5).

Waste (litter) management system: No appropriate waste management system for litter was found in any of the poultry farms surveyed. The practice of depositing litter for several



	Personnel hygiene				Toilet facilities			Waste management		
	+++	++	+	-	+++	++	+	++	+	-
Mean DI (%)	5.2	10.91	10.72	20.26	7.02	9.83	25.4	8.3	10.1	18.63

DI (%) varies with hygiene status of farms and poultry workers (Good = +++, moderate = ++, poor = +, none = -)

Fig. 5: Correlation of DI (%) in poultry flocks and hygiene status of farms and poultry workers

Low DI (5.20%) was found in poultry chicks where workers maintained proper personal hygiene status, however, poor personnel hygiene practice found to be responsible for higher DI (20.26%) in chicks. Proper use of toilets had a profound effect on lower DI in poultry flocks (7.02%) whereas higher DI (25.40%) had been documented when sanitation condition was in poor state

days was followed in most of the farms. Later on, decomposed waste materials were used as feed for pisciculture and sometimes it was used as fertilizer in agricultural land. No septic tank was found. The absorption pit was not constructed to treat daily sewage like sweeping of poultry sheds to remove litter or used chemicals or sanitizers during cleaning. In the case of litter disposal, 20% (n = 4/20) of poultry farms did not follow any waste disposal system whereas 55% (n = 11/20) farms had poor level facilities in disposal system, however, 25% (n = 5/20) poultry farms were in moderate level in the management of waste disposal (Table 2, Fig. 5). Low incidence of diseases (8.3%) was found in those poultry farms where a moderate level in the management of litter disposal was found rather than those poultry farms where no management system of waste products existed (DI = 18.63%) (Table 2, Fig. 5).

Satisfactory level: Of the twenty poultry farms surveyed, 15% of farms (n = 3/20, Farm 6, 9, 18) had followed proper hygiene rules and sanitary practices cumulatively according to European Poultry Meat Industry Guide, February-2010, however, in scale regarding the parameters of hygienic status and sanitary practices, rest of 85% the farms (n = 17/20) did not reach to the desired level (Table 2).

DISCUSSION

It was evident from the present study that the proper sanitation condition of the poultry farms, water quality and personal awareness of poultry farm's workers along with their hygiene practices reduced disease incidence of poultry flocks and could improve poultry production husbandry practices. The world's population is expected to grow to over 9 billion people by 2050 and demand for poultry, which represents a relatively healthy and efficient source of protein, is likely to be double what it was in 2005[14]. The human population benefits substantially from poultry meat and eggs containing high-quality protein with a low level of fat and a desirable fatty acid profile[15]. In Bangladesh, the development of the poultry business has been remarkable in the last two decades[2]. The continual urging for poultry meat, egg along with their products has been expanding these days as per the growth of household income, population growth and urbanization[16]. Since a healthy poultry chick can be translated into a productive flock, keeping the magnificent health status of poultry flocks is the primary objective of poultry farmers.

An increasing number of poultry farms facilitate the enhanced transmission of infectious pathogens among birds, such as avian influenza virus, *Escherichia coli*, *Salmonella* and *Campylobacter jejuni* etc. Those are capable of inducing human disease[16,17]. In our study, it was found that DI in poultry flocks correlated with quality of water as well as hygiene and sanitation status of the poultry farms where it was evident that lack of maintenance of personnel hygiene, cleanliness of farms along with poor waste disposal management posed a higher risk of disease incidence in poultry flocks. Drinking water plays a vital role in the transmission of some bacterial, viral and protozoan diseases that are common in poultry diseases[7]. The data showed that quality of water has a profound effect on DI where the minimum rate of disease incidence was found in those poultry farms where workers used deep tube-well water (8.03%) other than tube-well (10.948%) or municipal supply water (15.898%). It was evident that the quality of deep

