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Abstract

This paper is a part of a multi-disciplinary research "Application of Decentralized on Site Sewage Water Treatment*Japanese Johkasou System*in Egypt to investigate the environmental impact of implementing sewage water before and after treatment using the effluent of this system on broiler rearing and performance , as well as to strengthen the sanitary conditions of water resources. Both influent (no-treated sewage water, NTSW) and effluent (treated sewage water, TSW) were used. NTSWs (100% ,70%, and 30%),TSW, and tap water (TW) samples were analyzed chemically and bacteriologically before offering *adlibtum* to chicks. The impact of used water on broiler health and performance indices was investigated. 130 day old chicks were assigned into 5 groups (26 each). Food, water intakes and live body weight were estimated weekly (FI,WI, LBW). Higher values of chemical and bacteria parameters were recorded from NTSWs. TSW revealed decreased chemical values versus NTSW, as well as, Total Colony Count (TCC) and Total Colifom Counts relatively. Between the 2nd-5th weeks, both TSW and NTSW 30% increased the bird's desire to feed more than NTSW (100%, and 70%). Chickens which received NTSWs had lower LBW during 1st-3rd week compared to groups received TSW and TW. NTSW (100%,70%) where decreased performance indices (Food Conversion Rate, Live Body Weight, livability % and Production Efficiency Factor (FCR, LBW, LA and PEF respectively) with economic losses . Broiler reared with TSW achieved highest PEF Vs NTWS groups but still less than those reared with control TW. Water secure and resource sustainability in Egypt can be restored through treating sewage water biologically as with Japanese Johkasou system.

Key words: sewage water (SW), broiler, chemical oxygen demand (COD), Production Efficiency Factor (PEF), Livability % (LA).

Introduction

Water makes up a large proportion of the body of the chicken, from 55% to 75% **(Scott *et al.,* 1982)**. Indicator organisms are commonly used to assess the microbiological quality of surface waters, and Fecal Coliforms (FC) are the most commonly used bacterial indicator of fecal pollution **(South Africa, 1998)**.Poultry farms may use water from municipal sources (potable for humans). Water of low quality depress water consumption and may affect nutrient digestibility, metabolism, and production performance. Inferior quality water has detrimental effects on broiler performance, and is negatively correlated with body weight and immune resistance **(Robert & Swick,1998; Blake & Hess,2001).** Water is an excellent transmission route of agents responsible for human and animal diseases, mainly those in which fecal-oral transmission occurs, since contamination of water supplies is still gradually increasing as a result of urban and rural activities.**(Amaral,2004).**Water qualities are measured by a number of parameters which include chemical oxygen demand (COD), nitrate, phosphate, and pH **(Mijinyawa & Lawal, 2008).** Birds have been used as sentinels of ecosystem health subsequent to environmental contamination **(Esser & Jux, 2009; Grove *et al.,* 2009**).TC group comprise bacterial species of faecal origin that can survive and proliferate within the water environment. They are indicative of the general hygienic quality of the water, and potential risk of infectious diseases from it.**(Antony & Renuga,2012**).The untreated discharged sewage will contaminate the river water with pathogenic bacteria **(Subramani &Arulalan,2012) .**Domestic wastewater (sewage) is made up largely of organic carbon . Domestic sewage consists of black water composed of fecal matter (human and animal wastes) together with grey water sources composed of various wastewater constituents **(EPA,2013).**Birds consume from 1.5 to 2 times water as much as they consume feed. It is an important factor in poultry raising because a bird can survive several weeks without food, but only a few days without water **(Bobinienė *et al.,* 2014).** Increasing pressure on existing wastewater treatment plants has led to the discharge of inadequately treated effluent, reinforcing the need to improve and adopt more stringent methods for monitoring discharged effluent and surrounding water sources .Total Coliforms (TC) bacteria live in the human and animal intestine **(Naidoo & Olaniran, 2014).** Physico-chemical methods are increasingly being used for the preliminary treatment of wastewater before its biological purification. **(Hamawand, 2015) .**Broiler integrators and farmers around the world commonly use PEF as a performance indicator **(Shane, 2013).** In one study, PEF was calculated as 346 for 42-d-old Ross hybrids and as 376 for Cobb hybrids **(Marcu et al., 2013) .** The performance of those hybrids, in terms of LW (2.598-2.648), LA (99-100) and FCR (1.770-1.676), is not much better than that determined in the present study. Therefore, it can be said that PEF value is adequate in this study (298.8) **(Tandoğan and Çiçek ,2016).** The feed conversion ratio was determined as the ratio between the average feed intake and average weight gain per period, Livability per period was calculated as a percentage of live birds in each period**.(Martin et al.,2016).**The biggest concern associated with microbial pollution is the risk of human and livestock related illnesses after exposure to contaminated water sources. Preventive measures and solutions to problems that already exist must be considered. On–site sewage wastewater poses a challenging problem in Egypt and the other Arab countries. A Johkasou bioreactor was installed at Cairo University to study its applicability, and advantages of highly purified sewage water.The current experiment was conducted to evaluate the effectiveness of Japanese Johkasou system in biological treatment of influent sewage water before its discharge in the freshwater environment and the impact of use on broiler growth, health and survival.

