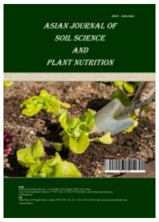

Asian Journal of Soil Science and Plant Nutrition

5(4): 1-17, 2019; Article no.AJSSPN.55692
ISSN: 2456-9682

Effect of Industrial Effluents on Rice Growth, Yield and Soil Chemical Properties

Md Rafiqul Islam[1*], Golam Kibria Muhammad Mustafizur Rahman[2] and Abu Saleque[1]

[1]Soil Science Division, Bangladesh Rice Research Institute (BRRI), Bangladesh.
[2]Department of Soil Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. Author MRI designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author GKMMR managed the analyses of the study. Author AS managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJSSPN/2019/v5i430075
Editor(s):
(1) Dr. Paola Angelini, University of Perugia, Italy.
Reviewers:
(1) Fábio Henrique Portella Corrêa de Oliveira, Universidade Federal Rural de Pernambuco, Brazil.
(2) Kaywood Elijah Leizou, Niger Delta University, Nigeria.
(3) Virendra Singh, IFTM University, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/55692

Original Research Article

Received 01 February 2020
Accepted 07 April 2020
Published 20 April 2020

ABSTRACT

Toxic pollutants and heavy metals in industrial effluents and city waste water are massive concern among the researchers, development worker, media personnel and policy makers. Keeping this in view-a pot experiment was conducted at the Bangladesh Rice Research Institute (BRRI), net house during T. Aman 2010 (wet season) and Boro 2011 (dry season) rice aimed to determining the effect of different industrial effluents on rice growth, yield and soil chemical properties. The irrigation effect of industrial effluents on rice production was more prominent in dry season (Boro) rice than wet season (T. Aman) rice. Perceptible changes in soil properties occurred through the effluents irrigation in rice-rice cropping pattern. Pharmaceutical and tannery effluents increased soil pH, EC, total N (%) available P (mg/kg). Exchangeable K, Ca, Mg and Na (cmol/kg) were increased due to irrigation with dyeing, pharmaceutical and tannery effluents. Dyeing, beverage, tannery and city waste water reduced percent soil organic carbon. Micronutrients (Zn, Fe, Cu and Mn) were increased significantly by the irrigation with dyeing,

**Corresponding author: Email: rafiqbrri@yahoo.com;*

pharmaceutical and tannery effluents in both wet and dry season rice. Heavy metals like Pb, Cd, Ni and Cr in soils were increased significantly through irrigation with effluents in rice-rice cropping pattern.

Keywords: Industrial effluents; rice growth; yield and soil chemical properties.

1. INTRODUCTION

The Industrial wastes and effluents have increased sharply in recent years in Bangladesh. Neighboring farmers of industrial areas grow rice in their field by using industrial waste water as an irrigation source in many years. Most of the industries in Bangladesh seldom pass the effluent through water treatment plant as a result untreated industrial waste water flood the land, most rice fields, surroundings the industries. Germination, root initiation, rate of root growth, stem growth, panicle emergence, filling of rice grain etc. are said to be greatly affected by industrial effluent [1]. Application of untreated waste water to irrigated rice fields is raising concern about possible health risks associated with the consumption of rice grain [2]. Albeit industrial waste water contains some plant nutrients that may enhance the growth of crop plants, toxic metals content in them may suppress plant growth severely.

Toxic metals in waste water contaminate the soil environment and also change the soil chemical properties like pH, EC, soil organic matter, primary, secondary nutrient elements including heavy metals [3]. Begum [4] expressed her concern about the accumulation of heavy metal in the agricultural soils of Bangladesh due the use of effluents irrigation. Industrial effluents have been pointed out as the main source of toxic metals both for plant and soils [5,6]. Among such metals cadmium and zinc are notoriously mobile and likely to move down through the soil profile to contaminate ground water [7], even though they are easily intercepted by clay particles in subsurface horizons [8]. Seneviratne [9] reported that controlled application of rubber effluent on land caused changes in soil properties and improved in soil water retention while Lim and P'ng [10] recorded increase in pH, Ca, Mg and organic matter content with the application of palm oil mill effluent. Nevertheless, the use of waste waters for agriculture is marred by several constraints due to various problems like soil salinity, interaction of chemical constituents of the wastes with the uptake of nutrient sand changes in soil property and micro flora [11]. Therefore, necessitates a detailed scientific study before any specific waste can be used for irrigation for a particular crop with particular soil and climate. Since crop plants are increasingly being exposed to the effluent discharge in the industrial area, an attempt has been done to study the effects of industrial effluents on rice growth and soil chemical properties.

2. MATERIALS AND METHODS

A pot experiment was conducted at the Bangladesh Rice Research Institute (BRRI), net house during T. Aman 2010 and Boro 2011 growing seasons. The soil for the experiment was collected from BRRI experimental farm (Madhpur tract, Agro Ecological Zone 28). It is middle part of Bangladesh (lat. 23°58'N, long. 90°23'E, 30 m above mean sea level) which has a long cropping history under rice-rice systems. The average temperature ranges from 8.2°C in winter to 36.6°C in summer. The mean annual rainfall is about 2,000 mm. After collection of soil, it was dried, crushed and mixed. The physical and chemical properties of experimental soil have been presented in Table 1.

Each pot was filled with 10 kg of soil. Pot soil was received basal dose of P and K fertilizer from TSP and MoP based on soil test both in T. Aman and Boro seasons. The N fertilizer was applied into three equal splits: 1/3rd as basal, 1/3rd at early active tillering stage and the remaining 1/3rd at 5-7 days before panicle initiation stage. The experiments were laid out in a completely randomized design with three replications. BRRI dhan49 and BRRI dhan29 were used as a test variety in T. Aman and Boro seasons, respectively. Pots filled with soil were fully saturated with different industrial effluents like, polyvinyl, dyeing, pharmaceutical, beverage, tannery, city waste water (CWW) and mixed waste water (MWW) (cannel effluent which received dyeing, beverage, textile etc effluent together). Soil saturated with underground water was considered as control. Soil of each pot was puddle thoroughly. After soil setting, four hills were transplanted to each pot with 2 seedlings per hill. Thirty day old and forty day old seedlings were transplanted in T. Aman and Boro seasons,

Table 1. The physical and chemical properties of initial soil

Soil properties	Value	SE
Texture	Clay loam	-
pH (H_2O)	7.12	0.018
pH (KCl)	6.45	0.003
∆pH	-0.66	0.019
Electrical conductivity (EC) (dS/m)	0.87	0.017
Organic carbon (%)	1.19	0.037
Total N (%)	0.13	0.003
Available P (modified Olsen) (mg/kg)	4.00	0.058
Exchangeable K (cmol/kg)	0.10	0.003
Exchangeable Na (cmol/kg)	0.72	0.000
Exchangeable Ca (cmol/kg)	9.13	0.310
Exchangeable Mg (cmol/kg)	1.03	0.110
Available Zn (mg/kg)	5.35	0.114
Available Fe (mg/kg)	1.07	0.000
Available Cu (mg/kg)	4.73	0.087
Available Mn (mg/kg)	8.34	0.597
Total Pb (mg/kg)	17.76	0.118
Total Cd (mg/kg)	0.16	0.005
Total Ni (mg/kg)	38.57	0.062
Total Cr (mg/kg)	42.04	0.301

respectively. Pots were irrigated with respective effluent regularly. Necessary intercultural operations were done as and when required. In T. Aman rice, tannery and pharmaceutical effluent irrigated rice plants were died 21 and 25 days after transplanting but in Boro rice, tannery and pharmaceutical effluent irrigated rice plants were died just after transplanting but dyeing effluent irrigated rice plants were died after 21 days of transplanting. The crops were harvested at maturity. The plant height (cm), tiller and panicle number per hill, panicle length (cm), filled and unfilled grain per panicle, percent sterility, 1000 grain weight (g), harvest index, grain (14% moisture) and straw yields (oven dry basis) per pot were recorded. After harvesting of T. Aman and Boro crops, about 500 g of soil samples were collected from each pot. The soil samples were air dried ground to pass through a 2-mm sieve. Analytical methods used for initial and post-harvest soil samples have been presented in Table 2. The obtained data were statistically analyzed following IRRISTAT version 4.3 [12].

3. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height (cm) was differed significantly by the tested effluent treatments both in T. Aman and Boro seasons (Table 3). The plant height of T. Aman rice was 106 cm in control pot which was statistically similar with polyvinyl, beverage and mixed effluents pot. Dyeing effluent had 9 cm lower plant height than that of control water treated pot. City waste water (CWW) showed an increase in plant height than the control by 7 cm.

During Boro rice, control water had the plant height of 82 cm. Polyvinyl and beverage gave the statistically identical plant height to that of control water. City waste water gave statistically higher while mixed effluent gave statistically lower plant height than that of control. City waste water showed an increase plant height than the control water by 7 cm. City waste water enhanced root and shoot growth through adequate nutrient supply resulting the taller plant height in bot T. Aman and Boro seasons. The negative effect on plant height was observed in present study due to the use of industrial effluents. This finding was agreed well with the findings of [20,21,22]. They stated that the stunted growth of rice and other plants through irrigation with water having toxic level of Zn, Cu, Mn, Pb, Cr, Ni and Cd.

3.2 Tillers per Hill

Tiller numbers per hill observed identical among the treatments in T. Aman rice while in Boro rice, it was differed significantly by the treatments (Table 3). In T. Aman rice, control treatment obtained the tillers/hill of 16. Mixed waste water gave the similar tillers/hill to that of control treatment. Both polyvinyl and beverage effluents.

Table 2. Details analytical methods used in initial and post-harvest soil analysis

Soil property	Method
pH (H_2O)	1:2.5 soil water ratio, using glass electrode method [13]. Ten g of air dried soil sample was taken in a 50 ml of beaker and 25 ml of distilled water was added. The suspension was stirred with a glass-rod at regular interval for 30 minutes. A glass electrode pH meter (WPA Linton Cambridge, UK) calibrated with buffer pH 7.0 and 4.0 measured the pH of the soil suspension.
pH (KCl)	The pH_{KCl} was determined by stirring 10 g soil in 25 ml 1.0 M KCl solution in a similar manner of pH_{H2O}determination.
∆pH	The difference between the pH in KCl and that in water gave the value of ∆pH, as $\Delta pH = pH_{KCl} - pH_{H2O.}$
Electrical Conductivity (dS/m)	A portion of 20 gm of air dried soil sample was taken in a 250 ml of conical flask and then 100 ml of distilled water was added. It was shaken for 30 minutes and filtered through Whatman # 42 filter paper. Electrical conductivity was measured from filtered sample using conductivity meter (YSI Model 32, [13]).
Organic Carbon (%)	Walkley and Black wet digestion method [14] was followed to determine organic carbon. The sieved soil was again passed through 0.5 mm sieve to determine organic carbon. One gm soil sample was taken in a 500-ml conical flask, and then 10 ml of 1 N $K_2Cr_2O_7$ solution and 20 ml of conc. H_2SO_4 was added. Flask was then kept for 30 minutes for completion of oxidation. Then 200 ml of distilled water, 10 ml of H_3P0_4 and 2 ml of di-phenyl amine indicator solution were added. The sample was then titrated with 1N $FeSO_4$ solution until green color was appeared. A blank sample was also taken to calculate the results.
Total N (%)	Modified Kjeldahl method [15] was followed to determine total N. One gm air-dried and 0.5 mm sieve soil was taken in a Kjeldahl flask, and then digested using 2g of salt mixture (K_2SO_4 + $CuSO_4$) and 5-7 ml conc. H_2SO_4 until the acid soil mixture turns white. After cooling the digest, 10 ml 4% H_3BO_3 and 2-4 drops of mixed indicator was taken in a 125 ml conical flask and placed under the condenser. Then the whole digest was transferred into distillation flask by washing with distilled water and added 20 ml of 40% NaOH. Absolute 40-50 ml distillate was collected and titrated the distillate against the 0.05 N H_2SO_4. A blank sample was also taken simultaneously to calculate the results.
Available P (mg/kg)	Olsen method [16] was followed to determine available P. A portion of 2.5 gm of air dried soil sample was taken in a 125 ml of conical flask and then 25 ml of extracting solution (0.5 M $NaHCO_3$, pH 8.5) was added. It was shaken for 30 minutes and filtered through Whatman # 42 filter paper. A portion of 2 ml of aliquot was taken into 25 ml test tube. Exactly 6 ml of distilled water and 2 ml of color reagent was added. The color reagent was prepared following [17]. Finally water was added to make volume up to the mark (10 ml). Reading was through Spectrophotometer at 710 nm wavelength.
Exchangeable Ca, Mg, K and Na (cmol/kg)	Thomas [18] method was followed to determine exchangeable cations. A portion of ten gm of air dried sieved soil sample was taken in a 125 ml of conical flask, then 50 ml of extracting solution (1 N $CH_3COONH_{4,}$ pH 7.0) was added. It was shaken for 10 minutes and filtered through Whatman # 42 filter paper. In case of exchangeable K and Na direct reading was taken from atomic absorption spectrophotometer at 766.5 nm and 589 nm wavelengths, respectively. For Exchangeable Ca was determined by diluting a portion of 2 ml of aliquot with 1 ml of La_2O_3 and 7ml of distilled water into 25 ml test tube and atomic absorption Spectrophotometer reading was taken at 422.7 nm wavelength. For Mg, 1 ml aliquot was diluted in 19 ml of distilled water into 25 ml test tube and atomic absorption Spectrophotometer reading was taken at 285.2 nm wavelength.
Trace elements (Zn,	Lindsay and Norvell [19] method was followed to determine trace elements. A portion of ten gm of air dried sieved soil sample

Soil property	Method
Fe, Mn and Cu) (mg/kg)	was taken in a 125 ml of conical flask, then 20 ml of extracting solution (EDTA-Ethylene Diamine Teteraacetic Acid) was added. It was shaken for 2 hours and filtered through Whatman # 42 filter paper. Concentrations of Zn, Fe, Mn and Cu were determined by atomic absorption Spectrophotometer with respective wavelength.
Heavy metals (Pb, Cd, Cr and Ni) (mg/kg)	Heavy metals analysis involved digestion of 0.5 g of soil sample with concentrated HNO_3 and $HClO_4$ (5:2) at 120^{0}C following the procedure described by Lindsay and Norvell, 1978 [19]. Finally the digest was filtered through Whatman # 42 filter paper and diluted to 50 ml with distilled water prior to analysis. Concentrations of Pb, Cd, Cr and Ni were determined by atomic absorption Spectrophotometer with respective wavelength (AAS; Model: Varian 55B).

