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Md. Tareq Bin Salam
Soil Science Discipline, Khulna University, Khulna-9208, Bangladesh

Shaikh Motasim Billah
Soil Science Discipline, Khulna University, Khulna-9208, Bangladesh

Sheikh Yesin Ali
Soil Science Discipline, Khulna University, Khulna-9208, Bangladesh

Correspondence:
Shaikh Motasim Billah
Associate Professor
Soil Science Discipline, Khulna University, Khulna-9208, Bangladesh
Tel: 01711-441463
E-mail: rekabegum@yahoo.com

Effects of shrimp industry-waste water on Maize (*Zea mays*) cultivation

Md. Tareq Bin Salam, Shaikh Motasim Billah, Sheikh Yesin Ali*

Abstract

A Comparative study was carried out to observe the response of Maize crop by using wastewater from shrimp processing industries at Rupsha Upazila under Khulna district during 2011-12. In the experiment, soil and water quality parameters were determined to sketch out the effect of growth and yield of Maize crop of the experimental area. The nutrient contents of water were analyzed for measuring pH, EC, salinity, sodium adsorption ratio (SAR), soluble sodium percentage (SSP), Hardness and some major ionic concentrations. For industrial wastewater, the average pH was 8.12 which reflected alkaline in nature. The values of SAR, SSP and Hardness were 4.28, 71.24 to 81.847 percent and 298.8 mg L-1 and for soil, the pH, EC and other major ionic concentration were determined and the value of wastewater irrigated soils was shown higher than the value of freshwater irrigated soils except magnesium. Loading of soil was not much higher except Na. For plant response, Plant height was significantly different from fresh water irrigation as well as leaf response was shown on average same results and moisture content of grain has indicated that yield was harvested at right time with yield response was moderately good in compare with fresh water. If proper management can be implemented for recycling this wastewater, then this wastewater can be used for sustainable production of maize crops.

Keywords: Shrimp industry, Maize, Waste water, Water Treatment Plant.

Introduction

Accelerating water demand due to increasing populations is an issue that many regions in the world are facing today. One way to meet future needs of water and mitigate pressure on fresh water sources is to recycle and treat wastewater from domestic and industrial uses.[1] Though shrimp farming has become one of the fastest growing industries in Bangladesh that is continuously polluting the irrigation water by discharging a number of wastes. Irrigating crops and pastures is only one of many ways in which to use waste water. However, there are still many concerns regarding wastewater which must be carefully investigated from a social, economical and environmental perspective.[2] Salt affected soils have received the attention of scientists and development workers throughout the world. The productivity of crops is adversely affected by high salt content in most of the soils.[3] In view of another projection, 2.1% of the global dry land agriculture is affected by salinity.[4]

In most of the Near South-West of Bangladesh, fresh water is scarce and getting scarcer. Growing rural and urban populations, higher cultivation intensities, increasing industrialization, and of late, environmental concerns, have all combined to put pressure on every country's internal renewable water resources.[4]

Maize is a semi-sensitive crop of salinity and needs relatively lower irrigation than that of other cereals. It is one of the oldest and most productive cereal food crops as well as is the third most planted crop after wheat and rice. Maize generally performed better on the heavier clay loams due to their higher nutrient and moisture-holding characteristics. Paddock yields of 4.0 to 5.0 t/ha were recorded but the average yield for the region was approximately 3.0 t/ha.

Bangladesh has a great potential for shrimp farming development. Most of the shrimp industries are situated under Khulna region. Due to scarcity of fresh water, waste-water which discharging by these industries is current issues for using in irrigation especially in south west part of the country like Rupsha Upazila.

At Bangladesh Water Treatment Plant (WTP) the recycling technique is relatively new and traditional. Hence, it is very important to know the current state of the soil as well as the components of the wastewater being irrigated and how a possibly inappropriate application of wastewater can change the soil.[5]

The maize is suitable for dry land short-season areas and irrigation situations are needed with various performances.

The purposes of this study were to see whether the wastewater suppressed the growth of maize.

