



**ASSESSMENT OF IRRIGATION WATER QUALITY AS  
DETERIORATED BY EFFLUENT DISCHARGED FROM  
MAJOR SHRIMP PROCESSING INDUSTRIES OF RUPSHA  
UPAZILA, KHULNA, BANGLADESH**

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**Abstract:** A Comparative study was carried out in different shrimp processing industries at Rupsha Upazila under Khulna district from January 2010 to December 2010. In the experiment, some water quality parameters were determined to sketch out the nutrient dynamics of the experimental area. The nutrient contents of water were analyzed for measuring temperature, pH, EC, salinity, sodium adsorption ratio (SAR), soluble sodium percentage (SSP), hardness and some major ionic concentrations. The temperature of the water samples were ranged from 29.1°C to 29.3 °C and the pH varied from 8.0 to 8.12 which reflected neutral to alkaline in nature. The values of SAR, SSP and hardness were ranged from 4.28 to 8.65, 71.24 to 81.847 percent and 239.1 to 312.3 mg L<sup>-1</sup>, respectively. Among the five industries the hazardous classes of the four industries reflected High sodium (alkali) content with medium salinity hazard. So, from the result, it may be concluded that appropriate sustainable management technologies need to be incorporated to control pH, hardness and salinity of that water.

**Keywords:** Water quality, effluents, shrimp processing industries, irrigation use, salinity

**Introduction**

Shrimp farming has become one of the Asia's fastest growing industries. The world cultured shrimp productions increased steadily and reached 600,000 mt. by 1990. The Asia-Pacific region continued to dominate the worlds cultured shrimp production with its 80.6% contribution in 1991 (Csavas, 1992). More than 85% of world's farmed shrimp is produced in coastal areas of the Asia-Pacific region and Bangladesh is the fifth largest producer in the world. In the fiscal year 2004-2005, shrimp culture area and production reached to 141,353 hectare and 66,902 mt, respectively which were only 115,088 hectare and 20,335 mt. respectively in the fiscal year 1991-92 (DOF, 2006). Coastal aquaculture in Bangladesh was initiated in 1970's as an important economic activity. The culture system was quite primitive with large and ill-designed ponds without pre-stocking pond preparatory techniques or any additional inputs into the system (Chhabra, 1996).

In Bangladesh, Shrimp processing was first established at Chittagong in 1959. There were few primitive shrimp processing plants at Khulna before 1971. In fact, the shrimp industry was first bloomed in 1977 at Khulna region. Among 130 shrimp processing industries, 61 shrimp processing industries are dead lock About 11.2 million people depend on these industries. These industries export shrimp products in foreign countries such as America, European Union, Canada, Japan, Russia etc.

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Many effluents are produced from these industries involving cutting heads, shell of shrimps, various cartons, polythene, dyes etc. The industries produce about 10,000 tons waste per days in the peak time. The authority follows local waste treatment processes. They separate cartons, polythene from the waste and sell them to another party. Remaining wastes are gone through the nearby 'Rupsha' river. Various chemicals are used during shrimp processing such as Sodium tri phosphate, Meta bisulfate, Sodium Chloride etc. These dyes are also responsible for water pollution (Saha, 2010).

Water quality is determined according to the purpose for which it will be used. For irrigation water, the usual criteria include salinity, sodicity (sodium content), and element toxicities. Many criteria are important in assessing water quality for other uses such as taste, color, odor, turbidity, temperature, hardness, pH, BOD, COD, nutrient content (Nand P), pathogenic organism-are sometimes, but not usually, important for irrigation water (Miller *et al.*, 1997). The classification of irrigation water is generally based on some quality factors like SAR, SSP, RSC, TDS and EC. The concentration of any elements in water attains level that causes significant degradation of water and this element is considered as pollutant. When polluted water is applied to soil for long-term irrigation, soluble salts and toxic elements may accumulate in the soil thus destroying soil properties.

Investigation has been conducted to assess the water discharged from Shrimp processing industries for irrigation use at five Shrimp processing industries (Modern sea food, Sabuj fish, Khulna fish, Lockpur fish processing ltd and Bright sea food) of Rupsha Upazila under Khulna district. Consequently, a research work has been made at the Discipline of Soil Science, Khulna University, Khulna with the following objectives: (a) to analyze the water quality parameters of the study area. (b) to compare with the standard irrigation water quality parameters to stay within the environmental capacity. (c) to assess the suitability of water for use in irrigation.

### **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 with 22°45' and 22°52' north latitude and 89°33' and 89°41' east longitudes. 'Rupsha' River flows beside the Upazila which is evolved 5.5 sq km (*Thana Nirdeshika*, SRDT, 1989).