Materials and methods

1-Birds and House Management

The effect of water treatment on the performance of poultry was conducted at an experimental unit in the Department of Pathology, Faculty of Veterinary Medicine, Cairo University. A total of 130 day old, unsexed commercial broiler chicks (Cobb 500) were purchased from a commercial farm (Badrashein, Giza). The chicks were assigned randomly into 5 pens (26 birds each). The house was an open side poultry house with litter covered floor (wood shaving). The feed was provided for all groups *ad-libitum* (0-35 days old) throughout the experiment which was formulated to meet or exceed the Nutritional Research Centre **(NRC, 1994)** requirements of broiler chicks. Water was offered *ad libitum* for different groups (table 1).

2-Water analysis

Non Treated Sewage Water (NTSW) was collected and diluted with distilled water into three different concentrations (NTSW 100%, 70%, and 30%). The treated sewage water (TSW effluent) was obtained from the Japanese Johkasou system. Physical and chemical examination of collected water samples (tap water TW, TSW and NTSW 100%, 70% and 30%) were accomplished at the department of Veterinary Hygiene and Management, Faculty of Veterinary Medicine, Cairo University. Chemical analysis included chemical oxygen demand (COD), ammonia, nitrite, nitrate, phosphates and chloride estimations was performed according to **(Subramani & Arulalan, 2012)**. Total hardness of water sample was estimated using "EDTA titrimetric method" , Chlorides (CL) using the Argentometric method, ammonia (NH3) concentration using phenate method ,nitrite (NO2) level using colorimetric method, suphates (SO4) concentration using the gravimetric method with drying of residues" ,phosphate of water using stannous chloride **(APHA ,1998**). Reaction (pH value) was determined by using a digital pH meter **(Jenway 3510, England**).Total colony forming unit count (TCC), Total Coliform and Fecal Coliform were estimated using Nutrient agar pour plate and multiple tube fermentation technique (MPN) respectively according to **APHA (1998).**

3-Broiler Performance Measurements

The water , feed intake and the water / feed intake ratio were calculated for each group in order to determine the palatability of NTSW with different concentrations offered to chicks till marketing (0-35 days old) versus TSW and TW. Performance parameters were investigated during the experimental period included: average weekly LBW, FCR the mortality , livability % **(acc. to Martins et al ,(2016**),, as well as the economic efficiency of growth, through the calculation of :Production Efficiency Factor (PEF) according to **Marcu et al., (2013).**

$$PEF = \frac{LW\ (kg) \times LA\ (\%)}{SA\ (days) \times FCR\ (kg)} \times 100$$

Where; LW (kg) = Live weight at the end of the rearing period, LA (%) = Livability (number of birds alive at the end of the rearing period relative to the number of chicks placed), SA (days) = Slaughter age of chicks, FCR (kg) = Cumulative feed intake (kg) / total weight gain (kg).

Results

Table (2): Mortality and Livability Percentages recorded at the 13th day old

Group	Treatment	Mortality Number	Mortality %	Livability %
1	TSW	2	7.6	92.4
2	NTSW100%	7	26.92	73.08
3	NTSW70%	7	26.92	73.08
4	NTSW 30	3	11.54	88.46
5	TW	2	7.6	92.4
Total		21/130	16.15	83.85

Data in table (2) revealed that the highest mortality were recorded in groups which had received 100% and 70% non-treated sewage water (7 for each), while the lowest mortality was in the control and treated groups (TW, TSW) at the 5^{th} week. Total mortality in all groups was (21/ 130 =16.15% and the livability was 83.85%). The mortality was associated with the vaccination schedule and increased indoor and outdoor temperature during summer 2015 in Giza city. These multiple stresses as well as received sewage water potentiated the recorded mortality.