The specific aims were:

- To assess the suitability of shrimp industry-waste water as irrigation water
- To analyze the effects of Shrimp industry waste water irrigation on growth and yield response of Maize

Materials and Methods

Study area

An investigation has been conducted to assess the quality of water where effluents discharged from shrimp processing industries for irrigation use at Rupsha Upazila under Khulna district.

Collection of soil and water sample

The sampling site is in Rupsha upazila under the district of Khulna. About Hundred Kg soil samples were randomly collected to cover most of the investigated area during 28th December, 2011. Sample was collected by following Quadrate method. Fifteen water samples were randomly collected to cover most of the investigated area during 3rd January, 2012. Sample was collected according to the sampling techniques as outlined by Hunt and Wilson.[7] Tap water was used as fresh irrigation water source. All samples were preserved into the Instrumental lab of Soil Science Discipline, Khulna University.

Pot preparation and experimental Design

Pot experiments were carried out. 10 kg soil samples were taken in each pot. Pots were arranged in a complete randomized design. The maize was sown on the 7th January, 2012. Two treatments with five replications were incorporated.

Research management

The insecticide such as Astound, Alpha-cypermethrin with an active constituent concentration of 100 g/L, was applied against heliothis at a rate of 400 ml/ha just after emergence. Continuous hand irrigation was given. The maize was harvested on the 8th May of this year. It is noted that uprooted of weeds was done continuously after sowing till harvesting. Table.1 shows the consequences of routine work.

Table 1: The consequences of routine work

Date	Operation
28-12-11	Collection of Soil Sample and preparation
07-01-12	Maize showing
28-01-12	Insecticide Spray
08-05-12	Harvesting

Soil and water Sample analysis

All soil samples were air-dried and the soil was grinded using a hammer to break up aggregates larger than 2 mm size. EC and pH was measured in a 1:5 and 1:2.5 (soil: water) extract according to Rayment and Higginson.[7] Basic routine analysis of soil was done by using suitable method. And water sample was also analyzed by using suitable method followed by Hess.[8]

The pH, EC and TDS values of the samples were measured by using Jenway pH meter, Jenway EC and Jenway TDS meter meter as described by Tan.[9]

Potassium and Sodium contents for both soil and water were determined separately by Flame emission spectrophotometer (Jenway, Model: PFP-7) using potassium and sodium filters, respectively as outlined by Jackson.[10]

Calcium, Magnesium, Chloride, CO_3^{2-} and HCO_3^- samples of soil and water were determined by titrimetric method as described by Jackson.[10]

Evaluation of water quality

The concentrations of major ions that is following water quality factors were considered in judging the water pollution or toxicity by the interpretation of analytical results of waters.

Sodium Adsorption Ratio (SAR)

The Salinity laboratory of The U.S Department of Agriculture recommended the Sodium Adsorption Ratio (SAR) because of its direct relation to the adsorption of sodium by the soil.[11] It is calculated by the following formula.

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

Soluble Sodium Percentage (SSP)

Todd[11] expressed SSP (Soluble Sodium Percentage) as:

$$SSP = \frac{Na^+ + K^+}{Ca^{++} + Mg^{++} + Na^+ + K^+} \times 100$$

Hardness

Todd[11] expressed HT (Hardness) as:

$$H_T = 2.5 \times Ca^{++} + 4.1 \times Mg^{++}$$

Whereas, all ionic concentrations were expressed as Cmol kg^{-1} but for hardness, cationic concentrations were expressed as mg L^{-1}.

Statistical analysis

The statistical analyses of the analytical results were performed as described by Zaman *et al*.[12] Standard deviation (SD) and ANOVA test at 95% confidence level were done following the standard method of Computer Program (Minitab 13.0)

Results and Discussion

Quality of waste water

The result of analysis of collected water samples are presented in Table 1. Major cation and anion are expressed in centi mol per liter (Cmol L-1). The unit used for measuring EC is dSm-1. The concentrations of some major ions (Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, CO_3^{2-} and HCO_3^-) have been illustrated in Fig. 1 by bar diagrams.