Gave 1 and dyeing effluent gave 2 tillers lower per hill over the control. The highest tillers/hill of 17 was obtained in CWW.

During Boro rice, control water gave the tillers/hill of 15. Except MWW, all the effluent treatments and CWW gave the statistically equal tillers/hill to that of control. The lowest tillers/hill of 12 was found in MWW which was statistically lower than the control.

3.3 Panicles per Hill

Panicle numbers per hill was identical among the treatments in T. Aman rice while in Boro rice, it was differed significantly by the treatments (Table 3). During T. Aman rice, control water treatment gave the panicles/hill of 14. Polyvinyl and beverage effluents showed the equal panicles per hill to that of control. Dyeing effluent had 1 lower while mixed effluent had 1 unit higher panicle/hill than that of control water treatment. City waste water showed an increase in panicles/hill than the control water by 2 units.

In Boro rice, the panicles/hill of 13 was recorded in control. Except MWW, all the effluent treatments and CWW gave the statistically equal tillers/hill to that of control. The lowest panicles/hill of 11 was found in MWW which was statistically higher than the control. Both in T. Aman and Boro rice, CWW gave the highest tiller and panicles/hill might be due to enhanced root and shoot growth through adequate nutrient supply resulting the maximum tillers and panicles number per hill. Dyeing and mixed waste gave the lowest tiller and panicles/hill might have caused poor aeration that hampering root growth. However, high content of Cu, Mn and Cr in these irrigation sources probably exerted toxic effects on rice plants leading to decreased shoot and root growth [23] that ultimately reduced the number of tillers and panicles/hill. The present study was in good agreement with the findings of several authors [22,24].

3.4 Panicle Length

Seasonal variation on the panicle length (cm) of rice showed insignificant effect (Table 4). In T. Aman rice, control water treatment gave the panicle length of 22 cm. Polyvinyl, beverage effluents and MWW gave the equal panicle length to that of control. Dyeing effluent recorded 1 cm lower while CWW gave 1 cm higher panicle length over the control.

During Boro rice, control showed the panicle length of 24 cm. City waste water gave the equal panicle length to that of control. Polyvinyl, beverage effluents and MWW recorded 1 cm lower panicle length than that of control. Polluted water contained the higher biological oxygen demand (BOD), chemical oxygen demand (COD) and toxic heavy metals like Cu, Mn, Cr and Ni which were harmful to rice, hampering dry matter accumulation as indicated by shorter plant height and consequently resulted in shorter panicle length [22].

3.5 Filled Grains/Panicle

Significant variation of filled grains/panicle was observed both in T. Aman and Boro rice due to the application of treatments (Table 4). In T. Aman rice, control treatment recorded the filled grains/panicle of 110. Polyvinyl and mixed effluents treatment gave the statistically equal filled grains/panicle to that of control. Dyeing effluent gave the statistically lower while CWW gave the statistically higher filled grains/panicle as compared to control. The highest filled grains/panicle of 131 was obtained in CWW.

During Boro rice, control treatment recorded the filled grains/panicle of 110. Except MWW, all the effluent treatments and CWW gave the statistically equal filled grains/panicle than that obtained in control. MWW showed to decrease in filled grains/panicle than the control water by 19 units. Polluted water contained some toxic ions like Cu, Mn, Cr and Ni which were harmful to rice and might have affected pollen germination and pollen tube length resulting in such lower number of filled grains/panicle with dyeing effluent and MWW in T. Aman and Boro rice, respectively.

3.6 Unfilled Grains/Panicle

Unfilled grains/panicle was differed significantly in T. Aman rice while in Boro rice unfilled grains/panicle was identical among the tested treatments (Table 4). During T. Aman rice, control treatment gave the unfilled grains/panicle of 38. Polyvinyl, CWW and mixed effluent gave the statistically equal unfilled grains/panicle to that of control water. Dyeing effluent gave the statistically higher while beverage effluent gave the statistically lower unfilled grains/panicle than that of control treatment.

In Boro rice, control water treatment recorded the unfilled grains/panicle of 16. Polyvinyl effluent gave the lower while beverage effluent gave 1 unit higher unfilled grains/panicle than that of control. MWW showed the equal result to that of beverage effluent. The highest unfilled grains/panicle of 18 was obtained in CWW.

3.7 Sterility Percent

Percent sterility was differed significantly in T. Aman rice while in Boro rice it was identical among the tested treatments (Table 5). In T. Aman rice, control water treatment gave the percent sterility of 26. All the effluent treatments and CWW gave the statistically identical percent sterility to that of control.

During Boro rice, control treatment obtained percent sterility of 13. Polyvinyl effluent gave 1% lower while beverage effluent gave 1% higher sterility than that of control. City waste water had the similar sterility % to that of control water. MWW showed an increase in percent sterility than the control water by 2%.

3.8 1000-Grain Weight

Like other yield attributes, 1000 grain weight (g) was affected significantly by the different industrial effluents irrigation (Table 5). In T. Aman rice, control treatment gave the 1000-grain weight of 16.42 g. All the effluents and CWW showed the negative impact on 1000-grain weight than the control. Except MWW, all the effluents and CWW gave the statistically equal 1000-grain weight to that of control. The lowest 1000-grain weight of 15.34 was recorded in MWW.

In Boro rice, the 1000-grain weight of 20.42 g was found in control treatment. All the effluents showed the negative while CWW showed positive impact on 1000-grain weight than the control. Polyvinyl, beverage and mixed effluents reduced in 1000-grain weight than the control by 3, 5 and 15%, respectively. The highest 1000-grain weight of 20.68 was recorded in CWW. Polluted waste water like dyeing and MWW contained toxic ions which decreased plant growth and development, damaged the enzyme, stomatal activities and photosynthesis of plant, causing reduced in plant nutrient uptake and thereby decreased 1000-grain weight. A similar observation was made by [22].

3.9 Harvest Index

Harvest index was differed significantly by the effluent treatments in T. Aman season but it was identical in Boro rice (Table 5). In T. Aman rice, control water had the harvest index of 0.35. City waste water had the similar harvest index to that of control water. Polyvinyl effluent had 3% and beverage effluent had 9% higher harvest index than that of control water. Dyeing and mixed effluents decreased in harvest index than the control water by 9% and 6%, respectively.

During Boro rice, control water had the harvest index of 0.48. Polyvinyl effluent and CWW had the similar harvest index to that of control water. Beverage and mixed effluents decreased in harvest index than the control by 4 and 6%, respectively. However, Boro rice showed the higher harvest index than that of T. Aman rice.

3.10 Grain and Straw Yield

Grain yield (g/pot) was differed significantly by the treatments both in T. Aman and Boro seasons rice (Table 6). During T. Aman season, control water treatment gave the grain yield of 39 g/pot. All the effluent treatment except dyeing treatment gave the statically similar grain yield to that of control water treatment. Dyeing effluent treatment had 11 g/pot lower grain yield than that of control water.

