Asian Australas. J. Biosci. Biotechnol. 2018, 3 (1), 33-39

Asian-Australasian Journal of Bioscience and Biotechnology
ISSN 2414-1283 (Print) 2414-6293 (Online)
www.ebupress.com/journal/aajbb

Article

Response of dairy farm's wastewater irrigation and fertilizer interactions to soil health for maize cultivation in Bangladesh

Nilima Das, Md. Touhidul Islam, Md. Symum Islam and A. K. M. Adham*

Department of Irrigation and Water Management, Bangladesh Agricultural University Mymensingh-2202, Bangladesh

*Corresponding author: Dr. A. K. M. Adham, Professor, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh. E-mail: adhamiwm@gmail.com

Received: 07 April 2018/Accepted: 23 April 2018/ Published: 28 April 2018

Abstract: The study was conducted at the experimental field of the Bangladesh Agricultural University (BAU) to demonstrate the evidence of the suitability of dairy farm's wastewater on soil properties in a maize field under three fertilizer doses and three irrigation treatments. Irrigation had three treatments - I_1: Irrigation with fresh water, I_2: Irrigation with mixed water (fresh water: dairy farm's wastewater = 1:1) and I_3: Irrigation with raw wastewater. There were three fertilizer treatments - F_0: No fertilizer, F_1: Half of recommended dose fertilizer and F_2: Full dose fertilizer. Wastewater contained different nutrients and organic matter, which optimistically contributed to the soil in the maize field. Both irrigation and fertilizer treatments employed different degrees of influence on the soil health. For the effect of irrigation treatments, the highest values of EC (0.223 dS/m), pH (8.18), OC (0.3733 %), total N (0.046 %), P (7.65 ppm), K (33 .08 ppm), Ca (297.80 ppm) and Mg (109.9 ppm) were recorded under the treatment of I_3, I_1, I_1, I_1, I_3, I_1, I_2 and I_3, respectively, and the lowest values of the soil quality parameters were counted under the treatment of I_1, I_3, I_3, I_3, I_2, I_2, I_1, and I_2, respectively. In case of fertilizer treatments, the maximum values of the soil quality parameters were obtained under the treatment of F_2, F_2, F_0, F_1, F_2, F_1, F_1, and F_1, respectively, and the lowest values were obtained under the treatment of F_0, F_0, F_1, F_0, F_0, F_0, F_0, F_2, respectively. For the irrigation and fertilizer interactions, the maximum values of EC (0.250 dS/m), pH (8.20), OC (0.38 %), total N (0.059 %), P (8.37 ppm), K (48.0 ppm), Ca (374.9 ppm) and Mg (112.60 ppm) were recorded under the treatment combinations I_3F_0, I_1F_2, I_3F_2, I_1F_2, I_3F_2, I_3F_1, I_2F_0 and I_3F_2, respectively, and thye lowest values were recorded under the treatment combinations of I_2F_0, I_1F_0, I_1F_0, I_1F_0, I_2F_0, I_2F_0, I_2F_2 and I_2F_2, respectively. Both the irrigation and fertilizer treatments and their combinations did not cause any significant variation in the quality parameters of the soil, except soil pH and phosphorus (P) content of the soil in the maize field.

Keywords: dairy farms; wastewater; irrigation; fertilizer; soil properties

1. Introduction

All field crops need soil, water, air and light (sunshine) for their survival, better development, and bumper production. Crops may highly suffer due to inadequate availability of water. In situations of inadequate water supply from natural sources, irrigation needs to be applied for ensuring proper crop plants growth and development. Irrigation water has to be applied in a controlled manner that matches the crop water requirement. Crop water requirement varies substantially over the growing season, mainly due to variation in crop cover and climatic conditions (Doorenbos and Pruitt, 1977). Freshwater is a renewable resource, yet the world's supply of such water is steadily decreasing. Water demand already exceeds supply in many parts of the world. Awareness of the global importance of preserving water for ecosystem services has only recently emerged. This is because, during the 20th century, more than half the world's wetlands have been lost along with their valuable environmental services. Biodiversity-rich freshwater ecosystems are currently declining faster than marine or land ecosystems (Hoekstra, 2006). Maize production in Bangladesh had increased gradually from 1997 to 2008 due to its higher profitability than other cereal crops. But, its production reduced drastically in 2008-2009, possibly due to the affection of farmers to other crops (BBS, 2009). More than 40% of food production comes from irrigated agriculture but using only 17% of land devoted to food production in the world (Fereres and Connor, 2004). As the stress increases on limited water resource, it is increasingly essential to look for nonconventional water resources. Wastewater may be an important water source to overcome the problem and increase the agricultural production.