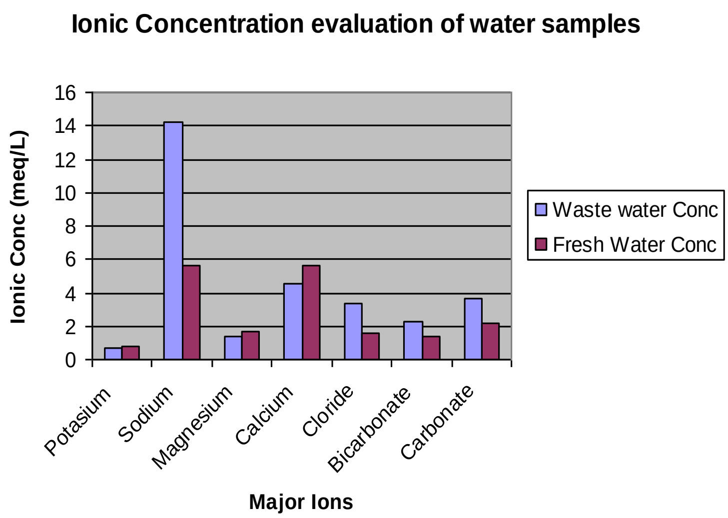

Figure 1: Graphical presentation of major ionic concentration in the water samples

The wastewater had higher amounts of sodium, and slight to moderate level of potassium and chloride. The amounts of calcium and magnesium were also moderate but lower than fresh water. Among anions, bicarbonates were slight to moderate while the amount of carbonates was relatively moderate to high. The industries waste water was found to be basic in reaction and had moderate value for electrical conductivity (EC). On the basis of electrical conductivity (EC) and sodium adsorption ratio (SAR) values as criteria for the classification of the wastewater of this industries fall in C3-S1 class presented in Table.3 i.e., High Na^+ (alkali) hazard and Low Salinity, and fresh water class was C1-S1, based Richards.[13]

Table 2: Chemical composition of water samples

Water sample	pH	EC dSm^{-1}	TDS Cmol L^{-1}	K^+ Cmol L^{-1}	Na^+ Cmol L^{-1}	Mg^{2+} Cmol L^{-1}	Ca^{2+} Cmol L^{-1}	Cl^- Cmol L^{-1}	HCO_3^- Cmol L^{-1}	CO_3^- Cmol L^{-1}
Irrigated waste water	8.12±0.06	1.21±0.02	1245±11.9	0.67±0.14	14.19±0.07	1.4±0.24	4.53±0.23	3.37±1.6	2.3±0.76	**3.69±2.71**
Fresh irrigation water	**7.69±0.05**	**0.85±0.02**	**169±5.6**	**0.75±0.12**	**5.6±0.05**	**1.69±0.21**	**5.59±0.21**	**1.6±0.8**	**1.37±0.46**	**2.2±1.21**

Note: All values are presented as Mean ± Standard deviation (SD). *S= Significant and NS= Non significant at 5% level.

Table 3: Quality rating and suitability of water used for irrigation

Water sample	SAR	SSP %	Hardness mg L^{-1}	Water class based on			Alkalinity and salinity hazard class
				SAR[1]	SSP[2]	H_T[3]	
Irrigated waste water	4.280±0.29	71.243±1.51	298.8±19.8	H1	fair	EH	**C3S1**
Fresh irrigation water	**2.93±0.11**	**46.59±0.83**	**20.91±2.6**	**H1**	**fair**	**S**	**C1S1**

Note: H_1=Low Na^+ hazard, H_2=Medium Na^+ hazard, H_3=High Na^+ hazard, Ex=Excellent, MH=Moderately Hard, H=hard, VH=very Hard.S_1=Low salinity hazard, S_2= Medium salinity hazard, S_3= High salinity hazard, S_4=Very high salinity hazard, C_1=Low Na^+ (alkali) hazard, C_2= Medium Na^+ (alkali) hazard, C_3= High Na^+ (alkali) hazard, C_4=Very high Na^+ (alkali) hazard.