Table 3. Effect of different industrial effluents on plant height, tillers and panicles number per hill in T. Aman (BRRI dhan49) and Boro (BRRI dhan29) rice

Treatment	Plant height (cm)		Tillers/hill		Panicles/hill	
	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro
Control	106	82	16	15	14	13
Polyvinyl	107	85	15	14	14	13
Dyeing	97	-	14	-	13	-
Beverage	106	84	15	14	14	13
City waste	113	89	17	15	16	14
Mixed waste	105	78	16	12	15	11
$LSD_{0.05}$	4	4	NS	1	NS	1
CV (%)	2	3	9	4	9	5

In Boro, ˉ means no result due to dying of rice plants after 21 days

Table 4. Effect of different industrial effluents on panicle length, filled and unfilled grain per panicle in T. Aman (BRRI dhan49) and Boro (BRRI dhan29) rice

Treatment	Panicle length (cm)		Filled grains/panicle		Unfilled grains/panicle	
	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro
Control	22	24	110	110	38	16
Polyvinyl	22	23	120	111	39	15
Dyeing	21	-	97	-	50	-
Beverage	22	23	123	105	27	17
City waste	23	24	131	116	40	18
Mixed waste	22	23	103	91	38	17
$LSD_{0.05}$	NS	NS	11	8	6	NS
CV (%)	5	3	16	4	10	12

In Boro, ˉ means no result due to dying of rice plants after 21 days

Table 5. Effect of different industrial effluents on % sterility, 1000 grain weight and harvest index in T. Aman (BRRI dhan49) and Boro (BRRI dhan29) rice

Treatment	% Sterility		1000 grain weight (g)		Harvest index	
	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro
Control	26	13	16.42	20.42	0.35	0.48
Polyvinyl	25	12	16.13	19.72	0.36	0.48
Dyeing	34	-	15.14	-	0.32	-
Beverage	17	14	16.35	19.36	0.38	0.46
City waste	23	14	15.63	20.68	0.35	0.48
Mixed waste	27	15	15.34	17.24	0.34	0.45
$LSD_{0.05}$	9	NS	0.92	0.92	0.03	NS
CV (%)	10	11	3.20	2.6	5.20	2.80

In Boro, ˉ means no result due to dying of rice plants after 21 days

Table 6. Effect of different industrial effluents on grain and straw yield in T. Aman (BRRI dhan49) and Boro (BRRI dhan29) rice

Treatment	Grain yield (g/pot)		Straw yield (g/pot)	
	T. Aman	Boro	T. Aman	Boro
Control	39	61	75	67
Polyvinyl	40	59	70	64
Dyeing	28	-	63	-
Beverage	40	57	69	68
City waste	42	64	76	70
Mixed waste	35	51	66	61
$LSD_{0.05}$	6	5	NS	3
CV (%)	9	5	8	3

In Boro, ˉ means no result due to dying of rice plants after 21 days

In Boro rice, control water treatment gave the grain yield of 61 g/pot. All the effluent treatments except mixed effluent treatment gave the statistically similar grain yield to that of control water treatment. Mixed effluent showed the lowest grain yield of 51 g/pot during Boro rice. The CWW treatment had the highest grain yield both in T. Aman and Boro rice. It might be due to the highest tillers/hill, panicles/hill, filled grains/hill and 1000-grain weight (g). Due to the highest unfilled grains/panicle and the lowest 1000-grain weight (g), the dyeing and mixed effluent treatments gave the lowest grain yield in T. Aman and Boro seasons, respectively.

Straw yield (g/pot) was identical in T. Aman rice while in Boro rice, it was differed significantly by the treatments (Table 6). During T. Aman rice, control water treatment obtained the straw yield of 75 g/pot. All the effluents had the negative while CWW had the positive effect on straw yield. Polyvinyl, dyeing and beverage mixed effluents showed to decrease in straw yield/pot than the control water by 5, 12and 6 g/pot, respectively.

The mixed effluent treatment gave the straw yield of 66 g/pot.

In Boro rice, control water treatment obtained the straw yield of 67 g/pot. Polyvinyl, beverage and CWW treatments gave the statistically similar straw yield to that of control water treatment. Mixed waste water had 6 g/pot lower grain yield than that of control water.

3.11 Soil Chemical Properties

Perceptible changes in soil characteristics and soil nutrient status occurred through the use of different types of industrial effluents as an irrigation source in the rice-rice cropping pattern. Soil properties that are changed due to effluents irrigation were presented in Tables 7-9.

3.12 Soil PH

Soil pH was differed significantly by the tested effluent treatments both in T. Aman and Boro seasons (Table 7). During T. Aman season, soil pH of the tested treatments ranged from 6.99 to 7.97 while in Boro season, it varied from 7.12 to 8.55. The initial soil pH value of the experimental soils was 7.12. In T. Aman season, control, polyvinyl and MWW gave the identical soil pH as that of initial soil. The dyeing and CWW showed an increase in soil pH than the initial soil by 0.18 and 0.46 units, respectively. The beverage effluent gave the equal soil pH with dyeing effluent.

A remarkable increase in soil pH was found in the pharmaceuticals and tannery industries effluents in T. Aman season. The pharmaceutical effluent had soil pH of 7.72 and in the tannery waste was 7.97.

During Boro season, all the effluent treatments and CWW showed an increase soil pH significantly than the initial soil. The control treatment gave the equal pH as that of initial soil. The polyvinyl, dyeing, beverage and MWW showed an increase in soil pH than the initial soil by 0.37, 0.79, 0.36 and 0.48 units, respectively. A remarkable increase in soil pH was found in the pharmaceuticals and tannery industries effluents in Boro season. The pharmaceutical effluent had soil pH of 8.02 and that in the tannery waste was 8.55. The CWW had almost the similar soil pH to that of pharmaceutical effluent.

In both the seasons, a considerable increase in soil pH was found in the pharmaceuticals and tannery effluents. Alkaline chemicals used in the pharmaceutical and tannery industries which might have released some Ca and Mg ions to the system that are responsible to increasing soil pH. Babyshakkila and Usha [25] reported that soil pH increase from 8.05 to 8.75 due to use of tannery effluent as irrigation source in *Vigna radiate.*

3.13 Soil EC

Significant variation of soil EC was observed both in T. Aman and Boro seasons due to the use of different effluents as irrigation source (Table 7). During T. Aman season, soil EC of the tested treatments ranged from 0.91 to 21.37 dS/m while in Boro season, it ranged from 0.90 to 32.37 dS/m. The initial soil EC value of the experimental soils was 0.87 dS/m. In T. Aman season, control, polyvinyl and beverage effluent treatments gave the statistical identical soil EC as that of initial soil. Dyeing, pharmaceutical, tannery, MWW and CWW showed an increase in soil EC significantly than the initial soil. The dyeing, MWW and CWW showed an increase in soil EC than the initial soil by 7.78, 6.05 and 0.78 dS/m, respectively. A remarkable increase in soil EC was found in the pharmaceuticals and tannery industries effluents in T. Aman season. The pharmaceutical effluent had soil EC of 12.63 dS/m and that in the tannery waste was 21.37 dS/m.