**Sampling:** Fifteen water samples were randomly collected to cover most of the investigated area during 11 October, 2009. Samples were collected according to the sampling techniques as outlined by Hunt and Wilson (1986). Point sampling was done with careful and at optimum time associated with environmental situation. Water samples were collected in new plastic bottles (500 ml) after rinsing it with water to be sampled 2 to 3 times. Then the bottles were completely filled with water in a way so that no air remains above the surface. All the samples were preserved into the Soil Chemistry lab of Soil Science discipline of Khulna University. Water samples were filtered with filter paper (Whatman No. 1) to remove undesirable solid and suspended materials before chemical analysis. The chemical analyses of water were performed as quickly as possible on arrival at laboratory. The water samples were collected from each sampling sites to avoid error. The sites were near Modern Sea Food, Sabuj Fish, Khulna Fish, Lockpur Fish Processing Ltd, Bright Sea Food where the effluents of shrimp processing industries were being discharged.

**Chemical Analyses:** The major chemical constituents of water and its quality factors were considered for analyses by following methodology. The pH value of water samples were measured by using pH meter (Jenway pH meter) as described by Tan (1996). Electrical conductivity (EC) of water was estimated by EC meter (Jenway EC meter). Total dissolved solid (TDS) was measured by TDS meter (Jenway TDS meter). Potassium and sodium contents were determined from water samples separately by flame emission spectrophotometer (Jenway, Model:

PFP-7) using potassium and sodium filters, respectively as outlined by Jackson (1973). Calcium and Magnesium were determined by titrimetric method as described by Jackson (1973). Chloride (Cl<sup>-</sup>) was determined by the titrimetric method as described by Jackson (1973). Carbonate and bicarbonate contents of the water samples were determined by titrimetric method as mentioned by Jackson (1973). The concentrations of major ions present in water samples affect the water quality. The following water quality factors were considered in judging the water pollution or toxicity by the interpretation of analytical results of waters: 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 (Todd (1980). It is calculated by the following formula.

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

Todd (1980) expressed SSP (Soluble sodium percentage) as:

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

Todd (1980) also expressed H<sub>T</sub> (Hardness) as:

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

Whereas, all ionic concentrations were expressed as meq L<sup>-1</sup> but for hardness, cationic concentrations were expressed as mg L<sup>-1</sup>. Standard deviation (SD) studies were done by following the standard method of Computer Program (Minitab 13.0).

### Results and Discussion

The physical and chemical properties of the collected water samples are presented in Table 1 and Table 2. Major cation and anion are expressed in milliequivalent per liter (meqL<sup>-1</sup>). The unit used for measuring EC is dSm<sup>-1</sup>. The results have mainly been discussed in the light of irrigation use. The advantages of water testing are initially judged from the nature and extent of its relationship with soils and crops.

Table 1: Physical compositions of industrial water

<i>Industry Name</i>	<i>Temp ° C (mean± SD)</i>	<i>Color</i>
Modern Sea Food	29.17±0.31	Cls to Br
Sabuj Sea Food	29.3±0.1	Gr to Dgr
Khulna Fish Ltd.	29.1±0.1	Gr to Dgr
Lockpur Fish Ltd.	29.1±0.15	Br
Bright Sea Food	29.2±0.2	Cls to Br

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Table 2: Chemical compositions of industrial water (Cont'd)

Industry Name	pH	EC	TDS	K <sup>+</sup>	Na <sup>+</sup>	CO <sub>3</sub> <sup>-</sup>
Modern Sea Food	8.09±0.04	1.51±0.033	1175±11.1	0.502±0.04	27.43±0.33	5.53±0.058
Sabuj Fish Ltd.	8±0.18	0.88±0.012	615±8.72	0.434±0.04	23.38±0.03	1.17±0.289
Khulna Fish Ltd.	8.12±0.06	1.21±0.02	1245±11.9	0.67±0.14	14.19±0.07	3.69±2.71
Lockpur Fish Ltd.	8.09±0.02	1.24±0.04	1138.7±5	0.55±0.07	23.37±0.09	4±2.65
Bright Sea Food	8.05±0.14	0.86±0.03	1231.7±22.5	0.43±0.04	23.96±0.06	5.13±0.15

Table 2: (Cont'd) Chemical compositions of industrial water

Industry Name	Mg <sup>2+</sup>	Ca <sup>2+</sup>	Cl <sup>-</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>-</sup>
Modern Sea Food	1.3±0.23	4.9±0.23	3.1±1.25	2.67±0.29	5.53±0.058
Sabuj Fish Ltd	1.0±0.2	3.73±0.23	2.4±1.0	1.3±0.29	1.17±0.289
Khulna Fish Ltd.	1.4±0.24	4.53±0.23	3.37±1.6	2.3±0.76	3.69±2.71
Lockpur Fish Ltd.	1.33±0.23	4.13±0.23	4±2.3	3.5±0.5	4±2.65
Bright Sea Food	1.87±0.23	5.37±0.21	5.4±0.72	3.87±0.32	5.13±0.15

Note: All parameters are in meq/100g except EC (ds/m) and All Values are putted as Mean±SD.