Table 4: Soil analysis before and after irrigation

Soil Sample	pH	EC dSm^{-1}	K^+ Cmol kg^{-1}	Na^+ Cmol kg^{-1}	Mg^{2+} Cmol kg^{-1}	Ca^{2+} Cmol kg^{-1}	SAR	SSP %
Before irrigation With waste water	7.79±0.06	4.8±0.02	0.88±0.14	12.26±0.07	5.38±0.24	32±0.23	2.85±0.27	**26.16±2.5**
After irrigation With waste water	8.25±0.05	6.82±0.02	2.13±0.12	19.35±0.05	4.79±0.21	35±0.21	4.31±0.31	**34.72±4.1**
***F>0.05**	**S**	**S**	**S**	**S**	**NS**	**NS**	**S**	**S**

Note: *S= Significant and NS= Non significant at 5% level Effect on Maize Crop

Effect on Maize Crop

Specific effects have been observed during research that is described below.

Seed germination

Fig. 2 shows changes with time in percentage germination of Zea mays in different treatments respectively. The rate of seed germination was much faster in fresh water treatments and there was a delay in the start of germination. Then the response of seedling in wastewater treatment was better and the data of germination rate.

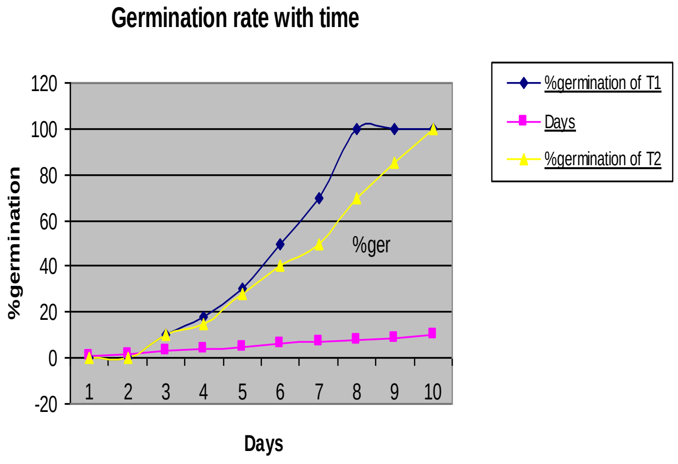

Figure 2: Germination (%) rate of Maize

It was indicated that it had no significant effects on seed germination of crops like Zea mays. However, some differences were found in some replications in wastewater treatment. The lower growth of the plant might have been due to high osmotic pressure and high salt concentration, which prevented the intake of necessary water, or possibly, due to the toxicity of specific ions, as has been reported by Hayward and Wadleigh.[14]

Plant response

Significant differences were observed between treatments with regard to plant height and leaves number are presented in Table 4. For clear understanding, Plant response is presented in following Fig. 3