During Boro season, control, polyvinyl and beverage effluent treatments gave the statistically equal soil EC of initial soil. Dyeing, MWW and CWW showed an increase in soil EC as compared to initial soil by 12.07, 0.95 and 6.78 dS/m, respectively. A considerable increase in soil EC was found in the pharmaceuticals and tannery industries effluents in Boro season. The pharmaceutical effluent had soil EC of 16.92 dS/m and that in the tannery effluent was 32.37 dS/m. In both the seasons, the highest soil EC was found in the tannery effluent treatment may be explained through the sodium equilibrium. The tannery industry usually uses sodium salt for its processing which might have released some Na ions to the system that are responsible to higher soil EC value. A similar finding was made by [25].

3.14 Soil Organic Carbon

The soil organic carbon (OC) in soils varied significantly due to the application of effluent treatments both in T. Aman and Boro seasons (Table 7). The soil OC ranged from 1.05 to 1.25% during T. Aman season while in Boro season, it ranged from 1.09 to 1.23%. In the initial soil, the value of OC was 1.19%. In T. Aman season, control, polyvinyl and MWW gave the similar soil OC value of initial soil. Dyeing, beverage and tannery effluents and CWW decreased in soil OC significantly than the initial soil. Pharmaceutical effluent showed an increase in soil OC than the initial soil by 0.06%.

During Boro season, control, polyvinyl and MWW treatments recorded the statistically equal soil OC like as initial soil. Soil OC content decreased significantly than the initial soil by dyeing, beverage, tannery effluents and CWW. Pharmaceutical effluent showed an increase in soil OC than the initial soil by 0.04%.

3.15 Total N

In the treatments, the total N in soil ranged from 0.13 to 0.18% during T. Aman season but in Boro season it ranged from 0.12 to 0.18% (Table 7). In the initial soil, the value of total N was 0.13%. Except tannery effluent, all the effluent treatments and CWW gave the statistically equal total N as that of initial soil in T. Aman season.

Like T. Aman season, Boro season showed the similar total N in soils among the treatments. Both in T. Aman and Boro seasons, the tannery effluent showed an increase in total N than the initial soil by 0.04 and 0.05%, respectively. The highest total N in soils was found in tannery effluent treatment may be due to higher N content in tannery effluent (12.17%).

3.16 Available P

In the treatments, the available P (mg/kg) in soil ranged from 4.10 to 8.93 mg/kg during T. Aman season but in Boro season it ranged from 4.12 to 9.33 mg/kg (Table 7). In the initial soil, the value of available P was of 4.00 mg/kg. In T. Aman season, control and beverage gave the statistically equal available P in soil to that of initial soil. Polyvinyl, dyeing, CWW and MWW treatments showed an increase in available P significantly than the initial soil. A noticeable increase in available P in soil was found in the pharmaceuticals and tannery industries effluents. The pharmaceutical effluent had available P of 8.93 mg/kg and that in the tannery effluent was 6.67 mg/kg.

During Boro season, control and beverage gave the statistically similar available P in soil value to that of initial soil. Polyvinyl, dyeing and MWW showed an increase in available P than that of initial soil by 0.87, 1.57 and 1.63 mg/kg. The CWW had the similar P content in soil to that of dyeing effluent. Like T. Aman season, a noticeable increase in available P was found in the pharmaceuticals and tannery industries effluents. The pharmaceutical effluent gave available P of 9.33 mg/kg and that in the tannery effluent was 7.10 mg/kg. In both the seasons, the highest available Pin soil was found in pharmaceutical effluent treatment that is responsible to higher P content (0.31 mg/L) in pharmaceutical effluent.

3.17 Exchangeable K

Application of the industrial effluents and CWW changed soil exchangeable K both in T. Aman and Boro seasons (Table 7). During T. Aman season, the exchangeable K ranged from 0.09 to 0.43 cmol/kg while in Boro season, it ranged from 0.10 to 0.48 cmol/kg. The exchangeable K value of 0.10 cmol/kg was in the initial soil. In T. Aman season, control, polyvinyl, beverage, CWW and MWW gave the statistically equal exchangeable K in soil as that of initial soil. Dyeing effluent gave 0.03 cmol/kg higher exchangeable K than the initial soil. A remarkable increase in exchangeable K was found in the pharmaceuticals and tannery effluents. The pharmaceutical effluent had exchangeable K of 0.43 cmol/kg and that in the tannery effluent was 0.30 cmol/kg.

During Boro season, control, polyvinyl, beverage and CWW treatments recorded the statistically equal exchangeable K value in soil as that of initial soil. Dyeing effluent and MWW showed an increase in K content than the initial soil by 0.07 and 0.03 cmol/kg, respectively. Like T. Aman season, a noticeable increase in exchangeable K content was found in the pharmaceuticals and tannery industries effluents. The pharmaceutical effluent had exchangeable K of 0.48 cmol/kg and that in the tannery effluent was 0.35 cmol/kg. The highest exchangeable Kin soil was found in pharmaceutical effluent treated soil that is responsible to higher exchangeable K content (34 cmol/L) in pharmaceutical effluent.

3.18 Exchangeable Na

In the treatments, the exchangeable Na in soil ranged from 0.72 to 4.49 cmol/kg during T. Aman season but in Boro season it ranged from 0.77 to 5.80 cmol/kg (Table 8). In the initial soil, the exchangeable Na value was 0.72 cmol/kg. In T. Aman season, control, polyvinyl and beverage treatments showed the statistically equal exchangeable Na in soil as that of initial soil.

Dyeing, MWW and CWW showed an increase in exchangeable Na than initial soil by 2.18, 1.50 and 0.77 cmol/kg, respectively. A considerable increase in exchangeable Na was found in the pharmaceuticals and tannery industries effluents. The pharmaceutical effluent had exchangeable Na of 3.67 cmol/kg and that in the tannery effluent was 4.49 cmol/kg.

During Boro season, control, polyvinyl and beverage treatments gave the statistically equal exchangeable Na content in soil as that of initial soil. Dyeing, MWW and CWW showed an increase in exchangeable Na than the initial soil by 3.10, 2.47 and 1.45 cmol/kg, respectively. Like T. Aman season, a considerable increase in exchangeable Na was found in the pharmaceuticals and tannery industries effluents. The pharmaceutical effluent had exchangeable Na of 4.93 cmol/kg and that in the tannery effluent was 5.80 cmol/kg. The highest exchangeable Nain soil was found in tannery effluent treated soil that is responsible to higher exchangeable Na content (1200 cmol/L) in tannery effluent.

3.19 Exchangeable Ca

In the treatments, the exchangeable Ca in soil ranged from 8.97 to 11.56 cmol/kg during T. Aman season but in Boro season it ranged from 9.15 to 11.71 cmol/kg (Table 5.20). In the initial soil, the exchangeable Ca value was 9.13 cmol/kg. In T. Aman season, control, polyvinyl, beverage and MWW treatments recorded the statistically equal exchangeable Ca in soil as that of initial soil. Pharmaceutical effluent treated soil gave 1.84 cmol/kg and CWW treated soil gave 0.84 cmol/kg higher exchangeable Ca than the initial soil. A considerable increase in exchangeable Ca was found in the tannery effluent. The exchangeable Ca of 11.56 cmol/kg was found in tannery effluent.