tube-well water is good over municipal supply water and tube-well water. Though there is no standard formula applicable to all poultry farms, it was reported elsewhere that biosecurity is an essential component of a disease control program in the poultry industry[18]. The occurrence of disease in poultry is influenced by environmental factors among which seasons have deep effects on disease occurrence in poultry[19-21]. The warm and humid environmental conditions favor higher incidences of avian coccidiosis[20]. Our data showed that temperature affected DI in poultry as in low temperature higher DI (DI = 18.23% at 14°C) was observed rather than higher ambient temperature (DI = 22% at 35°C) though no correlation of DI with RH had been found in this study. Adoption of good practices of poultry management and hygiene practices can improve the development of the poultry industry[16]. Recent studies showed broiler birds had the highest coccidian infection rate compared with the other types of birds, though cockerel also had an alarming prevalence rate[20]. Previous studies in Nigeria had reported disease incidence in broilers as 68.7% cockerel as 70.0%, layers as 41.5%[22]. It was found in this study that broiler was found to be more susceptible to be infected by disease-causing agents (DI = 6.92%) rather than the cock (DI = 3.74%) and Sonali (DI = 3.18%), however, the layer (DI = 2.89%) was less susceptible to be infected. Disease incidence was higher in farms where poultry workers did not follow rules and regulations of sanitation and hygiene practices appropriately. However, a low level of disease incidence was found in poultry flocks where workers are cautious about their hygiene condition. There is a direct correlation between the lack of personal hygiene and the occurrence of disease[23]. In the majority of developing countries, about 80% of disease outbreaks are associated with poor domestic and personal hygiene[24,25]. A study reported that farm boots samples are an important risk factor with a *Salmonella* spp. prevalence of 19.7% [26]. Usage of commercially available disinfectant at the recommended concentration can minimize the occurrence of disease in poultry[5]. Sanitization of hands with anti-bactericidal hand soap and disinfection of the footwear help the prevention of the spread of disease-causing agents such as bacteria[27]. To reduce the risk of DI, maintaining proper personal hygiene along with wearing protective clothing and footwear should be followed by workers while working in the area where poultry flocks are housed[28,29]. Moreover, workers should be required to shower-in and shower-out of the area to reduce the risk of disease introduction and escape from that specific area[30]. It has been found in our study that DI varied with personnel's hygiene status who worked in poultry farms as proper maintenance of hygiene status of workers of the farms related to lower DI (5.20%) in poultry chicks, however, poor personnel hygiene practice found to be responsible for higher DI (20.26%) in poultry farms. Proper use of toilets had a profound effect on lower DI in poultry flocks (7.02%) whereas higher DI (25.40%) had been documented when sanitation condition was in a poor state. Farm-level biosecurity can be described as the sequential activities of management practices that prevent the dissemination of pathogenic agents between animal groups on a farm and the management practices designed to prevent the pathogenic agents from departing the farm[31]. Better waste management and disposal practices improve the hygiene status of the farm to improve poultry production husbandry practices[5]. The introduction of equipment contaminated with poultry litter and other animal products (e.g., hair, feathers, saliva) to a farm is also a potential risk of disease incidence[32,33] with many studies highlighting the risk of the introduction of diseases, such as Newcastle disease, through the entry of contaminated equipment[34,35]. In consideration of waste management system, according to European Poultry Meat Industry Guide well management of litter disposal was found in some poultry farms where a low incidence of diseases (8.3%) was evident rather than those poultry farms where no management system of waste products existed (DI = 18.64%) in our study. Here, it was observed in this study that disease incidence of poultry is greatly influenced by the quality of water, sanitation condition of the farms along with personal hygiene of poultry workers and waste management practices. The reduction of disease incidence in poultry can significantly contribute to the improvement of food security and a vibrant farm economy.

CONCLUSION

Proper maintenance of the hygiene condition of poultry farms is required along with awareness among workers as well as better waste disposal practices should be ensured for minimizing the incidence of disease in poultry. As well-documented information of disease incidence of poultry and the sanitation and waste disposal practices are not available, surveillance-based data is required in this regard to figure out the possible reasons of disease incidence in poultry flocks.

SIGNIFICANCE STATEMENT

This study discovers the impact of maintaining proper sanitation conditions of the farms, water quality and personal awareness of workers along with their hygiene practices on disease incidence of poultry flocks. For minimizing the

incidence of disease in poultry, proper maintenance of hygiene conditions of poultry farms is required along with awareness among workers as well as better waste disposal practices should be ensured. This study will help the researcher to uncover the critical areas of minimizing the incidence of disease in poultry flocks and the necessity of having well-documented information on this regards. Thus a new theory on minimizing the incidence of disease in poultry chicks may be arrived at.

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