Table (3) Physical, Chemical and bacteriological analysis of used water.

Parameters	Water analysis				
Source	Tap water	**NTSW 100 %**	NTSW 70%	NTSW 30%	TSW
Appearance	Clear	Turbid	Turbid	Turbid	Clear
Color	Nil	Yellowish	Yellowish	yellowish	Nil
Odor	Negative	Foul	Foul	Foul	Negative
pH	8.4	7.7	8	8.2	8.8
Phosphate (ppm)	3	33	22	19	2
Sulphate (ppm)	25	55	45	40	35
Hardness (ppm)	160	170	170	170	140
Chloride (ppm)	100	330	250	300	90
Ammonia (ppm)	0.01	4	2.5	1.5	0.2
Nitrite (ppm)	0.01	4.5	3	2.5	0.02
Nitrate (ppm)	0.05	10	8	5.5	1
COD (ppm)	3	15	12	9	5
TCC	Zero	4×10^5	2×10^5	26×10^3	1×10^3
T.Coliform MPN/100ml	Zero	50->1600	60	50	2

Data shown in tables (3) revealed that the highest values of chemical and bacterial parameters that associated with the use of NTSW (100% ,70%, and 30%) and considering values decreased with dilution but still unaccepted for all.

Table (4): Impact of treated and untreated sewage water on broiler Feed Intake

FI/g	1st wk	2nd wk	3rd wk	4th wk	5th wk
TSW	242.10±1.0	437.00± 1.0	816.0±81.73	1328.57±79.7	1890.00±194.3
NTSW 100%	248.07± .0	447.00± 1.0	932.0±85.26	1364.29± 0.4	1870.00 ± 93.6
NTSW 70%	239.17±1.0	423.00± 1.0	904.0±65.04	1417.14±143.3	1851.43± 76.8
NTSW 30%	246.17±1.0	427.00± 1.0	932.0±57.62	1425.71 ± 72.3	1931.43±139.1
TW	234.17±1.0	486.33±58.6	990.0±105.83	1631.43±127.2	2348.57±173.2

Data shown in table (4) indicated that feed intake of chicks received NTSW was higher than those received TSW and TW at the 1st week. On the 2nd and 3rd weeks, feed intake (FI) of the chicks received TSW was lower than NTSW 100% and TW. At week 4 the diluted NTSW 70% and 30 % increased FI compared with NTSW 100%. At week 5, the TSW and NTSW 30% enhanced birds to feed more versus to NTSW (100% and70%). Feed intake of chickens received TW was the highest compared with other groups (in the weeks 2 through 5). All groups revealed lower FI on the 4th week compared to the 5th week, with highest relative increase occuring in control group 5 (TW). The ambient temperature at week 4 was recorded to be 40 ^{0}C which stressed the bird and discourged them to feed.

Table (5):Impact of treated and untreated sewage water on broiler water intake

Bird Water intake /mL	1st wk	2nd wk	3rd wk	4th wk	5th wk
TSW	320	730	3160	4850	5100
NTSW 100%	320	700	2500	3270	3730
NTSW 70%	330	700	2800	4070	4600
NTSW 30%	290	750	3080	4020	5000
TW	350	900	3400	5770	6000

Data in table (5) indicated that, during the 1st week the birds drank approximate same amount of NTSW and TSW, with the highest water intake (WI) from TW. The NTSW 100% was unacceptable to the birds for foul odor and microbial load shown in table (2a) despite NTSW 30% had the lowest WI. At weeks 4 and 5 (beak growth curve of broilers), the consumed NTSW (100%, 70%, and 30%) levels were lower than TSW and TW. Within diluted NTSW, the dilution with TW allowed birds to consume more amount of 70, 30 % versus 100%.