During Boro season, control, polyvinyl and beverage effluents showed the statistically equal exchangeable Ca in soil as that of initial soil. Dyeing, pharmaceutical and CWW treated soils showed an increase in exchangeable Ca content in soil than the initial soil by 1.20, 1.95 and 0.70 cmol/kg, respectively. Like T. Aman season, a considerable increase in exchangeable Ca was found in the tannery industries effluent. The tannery effluent recorded the exchangeable Ca of 11.71 cmol/kg. Both in the seasons, the highest exchangeable Ca in soil was found in tannery effluent treated soil that is responsible to higher exchangeable Ca content (61 cmol/L) in tannery effluent.

3.20 Exchangeable Mg

Among the treatments, the exchangeable Mg in soil ranged from 1.13 to 1.21 cmol/kg during T. Aman season while in Boro season, it was ranged from 1.11 to 1.23 cmol/kg (Table 8). In the initial soil, the exchangeable Ca was 1.11 cmol/kg. In T. Aman season, all the treatments showed an increase Mg content than the initial soil. The control, polyvinyl, dyeing and beverage treatments gave the statistically similar Mg content in soil as that of initial soil. Pharmaceutical, tannery and CWW showed an increase in Mg content than the initial soil by 4, 9 and 6%, respectively. Mixed waste water showed the similar Mg content to that of CWW.

During Boro rice, control and polyvinyl gave the statistically similar exchangeable Mg in soil to that of initial soil. Dyeing, pharmaceutical, beverage, tannery, MWW and CWW showed an increase in Mg content in soil than the initial soil by 4, 8, 7, 11, 6 and 9%, respectively. In both the seasons, the highest exchangeable Mgin soil was found in tannery effluent treated soil that is responsible to higher exchangeable Mg content (34 cmol/L) in tannery industry effluent.

3.21 Available Zn

The available Zn in soil resulted from the different effluent treatments ranged from 3.46 to 9.78 mg/kg during T. Aman season but in Boro season, it ranged from 5.27 to 13.91 mg/kg (Table 8) which was more or less equal to the values (3.20- 12.30 mg/kg) conveyed by Ahmed and Goni [26]. In the initial soil, the Zn content was 5 mg/kg. In T. Aman season, control, beverage, CWW and MWW treatments gave the statistically equal Zn content in soil as that of initial soil. Polyvinyl showed 2 mg/kg and dyeing effluent showed 3 mg/kg higher Zn content in soil than that of initial soil. Tannery effluent gave the equal Zn content to that of dyeing effluent. A considerable increase in Zn in soil was found in the pharmaceutical effluent treated soil. The pharmaceutical effluent recorded the Zn content in soil of 10 mg/kg.

During Boro rice, control, polyvinyl, beverage, CWW and MWW gave the statistically equal Zn content in soil as that of initial soil. Dyeing, pharmaceutical and tannery effluents treated soils showed an increase in Zn content than the initial soil by 5, 8 and 4 mg/kg, respectively.

3.22 Available Fe

The available Fe in different effluents treated soils ranged from 11 to 34 mg/kg during T. Aman season but in Boro season, it ranged from 8 to 35 mg/kg (Table 8). In the initial soil, the Fe content was 11 mg/kg. In T. Aman season, control, polyvinyl, beverage, CWW and MWW treated soils gave the statistically equal Fe content in soil as that of initial soil. The dyeing effluent treated soil gave 10 mg/kg higher Fe content in soil than that of initial soil. A considerable increase in Fe in soil was found in the pharmaceutical effluent treated soil. Both in pharmaceutical and tannery effluent treated soils showed an increase in Fe content than the initial soil by 23 mg/kg.

During Boro season, control, polyvinyl, beverage and CWW treated soils gave the statistically similar Fe content in soil to that of initial soil. The dyeing and MWW treated soil showed an increase in Fe content than the initial soil by 9 and 4 mg/kg, respectively. A considerable increase in available Fe was found in the pharmaceuticals and tannery effluents treated soil. The pharmaceutical effluent showed Fe content of 33 mg/kg and that in the tannery effluent was 35 mg/kg. Both in T. Aman and Boro seasons, the highest Fe content in soil was found in pharmaceutical and tannery effluents treated soils that are responsible to their higher Fe content on its effluents.

3.23 Available Cu

The available Cu in different effluents treated soils ranged from 4.21 to 5.43 mg/kg during T. Aman season while in Boro season, it ranged from 4.45 to 5.81 mg/kg (Table 8). In the initial soil, the Cu content was 4.73 mg/kg. In T. Aman season, control and pharmaceutical effluent treated soils gave the statistical equal Cu content in soil to that of initial soil. Dyeing, beverage and CWW treated soils tended to decrease in Cu content than the initial soil by 0.52, 0.35 and 044 mg/kg, respectively. Mixed waste water recorded the equal Cu content in soil to that of beverage effluent. However, polyvinyl effluent treated soil recorded 0.60 mg/kg and tannery effluent treated soil gave 0.70 mg/kg higher Cu content than the initial soil.

During Boro season, all the effluents treated soils except polyvinyl and tannery gave the statistically equal Cu content in soils to that of initial soil. Polyvinyl and tannery effluents treated soils showed an increase in Cu content than the initial soil by 0.98 and 1.08 mg/kg, respectively.

3.24 Available Mn

The available Mn in soils resulting from different effluent treatments ranged from 10 to 75 mg/kg during T. Aman season but in Boro season, it ranged from 8 to 64 mg/kg (Table 9). The Mn content in soil was 8 mg/kg in the initial soil. During T. Aman season, all the effluent treatments except control and beverage gave the statistically higher Mn content in soil than that of initial soil. Polyvinyl effluent gave 6 and dyeing effluent gave 12 mg/kg higher Mn content than the initial soil. A remarkable increase in Mn in soil was found in the pharmaceutical, tannery and MWW treated soils. Pharmaceutical, tannery and MWW treated soils showed an increase in Mn content than the initial soil by 4, 7 and 9 folds, respectively.

In Boro season, control and polyvinyl gave the equal Mn content as that of initial soil. Dyeing gave 6 and pharmaceutical effluent treated soil gave 4.5 folds higher Mn content than the initial soil. Tannery and CWW treated soils gave the statistically equal Mn content in soil to that of dyeing effluent treated soil. Mixed waste water showed an increase in Mn content than the initial soil by 8 folds.

3.25 Total Pb

The total Pb in different effluents treated soils ranged from 19 to 21 mg/kg during T. Aman season while in Boro season, it ranged from 18 to 29 mg/kg (Table 9) which was lower than the values (44- 52 mg/kg) reported by Ahmed and Goni [26]. The Pb content in initial soil was 19 mg/kg. During T. Aman season, control and CWW treated soils showed the identical total Pb content like as initial soil. Dyeing, pharmaceutical, beverage and MWW treated soils showed 2 mg/kg higher while polyvinyl and tannery effluents treated soils obtained 3 mg/kg higher Pb content over the initial soil.

In Boro rice, all the treatments except control gave the significantly higher Pb content than the initial soil. Polyvinyl gave 3 mg/kg and dyeing gave 8 mg/kg higher Pb content in soil than the initial soil. The CWW treatment showed the equal Pb content like as polyvinyl treatment. The pharmaceutical, beverage, tannery MWW treated soils showed an increase in Pb content than the initial soil by 7, 2, 11 and 5 mg/kg, respectively.