\*All values have been significant at t<0.05 level in 14 degrees of freedom.

**Water quality rating for irrigation usage:** Physical parameters such as temperature, color etc and various chemical parameters such as pH, EC, TDS etc are estimated for rating water quality.

The mean temperature of the water samples collected from Modern sea food, Sabuj fish, Khulna fish, Lockpur fish processing ltd and Bright sea food ranged from 29.1°C to 29.3 °C (Table 1). Water temperature plays a very important role in regulating the activities of cultured animals. The rate of chemical and biological reactions is said to double at every 10° C increase in temperature. This means that aquatic organisms will use twice as much as dissolved oxygen and chemical reactions will progress twice as fast at 30° C than 20° C (Rao *et al.*, 1982). Presence of transition and inner-transition metals produce various colors. Generally, water polluted from industrial discharge express such colors. Both the type of metal ions present and their valance impart the final color of water. The color of the discharged water from industries varied from dark to greenish and sometimes brownish. From analysis the quality of water on the basis of different chemical quality parameters are discussed as followings: The pH values of water samples of five industries ranged from 8.0 to 8.12 with reflecting neutral to alkaline in nature (Table 2). The third industry showed the highest pH value. The result of high pH value is due to the presence of appreciable amount of Ca<sup>2+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup>, and HCO<sub>3</sub><sup>-</sup> in wastewater (Michael, 2001) and Rao *et al.*, 1982). Ayers and Westcot (1994) mentioned that the normal pH for irrigation is usually from 6.5 to 8.4. So most of the water may be used but not safely for long-term irrigation and moderate restricted on use. The EC values of water samples of five industries ranged from 0.86 to 1.51 dSm<sup>-1</sup> (Table 2). According to Ayers and Westcot (1994), water samples is <0.7 dSm<sup>-1</sup> which has no restriction on use. But all mean EC values of the industrial water show the higher rate than that of 0.7 dSm<sup>-1</sup> but smaller than that of 3.0 dSm<sup>-1</sup>. Thus Water has slight to moderately restriction on use. The first Industry Modern sea food showed the highest EC value. High EC is due to the presence of high amount of Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup> and Mg<sup>2+</sup>. The TDS values of water samples of five industries ranged from 615 to 123 mg L<sup>-1</sup> (Table 2). The highest TDS value was observed in the