Increased urbanization and industrialization in the developing countries have been the cause of the production of a large volume of wastewater and effluents the disposal of which is becoming a major concern. A huge quantity of wastewater is produced from a dairy farm. It can be utilized to minimize water shortage for irrigation in the farm areas to a considerable extent if it can be managed properly. It is used to support livestock production. Water scarcity drives farmers to make use of wastewater, which is often available year-round. Groundwater may be too expensive to access due to declining water table that necessitates the drilling of deep wells, or groundwater may be too saline for use in agriculture. Fresh surface water may be available only intermittently during the rainy season. Any water source that requires pumping involves costs that are not usually needed for the use of wastewater. The activities directly dependent on wastewater are practiced by different social groups on a small, medium or large scale, and include, for example, agriculture, agroforestry, livestock rearing, aquaculture, and floriculture. Activities indirectly dependent on wastewater include the sale of seeds, pesticides and other inputs to wastewater farmers, renting of harvesting machinery or equipment, agricultural labor, services related to the transportation of products to markets, marketing of the products, animal husbandry with purchased wastewater-irrigated fodder and the provision of fish fry for aquaculture. Many resource-poor farmers (with and without land) and very poor agricultural laborers can earn an income or gain food security through the use of this degraded resource (Buechler, 2004).

The important quality parameters of wastewater, from an agricultural point of view (Kandiah, 1990) are: physical properties such as - total dissolved solids (TDS), electrical conductivity, temperature, color/turbidity, hardness and sediments, and chemical properties such as - acidity, type and concentration of cations and anions (calcium, magnesium, sodium, carbonate, bicarbonate, chloride, sulphate, sodium adsorption ratio, boron, trace metals, nitrate nitrogen and potassium). Wastewater, when typically stored in unlined lagoons, poses groundwater contamination problem. This is of particular concern in areas where drinking water comes from groundwater supplies. After some minimal settling of the suspended particles and decompositions of organic constituents, the wastewater may, however, be suitable for use in irrigation. The impacts of wastewater widely vary with the source of water, soil type and types of crops to be grown. But, in our country, the impacts of dairy farm's wastewater on the soil properties in a crop field (especially in a maize field) have not been studied thoroughly. While the additional nutrients can be a bonus as additional fertilizer, excess nutrients, particularly carbon and nitrogen, can have adverse effects through excessive microbial activity and growth. Therefore, it is necessary to evaluate the impacts of wastewater irrigation and fertilizer interactions on the soil health for maize cultivation in Bangladesh.

2. Materials and Methods

2.1. Experimental site and soil

The experiment was carried out at the central farm of the Bangladesh Agricultural University (BAU), Mymensingh to investigate the response of irrigation by dairy wastewater on the soil health in a maize field under different fertilizer doses and different irrigation treatments. The experimental site was located in the agro-ecological zone (AEZ) 9, which lies at 24.75° N latitude and 90.50° E longitude. The elevation of the experimental site is 18 m above mean sea level.

The soil of the experimental field is silt loam underlain by sandy loam, and it belongs to the Old Brahmaputra Floodplain (BARC, 2005). The organic matter content of the soil was low (0.48%). The top soils were moderately acidic but sub-soils were neutral in reaction. The average field capacity and permanent wilting point of the soil was 38.19 and 18.37 % (v/v), respectively and the bulk density was 1.33 g/cm^3. The initial pH of the field soil was 7.56, 7.72 and 7.83, respectively, and electrical conductivity was 0.23, 0.11 and 0.06 dS/m at 0−20, 20−40 and 40−60 cm depth, respectively.