Table 7. Post-harvest soil pH, EC, organic carbon, total N, available P and exch. K due to various effluents used after 1st (wet season) and 2nd (dry season) rice crop

Treatment	pH (1:2.5)		EC (dS/m)		Organic Carbon (%)		Total N (%)		Available P (mg/kg)		Exch. K (cmol/kg)	
	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro
Control	7.16	7.12	0.91	0.90	1.22	1.22	0.13	0.13	4.16	4.12	0.11	0.11
Polyvinyl	7.16	7.49	1.03	1.00	1.24	1.22	0.13	0.12	4.96	4.87	0.11	0.11
Dyeing	7.34	7.91	8.65	12.94	1.12	1.14	0.13	0.13	5.47	5.57	0.13	0.17
Pharmaceutical	7.72	8.02	12.63	16.92	1.25	1.23	0.14	0.13	8.93	9.33	0.43	0.48
Beverage	7.34	7.48	0.92	0.97	1.09	1.13	0.13	0.14	4.10	4.17	0.09	0.10
Tannery	7.97	8.55	21.37	32.37	1.07	1.09	0.17	0.18	6.67	7.10	0.30	0.35
City waste	7.62	8.00	1.65	1.85	1.05	1.11	0.13	0.13	5.30	5.57	0.09	0.11
Mixed waste	6.99	7.60	6.92	7.65	1.19	1.19	0.13	0.12	5.73	5.63	0.10	0.13
$LSD_{0.05}$	0.14	0.15	0.29	0.58	0.05	0.03	0.01	0.01	0.26	0.22	0.01	0.01
CV (%)	3.30	1.40	1.70	3.60	2.60	1.70	4.00	5.00	2.60	2.60	4.90	4.40
Initial soil	7.12		0.87		1.19		0.13		4.00		0.10	

Table 8. Post-harvest soil exch. Na, Ca, Mg, available Zn, Fe and Cu due to various effluents used after 1st (T. Aman) and 2nd (Boro) rice crop

Treatment	Exch. Na (cmol/kg)		Exch. Ca (cmol/kg)		Exch. Mg (cmol/kg)		Avail. Zn (mg/kg)		Avail. Fe (mg/kg)		Avail. Cu (mg/kg)	
	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro
Control	0.77	0.77	9.01	9.15	1.14	1.13	5	5	11	10	4.64	4.74
Polyvinyl	0.72	0.77	8.97	9.45	1.13	1.11	7	5	17	14	5.33	5.71
Dyeing	2.90	3.82	9.14	10.33	1.14	1.15	8	10	21	19	4.21	4.45
Pharmaceutical	3.67	4.93	10.97	11.08	1.15	1.20	10	14	34	33	4.73	5.03
Beverage	0.82	0.82	9.12	9.45	1.13	1.19	4	7	11	8	4.38	4.64
Tannery	4.49	5.80	11.56	11.71	1.21	1.23	8	9	34	35	5.43	5.81
City waste	1.59	2.17	9.97	9.83	1.18	1.21	6	6	11	8	4.29	4.55
Mixed waste	2.32	3.19	9.20	9.83	1.18	1.18	6	7	14	15	4.38	4.65
$LSD_{0.05}$	0.22	0.32	0.42	0.46	0.03	0.03	1	3	6	3	0.32	0.35
CV (%)	5.80	6.70	5.80	2.60	7.70	1.40	1	11	11	13	4.00	4.10
Initial soil	0.72		9.13		1.11		5		11		4.73	

Table 9. Post-harvest soil available Mn, total Pb, Cd, Ni and Cr due to various effluents used after 1st (T. Aman) and 2nd (Boro) rice crop

Treatment	Avail. Mn (mg/kg)		Total Pb (mg/kg)		Total Cd (mg/kg)		Total Ni (mg/kg)		Total Cr (mg/kg)	
	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro	T. Aman	Boro
Control	10	8	19	18	0.15	0.16	39	39	42	43
Polyvinyl	14	8	21	22	0.18	0.23	40	41	55	48
Dyeing	20	48	20	26	0.19	0.30	41	41	47	51
Pharmaceutical	31	37	20	25	0.20	0.23	41	41	53	50
Beverage	11	18	20	20	0.18	0.21	39	39	53	47
Tannery	56	46	21	29	0.22	0.31	42	45	63	54
City waste	28	48	19	21	0.19	0.25	40	38	48	49
Mixed waste	75	64	20	23	0.21	0.22	40	40	58	51
$LSD_{0.05}$	3	7	1	1	0.01	0.10	2	2	5	5
CV (%)	5	11	2	6	3.90	5.10	2	4	5	6
Initial soil	8		18		0.16		39		42	

3.26 Total Cd

The total Cd in different effluents treated soils ranged from 0.15 to 0.22 mg/kg during T. Aman season while in Boro season, it ranged from 0.16 to 0.31 mg/kg (Table 9) which was lower than the values (6.21-16.11 mg/kg) told via Ahmed and Goni [26]. In the initial soil, the Cd content in soil was 0.16 mg/kg. During T. Aman season, except control all the effluents gave the statistically higher total Cd content in soil as compared to initial soil. Polyvinyl effluent treated soil gave 13% and dyeing gave 19% higher Cd content in soil than the initial soil. Beverage recorded the equal total Cd content in soil to that polyvinyl treated soil while CWW gave the equal Cd content in soil as that of dyeing effluent treated soil. Pharmaceutical, tannery and MWW treated soils showed an increase in Cd content than the initial soil by 25, 38 and 31%, respectively.

In Boro rice, except control all the treatments gave the significantly higher Cd content than that of initial soil. Polyvinyl gave 44% higher while beverage gave 31% higher Cd content in soil than that of initial soil. Pharmaceutical effluent showed the similar Cd content in soil to that of polyvinyl effluent. City waste water and MWW treated soils showed an increase in Cd content than the initial soil by 56 and 38%, respectively. A remarkable increase in Cd content was found in the dyeing and tannery effluents treated soils. The dyeing effluent recorded Cd content of 0.30 mg/kg and that in the tannery effluent was 0.31 mg/kg.

3.27 Total Ni

The total Ni in different effluents treated soils ranged from 39 to 42 mg/kg during T. Aman season but in Boro season, it ranged from 39 to 45 mg/kg (Table 9) which was lower than the values (36- 74 mg/kg) stated by Ahmed and Goni [26]. The total Ni content in initial soil was 39 mg/kg. During T. Aman season, except tannery effluent all the treatments gave the statistically identical total Ni content in soil to that of initial soil. The tannery effluent treated soil showed an increase in total Ni content than the initial soil by 3 mg/kg. Boro rice soils showed the similar results as that of T. Aman rice.

3.28 Total Cr

The total Cr in different effluents treated soils ranged from 42 to 43 mg/kg during T. Aman season but in Boro season, it ranged from 43 to 54 mg/kg (Table 9). Ahmed and Goni [26] informed that the concentration of Ni in waste water irrigated soil ranged from 36-74 mg/kg. The total Cr content in initial soil was 42 mg/kg. During T. Aman season, control and dyeing treatments gave the statistically similar Cr content with initial soil. Polyvinyl gave 13mg/kg and pharmaceutical effluent gave 11 mg/kg higher Cr content in soil over the initial soil. Beverage effluent showed the similar Cr content to that of pharmaceutical effluent. The CWW and MWW showed an increase in Cr in soil than the initial soil by 6 and 16 mg/kg, respectively. A considerable increase in Cr in soil was found in the tannery effluent treated soil. The tannery effluent treated soil had Cr content of 63 mg/kg.