Table (6):Impact of treated and untreated sewage water on Water/Feed intake ratio

W I /Fl	1st wk	2nd wk	3rd wk	4th wk	5th wk
TSW	2.69	2.50	4.31	2.72	2.94
NTSW100%	2.81	2.95	4.55	2.73	2.33
NTSW 70%	2.89	2.94	4.67	2.63	2.71
NTSW 30%	2.32	3.00	4.76	2.72	2.86
TW	2.19	2.19	4.33	2.99	2.99

Data in table (6) indicated that consumed water Vs food intake was increased in all groups. Within NTSW this ratio varied relatively where the birds used lesser raw NTSW 100% compared to diluted NTSW 70% and 30% . The TSW and TW were consumed by birds more than NTWS .

Table (7): Impact of treated and untreated sewage water on broiler Live Body Weight

Water source	Live body weight per gram (LBW/ gm)				
	1stwk	2ndwk	3rdwk	4thwk	5thwk
TSW	119	292	633	1220	1733
NTSW100%	114	237	550	1200	1600
NTSW 70%	114	238	600	1200	1700
NTSW 30%	125	250	627	1350	1750
TW	160	310	786	1529	2010

Data shown in table (7) revealed that chicks received NTSW (100%, 70%, and 30%) had lower LBW through weeks 1- 3 compared to TSW and TW. The raw NTSW 100% induced lower LBW than NTSW 70, and 30 % confirmed negative influence of NTSW on broiler LBW and consequent performance indices. Despite, **Virden *et al.* (2009)** findings that COD in contaminated water didn't significantly affect birds 'performance.

Table (8): Impact of treated and non-treated sewage water on broiler performance indices

Groups/ parameters	Final LBW(kg) /35ds	Feed intake / kg /35ds	FCR	Livability (%)/35ds	Production Efficiency Factor (PEF)
TSW	1.733	1.890.00±194.3	1.14	92.4	**521.56**
NTSW 100%	1.600	1.870.00±93.6	1.17	73.08	390.00
NTSW 70%	1.700	1.851.43± 76.8	1.09	73.08	387.00
NTSW 30%	1.750	1.931.43±139.1	1.10	88.46	487.00
TW	2.010	2348.57±173.2	1.17	92.4	**621.00**

Data recorded in table (8) summarize the final performance indices of broiler to throw light on the socioeconomic impact of used treated sewage water via Japanese Johkasou Decentralised Sewage Wastewater System. Broiler reared with TSW achieved highest PEF (**521)** Vs NTWS groups but still less than those reared with control TW (**621)**