2.2. Experimental treatments

The variety named BARI Hybrid - 9, developed by Bangladesh Agricultural Research Institute (BARI) was used in the experiment. The experimental land, after adequate plowing, was divided into three equal blocks, which represented three replications. Each block was divided into nine unit plots having 3 m x 2 m size. A buffer of

1m between the adjacent blocks and 0.5 m between the adjacent unit plots were maintained to minimize interference effect between the adjacent plots and blocks. The experiment was laid out in a split plot design with three replications (R_1, R_2 and R_3). The treatments of the experiment comprised two factors: irrigation with three different percentages of wastewater and fertilizer having three different doses. There were thus nine treatments combinations. The planned treatments were:

1) I_1F_0 = irrigation with fresh water (I_1) + No fertilizer dose (F_0)
2) I_1F_1= irrigation with fresh water (I_1) + application of one half of (standard recommended) fertilizer dose (F_1)
3) I_1F_2 = Irrigation with fresh water (I_1) + application of full dose of fertilizer (F_2)
4) I_2F_0 = Irrigation with mixed water (fresh water: dairy wastewater = 1:1) (I_2) + No fertilizer dose (F_0)
5) I_2F_1 = Irrigation with mixed water (fresh water: dairy wastewater = 1:1) (I_2) + application of half dose of fertilizer (F_1)
6) I_2F_2 = Irrigation with mixed water (fresh water: dairy wastewater = 1:1) (I_2) + application of full dose of fertilizer (F_2)
7) I_3 F_0 = Irrigation with raw dairy water (l_3) + No fertilizer dose (F_0)
8) I_3F_1 = Irrigation with raw dairy water (l_3) + application of half dose of fertilizer (F_1)
9) I_3F_2 = Irrigation with raw dairy water (l_3) + application of full dose of fertilizer (F_2)

2.3. Field plot preparation
The experimental land was ploughed with a power tiller and kept exposed to the sun. It was prepared later by ploughing followed by laddering. After final land preparation, the plots were demarcated and levees were made around each plot to retain applied irrigation water. The buffer zone was provided to prevent seepage of water between the adjacent plots. Each plot was fertilized uniformly with a basal dose of urea, triple superphosphate, muriate of potash and gypsum at the final land preparation.

2.4. Fertilizer application
The recommended doses of urea, triple superphosphate, muriate of potash, gypsum and zinc sulphate were applied at the rate of 540, 240, 240, 15 and 5 kg ha^{-1}, respectively (BARC, 2005). One-third of urea and the entire doses of other fertilizers were applied at the time of final land preparation. The rest of two-thirds of urea was top dressed in two equal splits at 50 and 83 DAS, respectively.

2.5. Collection of soil samples
Soil samples were collected from five sampling points with a hand auger to know the initial properties of the soil of the experimental field before setting up the experiment. The collected samples were dried, crushed and sieved through a 2 mm mesh sieve. Dry roots, grasses and other substances were removed from the samples. For each depth and treatment, a 500 g sample was taken in a polyethylene bag and stored for analysis.

2.6. Measurement of soil quality parameters
The quality parameters of the irrigated soil were measured very carefully. The major quality parameters of the soil were electrical conductivity (EC), pH, organic carbon (OC), total nitrogen, phosphorus (P), potassium (K) and calcium (Ca). After measuring the data of the quality parameters of the soil, these parameters were analyzed statistically.

2.7. Statistical analysis
The collected soil data were analyzed using analysis of variance (ANOVA) technique with MSTAT statistical package and the mean differences were adjusted by Duncan's Multiple Range Test (DMRT).

3. Results and Discussion
The results obtained in the experiment are presented, interpreted and discussed under relevant headings and sub-headings with necessary tables. Analysis of variance (ANOVA) of different data demonstrates statistical significance ($p = 0.05$) of the irrigation suitability of dairy farm's wastewater on the soil health for maize cultivation in Bangladesh.