During Boro rice, control and beverage treatment recorded the statistically similar Cr content to that of initial soil. Polyvinyl and dyeing effluents increased in Cr content in soil than the initial soil by 6 and 9 mg/kg, respectively. Mixed waste water gave the similar Cr content to that of dyeing effluent. The pharmaceutical and CWW treatments showed an increase in Cr than the initial soil by 8 and 7 mg/kg, respectively. Like T. Aman rice, a considerable increase Cr in soil was found in the tannery effluent treated soil. The tannery effluent treated soil recorded the Cr content of 54 mg/kg. In both the seasons, the highest total Cr content in soil was found in tannery effluent treated soils that are responsible to higher Cr content (0.38 mg/L) in tannery effluent.

4. CONCLUSION

The irrigation effect of effluents on rice growth and yield were observed in both wet and dry seasons rice. The irrigation effect was found more prominent in dry season (Boro) rice over the wet season (T. Aman) rice. Changes in soil properties occurred through the effluents irrigation in rice-rice cropping pattern. Micronutrients (Zn, Fe, Cu and Mn) and heavy metals (Pb, Cd, Ni and Cr) were increased in soils through the effluents irrigation in rice-rice cropping pattern. Continuous irrigation with industrial effluents in rice fields increased soil pH and EC that developed soil salinity. Development of soil salinity in inland associated with the industrial effluents irrigation for rice cultivation is one of the unique findings which would be the great threat for declining soil quality as well as rice production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nuruzzaman M. Industrial pollution of soils crops sediments and water system around Dhaka city. PhD. Thesis. Department of Soil, Water and Environment. Dhaka University, Dhaka; 1992.
2. Abdu N, Abdulkadir A, Agbenin JO, Buerkert A. Vertical distribution of heavy metals in waste water irrigated vegetable garden soils of three African cities. Nutr. Cycl. Agroecosyt. 2011;89:387-397.
3. Darvishil HH, Manshouri M, Farahani HA. The effect of irrigation by domestic waste water on soil properties. J. Soil Sci. Environ. Mgt. 2010;1(2):30-33.
4. Begum RA. Assessment of water and soil pollution and its effect on rice and red amaranth. PhD thesis. Department of Agricultural Chemistry. Bangladesh Agricultural University. Mymensingh; 2006.
5. Khan A, Ibrahim M, Ahmed N, Anwar SA. Studies on accumulation and distribution of heavy metals in agricultural soils receiving sewage effluent irrigation. Efficient use of plant nutrients in Proc. 4th Natl. Cong. Soil Sci. Islamabad. 1994;607–9.
6. Qadir M. City people eating poisoned vegetables. The Daily Dawn. Pakistan. Natl. News Paper; 1999.
7. Citeau L, Lamy I, Oort FV, Elsass F. Colloidal facilitated transfer of metals in soils under different land use. Colloids Surf A Physicochem Eng Asp. 2003;217:11-19.
8. Fernandez C, Labanowski J, Cambier P, Jongmans AG, Oort FV. Fate of airbone metal pollution in soils as related to agriculture management.1. Zn and Pb distribution in soil profiles. Eur J Soil Sci. 2007;58:547-559.
9. Seneviratne NMG. Waste water from raw rubber processing industry in Srilanka and related environmental aspects. Bull. Rubb. Res. Inst. Sri. 1997;35:42-48.
10. Lim CA, P`ng TC. Land application of digested palm oil mill effluent by sprinkler system. Proceeding of the seminar on land application of oil palm and rubber factory effluent. Serdang; 1983.
11. Goel PK, Kulkarni SM. Effects of sugar factory waste on germination of Gram seed (*Cicer aeritinum* L.). J. Environ. Pollution. 1994;1:35-53.
12. IRRI (International Rice Research Institute). Irristat for Windows, Version 4.3. Biometric unit, International Rice Research Institute, Los Banos, Laguna, Phillippines; 1998.
13. Jackson ML. Soil chemical analysis. Prentice Hall of India Private Limited, New Delhi; 1967.
14. Nelson DW, Sommers LE. Total carbon, organic carbon and organic matter. In: Page AL, Miller RH, DR Keeney (ed.). Methods of soil analysis, Part 2. Chemical and Microbiological Properties Second Edition. Madison, Wisconsin USA. Nutrient distribution on vertisols. J. Prod. Agric. 7:364-373. nutritions in soil profiles. J. Fert. 1982;2:86-90,539-77.
15. Bremner JM, Mulvaney CS. Nitrogen-total. In Page AL, Miller RH, Kenney DR (eds) Methods of Soil Analysis, Agronomy, Part 2. Am. Soc. Agron., Soil Sci. Soc. Am. J. Madison, Wisconsin, USA. 1982;595-624.
16. Olsen SR, Sommers LE. Phosphorus. In: Page AL, Miller RH, Keeney DR (ed.). Methods of soil analysis, Part 2. 2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI. 1982;403-427.
17. Murphy J, Riley JP. A modified single solution method for determination of phosphate in natural waters. Analytica chemica Acta. N,P,K and pH in continuous no-tillage corn production. In M.D. Mullen and B.N. Duck (ed.) Proc. 1992 Southern Conservation Tillage Conference. Tenn. Agric. Exp. Stn. Spec. Publ. 1962;27:31-36,6-10.
18. Thomas GW. Exchangeable Cations. In: Page AL, Miller RH, Eeeny DR (ed.). Methods of soil analysis, Part. 2. Chemical and Microbiological Properties. Second Edition. Madison, Wisconsin, USA. 1982; 159-164.
19. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, iron, copper and manganese. Soil Sci. Soci. Amer. J. 1978; 42:421-428.
20. Woothouse HW. Toxicity and tolerance in the responses of plants to metals. In Lange OL, Novel PS, Osmand CB, Ziegler H. (eds), Encyclopedia of Plant Physiology. Springer Verlag, Berlin. 1983;245-262.
21. Sarkunan V, Misra AK, Nayar PK. Interaction of Zn, Cu and Ni in soil on yield and metal content in rice. J. Environ. Sci. Health. 1989;24(5):459-466.

22. Yagdi K, Kacar O, Azkar N. Heavy metals concentration in agriculture. Topraklardeki agir metal Kirligi ve tarinsal etikileri ondokuz Mayis Universitasi, Ziraat Fahultasi Dergisi. 2000;15(2):109-115.
23. Yamaguchi T, Aso S. Chromium from the stand point of plant nutrition: Effect of Cr concentration on the germination and growth of plants. J. Sci. Soil Manure. 1977; 29(48):466-470.
24. Khalid BY, Tinsely J. Some effects of heavy metal toxicity on rye grass. Plant Soil. 1980;55:139-144.
25. Babyshakila P, Usha K. Effect of diluted effluent on soil properties and plant growth. Adv. Studies Biol. 2009;1(8):391–398.
26. Ahmed JU, Goni MA. Heavy metal contamination in water, soil and vegetables of the industrial areas in Dhaka, Bangladesh. Environ Monit Assess. 2010; 166:347-357.

© 2019 Islam et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/55692