third industry. A sufficient quality of bicarbonate, sulfate and chloride of  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and  $\text{Na}^+$ , caused high TDS values (Karanth, 1994). According to Tood (1980) as reported in all water samples under investigation contained less than  $1,000 \text{ mg L}^{-1}$  TDS were classified as freshwater in irrigation quality. So, except Sabuj Fish Ltd, all industries water sample can be considered as contaminated water and this water would be affected the osmotic pressure of soil solution and cell sap of the plants when applied to soil as irrigation water. The detected amounts of ions present in all samples in relation to irrigation water quality have been discussed as follows: The Potassium values of water samples of five industries ranged from  $0.43$  to  $0.67 \text{ meq L}^{-1}$  (Table 2). The presence of higher quantity of  $\text{K}^+$  in some water samples might be due to some potash bearing minerals like sylvite ( $\text{KCl}$ ) and nitrate ( $\text{KNO}_3$ ) (Karanth, 1994). Recommended maximum concentrations of  $\text{K}^+$  for long term irrigation use on all soils are  $2 \text{ meq L}^{-1}$  (Ayers and Westcot, 1994). The recorded quantity of  $\text{K}^+$  in all collected water samples is lesser than the recommendation concentration. So, concentration of  $\text{K}^+$  has no significant impact on water quality for irrigation. The Sodium values of water samples of five industries ranged from  $14.19$  to  $27.43 \text{ meq L}^{-1}$  (Table 2). Recommended maximum concentrations of  $\text{Na}^+$  for long term irrigation use on all soils are  $40 \text{ meq L}^{-1}$  (Ayers and Westcot, 1994). The recorded quantity of  $\text{Na}^+$  in all collected water samples is lesser than the recommendation concentration. So, concentration of  $\text{K}^+$  has no significant impact on water quality for irrigation. The Calcium values of water samples of five industries ranged from  $3.73$  to  $5.37 \text{ meq L}^{-1}$  (Table 2). The maximum concentration (avg.  $5.4 \text{ meq L}^{-1}$ ) was found at Bright Sea Food industry and minimum value ( $3.7 \text{ meq L}^{-1}$ ) was observed at Sabuj Fish industry. The contribution of Ca content in water was largely dependent on the solubility of  $\text{CaCO}_3$ ,  $\text{CaSO}_4$  and rarely on  $\text{CaCl}_2$  (Karanth, 1994). Irrigation water containing less than  $20 \text{ meq L}^{-1} \text{ Ca}^{2+}$  is suitable for irrigating crops (Ayers and Westcot, 1994). On the basis of Ca content, all industrial water could be used for irrigation but would be affected soils linearly in long term irrigation. The Magnesium values of water samples of five industries ranged from  $1.0$  to  $1.87 \text{ meq L}^{-1}$  (Table 2). Irrigation water containing less than  $5 \text{ meq L}^{-1}$  is suitable for irrigating crops (Ayers and Westcot, 1994). In the investigated area, most samples were not exceeded this permissible limit. Therefore, water can be used for irrigation. The Chloride concentrations of water samples of five industries ranged from  $2.4$  to  $5.4 \text{ meq L}^{-1}$  (Table 2). Irrigation water containing less than  $4 \text{ meq L}^{-1}$  is suitable for irrigating crops (Ayers and Westcot, 1994). So, it can be decided that all industries except Lockpur Fish and Bright Sea Food industry are suitable for irrigation. Most of the chloride in water present as sodium chloride ( $\text{NaCl}$ ) but chloride content might exceed sodium due to the Base Exchange phenomena (Karanth, 1994). The Carbonate concentrations of water samples of five industries ranged from  $1.17$  to  $5.53 \text{ meq L}^{-1}$  (Table 2). Irrigation water containing carbonate ions from  $5$  to  $10 \text{ meq L}^{-1}$  may cause toxic effect to the plant growth (Gupta and Gupta, 1987). In the investigated area, Sabuj Fish, Khulna Fish and Lockpur Fish industries were found below toxic limit (Table 2). Therefore, water samples have moderate restriction on use in the Modern Sea Food and Bright Sea Food industry. The Bicarbonate concentrations of water samples of five industries ranged from  $1.3$  to  $3.87 \text{ meq L}^{-1}$  (Table 2). Irrigation water containing  $1.5$  to  $8.5 \text{ meq L}^{-1}$  has slight to moderate degree of restriction for irrigation (Ayers and Westcot, 1994). So it can be decided that all industrial water except Sabuj Fish industry had slight to moderate restriction on use. The SAR of the water samples collected from Modern sea food, Sabuj fish, Khulna fish, Lockpur fish processing Ltd. and Bright sea food ranged from  $4.28$  to  $8.647$  (Table 3). Out of the 5 industries, all SAR values except Khulna fish industry are same. By putting the SAR value against EC in Fig. 1, it may be decided that maximum industrial water were moderately restricted on use and have significant effects on salinity. The mean SSP of the water samples collected from Modern sea food, Sabuj fish, Khulna fish, Lockpur fish processing Ltd. and Bright sea food ranged from  $71.243$  to  $81.847$  percent (Table 3). Irrigation water having soluble sodium percentage (SSP) value of  $60$  and above is considered as harmful (Gupta and Gupta (1987)]. According to water classification proposed by

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Wilcox (1955) and Bear (1945), almost all samples fall in fair to poor classes. In the study area, the water can not be applied safely for irrigating agricultural crops. The mean hardness of the water samples collected from Modern sea food, Sabuj fish, Khulna fish, Lockpur fish processing ltd and Bright sea food ranged from 239.1 to 312.3 (Table 3). Some value of hardness is very high due to the abundant presence of divalent cations like  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  (Todd, 1980). According to the criteria proposed by Todd (1980) as shown in Fig. 1, two industrial water were graded as very hard and the rest of were extremely hard. Thus In the study area, the water can not be applied safely for irrigating agricultural crops in this point of view.

### Conclusion

The concentration of  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  and the pH under investigated area were not problematic to use safely for long term as irrigation. All the water quality indices (SAR, SSP and  $\text{H}_T$ ) were not found at suitable range. Alkalinity and salinity hazard were the common phenomenon and high level of TDS, hardness indicated that the water had moderate to high level of restriction for irrigation. It is evident from the above discussion that all water samples under investigation were not found suitable for long term irrigation. More or less all water samples of the study area are suitable only on the basis of one or two particular criteria but were not able to satisfy all the water quality. Alkalinity hazard were observed for all samples. Hence, they were not suitable for specific purpose because their long term use may affect soil permeability, destroy soil structure, increase osmotic potential etc.

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