3.1. Present status of dairy farm's wastewater in Bangladesh
The present status of dairy farm's wastewater in Bangladesh is summarised in Table 1.

Table 1. Present status of dairy farm's wastewater in Bangladesh.

Name of dairy farm	Location	Number of cattle and goat	Source of water	Use/disposal of wastewater	Problems faced due to wastewater
BAU Dairy Farm	BAU, Mymensingh Sadar	220	DTW	Fodder irrigation, disposal to drain	Bad smell
Boira Dairy Farm	Mymensingh Sadar	68	Pump (Groundwater)	Disposal to drain	Bad smell, damage some lands
Sonali Dairy Farm	Tangail Sadar	30	Pump (Groundwater)	Fodder irrigation, disposal to drain	Bad smell
Sahib's Dairy Farm	Chirirbondor, Dinajpur	62	Pump (Groundwater)	Disposal to drain	Bad smell, damage some lands
Pakoria Dairy Farm	Sherpur Sadar	78	Pump (Groundwater)	Disposal to drain	Bad smell, damage some lands

The dairy farm's wastewater has not been formally utilized yet for irrigation in Bangladesh. Based on a survey, a portion of the dairy farm's wastewater was used in irrigating fodder crops for the cattle of the farms. The huge quantity of the wastewater was disposed off in the drainage canals. The Boira farm, located at Mymensingh Sadar, which is a personally owned and managed farm, disposes off all its wastewater to a local canal. A major problem faced by the community was the bad smell due to the wastewater. People around all dairy farms considered the wastewater as dirty and unusable water. The drains for disposing the wastewater at these dairy farms were not well constructed and managed. As a result, the wastewater often flows over some adjacent agricultural lands and keeps the lands almost continuously wastewater logged. Thus the affected lands remain unproductive for a long period.

3.2. Quality parameters of dairy wastewater

Some important quality parameters of wastewater of BAU dairy farm are presented in Table 2 along with the FAO standard and Bangladesh standard of water for irrigation. The EC of wastewater varied from 0.51 to 0.74 dS/m. The FAO (1992) recommended a standard value of EC for irrigation is 0.70 dS/m and in Bangladesh standard, it is 1.2 dS/m shown in Table 2. Wilcox (1955) classified irrigation water as excellent, good, permissible, doubtful and unsuitable depending on EC values as <0.25, 0.25−0.75, 0.75−2.0, 2.0−3.0 and >3.0 dS/m, respectively. So, comparing with the standard values of EC for irrigation, the dairy farm's wastewater was good for irrigation. The pH of wastewater varied from 7.2 to 7.8, whereas the FAO standard for an acceptable range of pH for irrigation water is 6.5-8.0 and with respect to Bangladesh standard, it is 6.0-9.0, as reported in Table 2. The values of the concentration of NH_3-N, PO_4, P_2O_5, P, and K of wastewater were higher than the limits set by FAO. The value of the concentration of NO_2-N was very low in the wastewater. The concentrations of NO_3-N, Zn and B were not detected in the wastewater.

Table 2. Some important quality parameters of wastewater of BAU dairy farm along with the FAO and Bangladesh standard for irrigation (Islam *et al.*, 2017).

Quality parameters of wastewater	Date			FAO standard	Bangladesh Standard
	10 January 2016	25 January 2016	15 February 2016		
pH	7.20	7.80	7.35	6.5-8.0	6.0-9.0
EC (dS/m)	0.51	0.70	0.74	0.7	1.2
BOD (mg/1)	120	140	133	-	10
COD (mg/1)	400	480	488	-	<400
NH_3-N (mg/1)	55	22.10	33.6	-	-
NO_3-N (mg/1)	ND	ND	ND	10	-
NO_2-N (mg/1)	0.0065	ND	ND	-	-
PO_4 (mg/1)	30.15	41.11	30.5	10	
P_2O_5 (mg/1)	22.22	31.2	29.1	-	-
P (mg/1)	11.0	13.1	13.5	-	15
Zn (mg/l)	ND	ND	ND	2.0	10
K (mg/1)	60.1	57.7	56.7	30	
B (mg/1)	ND	ND	ND	2.0	2.0