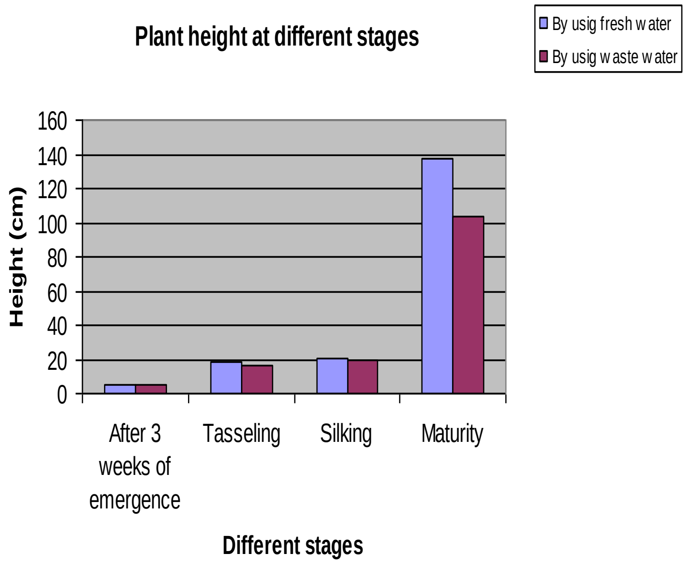

Figure 3: Plant heights at different stages

From above figure, a significant difference was observed at different stages between two treatments. Fresh water treatment shows better response in terms of plant height than waste water treatment. This may due to wastewater from Shrimp industries had toxic amount of sodium (Table 1). The lower growth of the plant might have been due to high osmotic pressure and high salt concentration, which prevented the intake of necessary water, or possibly, due to the toxicity of specific ions, as has been reported by Hayward and Wadleigh.[14]

Yield response

Yield was observed better in fresh water treatment than that of waste water and the moisture content of grain is presented at Table 4. A significant difference at moisture content between two treatments was observed. The moisture content is higher in fresh water treatment than wastewater treatment (Table 4). The fresh water treatment also showed better yield than wastewater treatment. This may due to high moisture content may lead the solubility of nutrients that have positive impact on grain yield, as has been reported by Hayward and Wadleigh.[14]

Changes of soil chemical properties due to waste water irrigation

According to Table 3, a significant difference was observed in soils before and after irrigation. Irrigated waste water have high Na content as shown in Table 3, inevitably result in accumulation of exchangeable Na in the soil. Although, in general, monovalent cations are held less strongly on cation exchange sites than divalent ones, by mass action the added Na displaces other cations (e.g. Ca and Mg) into soil solution and they can then be leached down the soil profile. A decrease in exchangeable Ca and Mg is therefore commonly reported where Na-enriched effluents have been repeatedly applied. At these sites, a decrease in exchangeable Mg was evident (Table 3) but exchangeable Ca levels were not greatly changed (Table 3). These may attributed due to exchangeable Na were not able to exchange Ca due to the calcariousness of soils that occurred at the irrigated sites.[15] Effluent irrigation also, as expected, increased soluble salt levels and, because of its significant K content, exchangeable K levels were also elevated (Table 4.3). The increase in pH is attributable to the high pH.

Although EC values were moderate in irrigated soils, ESP values of 9-11% reflect sodic conditions.[16] There was a significant difference also found in SAR and SSP values. Irrigation water quality must be considered not only with regards to its immediate effect on soils and crops but also with regards to the welfare of consumers.[17] Excess amount of Na is worst for optimum crop production. It may reduce growth or death of growing tips by causing delay in nutrient supply through the growing plants.[18] Higher Na content may have detrimental effect on plant growth. Some time shoot or bud of the crop can fall due to lack of availability of growth nutrients though the nutrient concentrations are higher in soils.[17] This may due to the possible reasons for poor yield of Maize by using waste water.

Conclusion

Bangladesh is now facing immense challenge for fresh water availability especially for irrigation like other third world countries. In south east and south west part of the country, fresh water scarcity is becoming severe where waste water generation is also increasing day by day due to shrimp industrialization. For this reason, waste water has been tested to a second crop like Maize to observe its response and suitability of this industry waste water for irrigation. The major findings of the research are

Plant high was significantly different from fresh water irrigation

- Leaf response was shown on average same results in compare with fresh water irrigation
- Moisture content of grain has indicated that yield was harvested at right time and yield response was moderately good in compare with fresh water
- Loading of soil was not much higher except Na.

Since the wastewater is sufficiently rich in nutrients, the cost of inorganic fertilizer may be saved. The most important concern is to use of this water, may have environmental problems. But providing better management, considerable quantities of fresh water can be saved for human consumption. Besides, this technology can be used for sustainable production of maize and other crops.

Altogether, the picture of soils is that the risk of heavy metal uptake by wastewater irrigated crops is high even though it was not determined in this research. But this research is worthwhile doing a comprehensive analysis of both soil and crop and may create a path for advance research.

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