Discussion

The used NTSW analysis revealed high levels of chlorides as noticed by **Metcalf and Eddy (1991)** where they found that conventional methods of sewage treatment do not significantly remove chlorides. Detection of higher than normal concentrations of chloride in a body of water may indicate that treated sewage is being discharged into it as well contamination by treated or untreated sewage. The health impact of higher chloride on broiler chickens was reported by **East *et al.,* (2008),** where they found that a level of 14 mg/l in drinking water can be detrimental to broilers if combined with 50 mg/l of sodium. Chloride levels as high as 25 mg/l are not a problem if the sodium level is in the normal range. **Abbas *et al.,* (2008)** said that water consumption of broiler chicks is reduced as chloride concentration of the water increases. The foul odor of NTSW was associated with higher levels of ammonia 4 mg/l, nitrate 4.5 mg/l and nitrites 10mg/l. These recorded values are higher and detrimental to broiler performance than recommended in many researches. **Carlile (1984)** declared that when ammonia exceeded permissible limits in water, broiler performance is highly affected. **Carter & Sneed, (1997)** reported that the toxicity of nitrates to poultry varies with the age of the birds, older birds being more tolerant. For commercial broilers, nitrate levels greater than 20 mg ammonia had a negative effect on weight, feed conversion, or performance. Levels between 3 and 20 mg ammonia were suspected to affect performance. Nitrites are toxic at much lower levels than nitrates; concentrations as low as 1 mg ammonia can be toxic. **Wilczak *et. al.,* (1996)** reported that the presence of ammonia in drinking water is undesirable because nitrification might lead to toxic levels of nitrite and might increase heterotrophic bacteria including opportunistic pathogens. Nitrification in distribution systems can increase nitrite levels, usually by 0.2–1.5 mg/liter. The guideline value for nitrite must be correspondingly lower than that for nitrate, and it was noted that the nitrite-nitrogen level should be considerably lower than 1 mg/liter **(WHO, 2006).** Increased indicator bacteria of fecal contamination in NTSW were expected by default. **APHA (1995)** confirmed that the use of indicator bacteria such as fecal Coliform for assessment of fecal pollution and possible water quality deterioration in fresh water sources was widely used. TSW decreased all chemical parameter values versus NTSW as well as TCC and Total Colifom Counts **(table 3).** Even though 1,000 bacteria per milliliter is the acceptable standard for poultry drinking water, up to 1 million bacteria per milliliter have been found in contaminated water **(Watkins, 2002).** Ammonia level was 0.2 mg /l which is less than the 1.5 mg/l (a taste threshold of 35 mg/liter has been proposed), while recorded nitrite level was 0.02 mg/l which is agreed with that recommended by **WHO (2006).**It was noted that the nitrite-nitrogen level should be considerably lower than 1 mg/liter. Current study clarified the effect of biological activity in sewage water when subjected to the Johkasou system. This activity was manifested by reduction of organic contents and release of oxidized and reduced forms of organic–nitrogen (ammonia- nitrate-nitrites) as compared to NTSW. **Black & Hess (2001)** reported that tastes and odors are usually produced by certain impurities mainly organic in nature and some inorganic salts and algae. **The result obtained in table (5**) must be considered on disposing wastewater in current water stream rather than stagnant water bodies, if village farmers have to use this untreated waste water for agriculture activities. Water of low quality depresses water consumption and broiler performance and is negatively correlated with body weight and immune resistance **(Robert & Swick,1998; Blake & Hess, 2001). C**onsumed water Vs food intake **(table 6)** was increased in all groups compared to that value (1.5-2) as recorded by (**Bobinienė *et al.,* 2014).** Within NTSW this ratio varied relatively where the birds used lesser raw NTSW 100% compared to diluted NTSW 70% and 30%. The TSW and TW were consumed by birds more than NTWS .The unexpected values of consumed water especially NTSW (100% and 70%) might be attributed to keeping wastewater tanks with their concentrations in experimental unit where non controled environemnt with high ambient temperature **(June–July, 2015)** in Egypt ,which may facilitate aerobic decomposition for the organic-nitrogenous load in NTSW and potentiated Reduction-Oxidation process of ammonia-nitrogen.The end metabolites in this water are not yet estimated in current experiment that may hence , affected water palatability and water and feed intake**.(table 7).** The increased water consumption through this experiment which exceeded that reported by previous studies and may be attributed to bird were enforced to drink to cope high ambient temperature despite of water foul odor (not only because of organic matter but also some inorganic salts) as explained by **Blake & Hess,(2001),** as well as high microbial load of NTSW70 % and 30%. A 2.3 kg broiler will consume about 8.2 kg of water, compared to approximately 4.6 kg of feed **(Lacy, 2002).** The correlation between feed and water consumption was estimated to be 0.98 according to **Lott *et al.*, (2002).** Broiler reared with TSW achieved highest PEF (**521)** Vs NTWS groups but still less than those reared with control TW (**621)** as revealed in **table (8).** Within NTSW the 30% water induced highest PEF (487) Vs 100 % & 70% (390 & 387 respectively). In one study, PEF was calculated as 346 for 42-d-old Ross hybrids and as 376 for Cobb hybrids **(Marcu et al., 2013).** The performance of those hybrids, in terms of LW (2.598-2.648), LA (99-100) and FCR (1.770-1.676), is not much better than that determined in the present study. Therefore, it can be said that PEF value is adequate in this study (298.8) **(Tandoğan and Çiçek ,2016).** Current PEF values for Cobb500 are different may be due to age of slaughter was 35 and previous researchers was at 42days and their used breed was Cobb hybrids .In addition current work birds were stressed by ambient temperature and used TSW and NTSW .**In conclusion,** non-treated sewage water (NTSW100%) used for rearing broiler chickens was badly affected bird health and performance compared to treated sewage water with Johkasou system and tap water. On subjecting sewage water to Japanees Johkasou system reduction of organic contents was attained ,and release of oxidized and reduced forms of organic – nitrogen (ammonia-nitrate–nitrites) versus NTSW. Also decreased performance indices (FCR, LBW, EPE and PEP) with expected economic losses .Water secure and resources sustainability in Egypt can be restored via treating sewage water biologically.

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Conflict of Interest

No conflict of interest

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