* ND: Not Detectable

3.3. Effect of irrigation on soil quality

The quality parameters of the soils under various irrigation treatments are given in Table 3. For the effect of irrigation treatments, the highest values of EC (0.223 dS/m), pH (8.18), OC (0.3733 %), total N (0.046 %), P (7.65 ppm), K (33 .08 ppm), Ca (297.80 ppm) and Mg (109.9 ppm) were recorded under the treatment of I_3, I_1, I_1, I_1, I_3, I_1, I_2 and I_3, respectively. For the effect of irrigation treatments, the lowest values of EC (0.160 dS/m), pH (8.05), OC (0.3067 %), total N (0.045 %), P (6.42 ppm), K (30.51 ppm), Ca (276.50 ppm) and Mg (78.82 ppm) were recorded under the treatment of I_1, I_3, I_3, I_3, I_2, I_2, I_1 and I_2, respectively.

Table 3. Some important quality parameters of irrigated soil under three irrigations treatments for maize production.

Treatment	EC (dS/m)	pH	OC (%)	Total N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
I_1	0.16^C	8.18^B	0.37^A	0.046^A	6.55^B	33.08^A	276.5^B	95.75^B
I_2	0.20^B	8.10^A	0.33^B	0.046^A	6.42^B	30.51^B	297.80^A	78.82^C
I_3	0.22^A	8.05^A	0.31^C	0.045^A	7.65^A	30.82^B	278.70^B	109.9^A
$LSD_{0.05}$	0.0124	0.242	0.0190	0.0022	0.221	1.79	13.30	3.44
Level of significance	**	**	**	NS	**	**	**	**

Common letter within the same column does not differ significantly at 5% level of significance analyzed by Duncan's Multiple Range Test. I_1 = Irrigation with fresh water, I_2 = Irrigation with mixed water (FW: WW =1:1) and I_3 = Irrigation with wastewater.

The irrigation treatments did not cause any significant variation in the quality parameters of the soil except soil pH and phosphorus (P) content of the soil. Irrigation by raw wastewater significantly reduced the soil pH; the mixed water and fresh water employed identical effect on the soil pH. Raw wastewater irrigation also caused significant variation in soil P content and added more P in the irrigated soils. The effect of various irrigation treatments on soil quality in a wheat field was studied by Islam *et al.* (2015), and our recorded result was almost similar to their statement.

3.4. Effect of fertilizer on soil quality

For the effect of fertilizer treatments, the highest values of EC (0.2267 dS/m), pH (8.10), OC (0.3433 %), total N (0.0496 %), P (7.95 ppm), K (32.74 ppm), Ca (312.50 ppm) and Mg (102.50 ppm) were recorded under the treatment of F_2, F_2, F_0, F_1, F_2, F_1, F_1 and F_1, respectively, as presented in Table 4.

Table 4. Some important quality parameters of irrigated soil under three fertilizer treatments for maize production.

Treatment	EC (dS/m)	pH	OC (%)	Total N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
F_0	0.15^C	7.57^B	0.34^A	0.041^B	5.42^C	29.95^B	261.00^C	98.58^B
F_1	0.20^B	8.05^A	0.33^A	0.049^A	7.25^B	32.74^A	312.50^A	102.50^A
F_2	0.23^A	8.10^A	0.34^A	0.047^A	7.95^A	31.71^{AB}	279.50^B	83.40^C
$LSD_{0.05}$	0.0124	0.242	0.0190	0.0022	0.221	1.79	13.30	3.44
Level of significance	**	**	NS	**	**	**	**	**

Common letter within the same column does not differ significantly at 5% level of significance analyzed by Duncan's Multiple Range Test. F_0 = No application of fertilizer, F_1 = Half dose fertilizer and F_2 = Full dose fertilizer.

For the effect of fertilizer treatments, the lowest values of EC (0.1533 dS/m), pH (7.57), OC (0.3300 %), total N (0.0410 %), P (5.42 ppm), K (29.95 ppm), Ca (261.0 ppm) and Mg (83.40 ppm) were recorded under the treatment of F_0, F_0, F_1, F_0, F_0, F_0, F_0, F_2. The quality parameters of the soil except for soil pH and phosphorus (P) content and calcium (Ca) content of the soil were not significantly changed under the fertilizer treatments. Full dose fertilizer treatment significantly reduced the soil pH, whereas the half and no dose fertilizer treatments showed the almost same impact on the soil pH. Full dose fertilizer treatment also caused a significant change in soil P content and added more P in the irrigated soil. The effect of various fertilizer treatments on soil quality in a wheat field was studied by Islam *et al.* (2015), and our experimental result was almost similar to their statement.

3.5. Interaction effects between irrigation and fertilizer on soil quality

For the interaction effects between irrigation and fertilizer, the highest values of EC (0.250 dS/m), pH (8.20), OC (0.38 %), total N (0.059 %), P (8.37 ppm), K (48.0 ppm), Ca (374.9 ppm) and Mg (112.60 ppm) were recorded under the treatment combinations I_3F_0, I_1F_2, I_3F_2, I_1F_2, I_3F_2, I_3F_1, I_2F_0 and I_3F_2, respectively, as presented in Table 5. The lowest values of EC (0.177 dS/m), pH (8.01), OC (0.24 %), total N (0.029 %), P (6.01 ppm), K (38.5 ppm), Ca (290.60 ppm) and Mg (56.60 ppm) were recorded under the treatment combinations I_2F_0, I_1F_0, I_1F_0, I_1F_0, I_2F_0, I_2F_0, I_2F_2 and I_2F_2, respectively. The combinations between irrigation and fertilizer treatments did not cause any significant change in the quality parameters of the soils except soil pH and phosphorus (P) content of the soil. The combination between raw wastewater irrigation and full dose fertilizer also caused a significant difference in soil P content and added more P in the irrigated soils. The effect of interactions between irrigation and fertilizer treatments on soil quality in a wheat field was studied by Islam *et al.* (2015), and our recorded result was almost similar with their experimental result.

Table 5. Some important quality parameters of irrigated soil under interactions of three irrigations and three fertilizer treatments for maize production.

Treatment	EC (dS/m)	pH	OC (%)	Total N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
I_1F_0	0.10^{D}	6.88^{C}	0.43^{A}	0.040^{D}	4.41^{G}	30.33^{BCD}	247.7^{C}	93.88^{D}
I_1F_1	0.18^{BC}	7.93^{AB}	0.29^{DE}	0.045^{C}	7.25^{CD}	35.41^{A}	291.4^{B}	101.5^{C}
I_1F_2	0.20^{B}	8.00^{AB}	0.40^{A}	0.053^{A}	8.00^{B}	33.50^{AB}	290.5^{B}	91.90^{D}
I_2F_0	0.17^{C}	7.63^{B}	0.33^{BC}	0.048^{BC}	5.30^{F}	30.00^{CD}	267.3^{BC}	91.69^{D}
I_2F_1	0.20^{B}	8.11^{A}	0.35^{B}	0.051^{AB}	6.97^{D}	28.33^{D}	358.9^{A}	92.45^{D}
I_2F_2	0.23^{A}	8.20^{A}	0.32^{BCD}	0.041^{D}	7.00^{D}	33.19^{ABC}	267.3^{BC}	52.33^{E}
I_3F_0	0.19^{BC}	8.20^{A}	0.27^{E}	0.035^{E}	6.57^{E}	29.53^{D}	267.9^{BC}	110.2^{AB}
I_3F_1	0.23^{A}	8.13^{A}	0.35^{B}	0.053^{A}	7.53^{C}	34.49^{A}	287.3^{B}	113.6^{A}
I_3F_2	0.25^{A}	8.10A	0.30^{CDE}	0.049^{ABC}	8.87^{A}	28.44^{D}	280.9^{B}	106.0^{BC}
CV (%)	6.44	3.06	5.64	4.88	3.21	5.70	4.68	3.63
$LSD_{0.05}$	0.0216	0.420	0.0329	0.00390	0.383	3.10	23.04	5.96
Level of significance	**	**	**	**	**	**	**	**

Common letter within the same column does not differ significantly at 5% level of significance analyzed by Duncan's Multiple Range Test. I_1 = Irrigation with fresh water, I_2 = Irrigation with mixed water (FW: WW =1:1) and I_3 = Irrigation with wastewater. F_0 = No application of fertilizer, F_1 = Half dose fertilizer and F_2 = Full dose fertilizer.

4. Conclusions

Based on the survey, a portion of the dairy farm's wastewater was used in irrigating fodder crops for the cattle of the farms, and the huge amount of the wastewater was disposed off in the nearby drainage canals. For the purpose of irrigation in the maize field, the quality parameters of the wastewater of BAU dairy farm were in the FAO and Bangladesh standards. Both the irrigation and fertilizer treatments and their combinations did not cause any significant change in the quality parameters of the soils, except soil pH and phosphorus (P) content of the soils. Irrigation by dairy wastewater significantly reduced soil pH; the mixed water and raw wastewater however employed identical effect on soil pH. Wastewater irrigation also caused a significant variation in the soil P content and also added more P in the irrigated soil. These results revealed that raw wastewater supplied more nutrients to the soil and the soil was moderately alkaline. Therefore, irrigation by wastewater did not significantly alter the quality parameters of the irrigated soil in the maize field.

Conflict of interest

None to declare.

References

BARC (Bangladesh Agricultural Research Council), 2005. Soil fertility status of different agro-ecological zones, BARC Soils Publication No. 45, pp. 15-32.

BBS (Bangladesh Bureau of Statistics), 2009. Monthly statistical bulletin - Bangladesh, August 2009. p. 66.

Buechler S, 2004. A sustainable livelihoods approach for action research on wastewater use in agriculture. In: C. Scott. N. Faruqui and L. Rachid-Sally (Eds.). Wastewater use in irrigated agriculture: Confronting the livelihood and environmental realities. Wallingford. IJK: CAB International in Association with International Water Management Institute and International Development Research Center, pp. 25-40.

Doorenbos J and WO Pruit, 1977. Crop water requirement. Food and agricultural organization of the United Nations (FAO). Irrigation and Drainage. Rome. Italy, pp. 24-144.

FAO (Food and Agriculture Organization), 1992. Wastewater treatment and use in agriculture. M.B. Pescod (ed.). FAO Irrigation and Drainage Paper 47, FAO, Rome, p. 125.

Fereres E and DJ Connor, 2004. Sustainable water management in agriculture. In: Cabrera E, Cobacho R, editors. Challenges of the new water policies for the XXI century. Lisse, The Netherlands: (Ed) A.A. Balkema, pp. 157-170.

Hoekstra AY, 2006. The global dimension of water governance: Nine reasons for global arrangements in order to cope with local problems. Value of water research report series no. 20, UNESCO-IHE Institute for Water Education.

Islam MS, MT Islam, SAAM Hossain, AKM Adham and D Islam. 2017. Impacts of dairy farm's wastewater irrigation on growth and yield attributes of maize. Journal of Fundamental and Applied Agriculture, 2: 247-255.

Islam MT, AKM Adham and D Islam, 2015. Effects of dairy farm's wastewater irrigation on wheat production and soil health. Journal of Environmental Science & Natural Resources, 8: 157-162.

Kandiah A, 1990. Water quality management for sustainable agricultural development. Nat. Resour. Forum, 14: 22-23.

Wilcox LV, 1955. Classification and use of irrigation water, United States Department of Agriculture. Circular no. 969, Washington D. C., p. 19.