BCSIR

Available online at www.banglajol.info

Bangladesh J. Sci. Ind. Res. **45(1)**, 79-84, 2010

Short Communication

BANGLADESH JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

E-mail: bjsir07@gmail.com

Characterization of Textile Industrial Effluents and its Effects on Aquatic Macrophytes and Algae

R. Roy,[a] A.N.M. Fakhruddin,[a] R. Khatun,[b] M.S. Islam*,[c] M.A. Ahsan,[c] A. J. M. T. Neger[d]

[a]Department of Environmental Sciences, Jahangirnagar University, Savar, Dhaka-1342, [b]Biological Research Division, Bangladesh Council of Scientific and Industrial Research, Dhaka- 1205, [c]Analytical Research Division, Bangladesh Council of Scientific and Industrial Research, Dhaka- 1205 and [d]IGCRT, Bangladesh Council of Scientific and Industrial Research, Dhaka- 1205, Bangladesh

Abstract

Textile industries release huge amount of effluents to aquatic systems, which contain toxic and hazardous pollutants degrading the environment. A laboratory scale study was conducted to characterize physicochemical parameters of local textile industrial effluents and evaluate their impact on aquatic macrophytes and algae. Total suspended solids (TSS) and total dissolved solid (TDS) was found 100 to 336 mg/L and 1856 to 4356 mg/L, respectively. The recorded pH was 9.6 to 11.2 and temperature 40.5 to 43 ^{O}C. Dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD) was recorded 0.11 to 0.5, 151.24 to 299.1 and 652.8 to 2304 mg/L, respectively. Electrical conductivity (EC) was monitored 2210 to 6020 µs/cm; salinity was found 1.1 to 3.3 ‰, and color 1890.75 to 5625 PCU. Zinc (Zn), cadmium (Cd), copper (Cu) were 0.0838 to 0.596, 0.0 to 0.0006, 0.018 to 0.1727 ppm, respectively. Except heavy metals concentrations all of the physicochemical parameters were found beyond the standard limit set by department of Environment (DoE). Textile industrial effluents showed the toxic effects on aquatic macrophytes and algae, as aquatic macrophytes could hardly survive 2 days on textile effluents and noticeable reduction of algal concentration was found when grown on textile effluents.

Key words: Textile effluents, Toxic effects, Physicochemical parameter, Aquatic macrophytes, Algaee

Introduction

Textile is one of the largest and vital industrial sector of Bangladesh with regard to earn foreign exchange and labour employment. This sector provides 4.5 million jobs of which 80% are women and contributes 13% to GDP (BTMA annual report, 2007). Textile processing employs a variety of chemicals, depending on the nature of the raw material and product. These chemicals are mostly enzymes, detergents, dyes, acids, alkalies and salts. The quantities and characteristics of discharged effluent vary from mill to mill depending on the water consumption and the average daily product (Saha, 2007). Environmental problems of the textile industries are mainly caused by discharges of wastewater/ effluents. Wastewater could pose threats to public health and/or affect the aesthetic quality of potable water (Aslam *et al*., 2001).

Textile industries sector in Bangladesh produce huge amount of effluent which are very toxic for environment. In the dying and finishing processes a considerable amount of wastewater is generated. Textile wastewater is notoriously known to contain strong color, a large amount of suspended solids, a highly fluctuating pH, a high temperature, COD, BOD etc. (Gurnham, 1965). Because of these characteristics, treatment of textile wastewater is inevitable before being disposed to natural water system (Kabir *et al*., 2002).

The objectives of the present study were to characterize of textile effluent and evaluate the toxic effects of textile effluent on aquatic macrophytes and algae.

Materials and Methods

Collection of effluent samples

Effluent was collected from Harunur Rashid (H.R.) Textiles Mills Ltd., which is located at Kornapara in Savar upazilla. H.R. Textiles Mills Ltd. is situated at N 23^{O} 49' 31" and E 90^{O} 15' 27.72". This industry has equalizer tank which collect effluent of various time and mix them well. Effluent

* Corresponding author: E-mail: sislama@hotmail.com

samples were collected in the afternoon because at that time one cycle is completed. Samples were collected in December, 2007 and February, May, July, 2008.

Analysis of physicochemical parameters

Sampling protocol was followed carefully to inhibit the intrusion of any foreign particles that may affect the results. Color of the samples was measured by colorimeter Hanna instrument: HI93727. Temperature was measured at the time of sample collection by mercury thermometer graduated 0 to 100^{O}C. A quantitative analysis for the determination of total suspended solid (TSS) and total dissolved solid (TDS) was carried out by simple laboratory method (Tufekci *et al.*, 1998). Dissolved oxygen (DO), Electrical Conductivity (EC) and Salinity of the effluent samples were measured by Hanna Instruments: H19143. The pH of water was determined by using a glass electrode pH meter (Jenway pH meter, Model 3305). BOD and COD were determined by 5-Day BOD test and Closed Reflux, Titrimetric Method, respectively (APHA, 1998). Heavy metal was measured by Atomic Absorption Spectroscopy (SIMADZU, Model-AA6401F AAS).

Collection of aquatic macrophytes and algae

Aquatic macrophytes were collected from the Jahangirnagar University campus lakes because those lakes had no connection with the delivery chambers of textile effluent. The aquatic macrophytes were preserved in the artificial pond in Biological Research Division of Bangladesh Council of Scientific and Industrial Research (BCSIR) using tap water at normal temperature and with no added nutrient. Inoculum of Nostoc was provided by the Biological Research Division, BCSIR, Dhaka.

Methods for toxicity testing on aquatic macrophytes and algae

Collected effluent sample was taken on a big plastic bowl and settled it for 3 days. After settlement the effluent was taken for toxicity testing. Four types of aquatic macrophytes (*Salvinia cuculata, Pistia stratiotes, Nymphoides indicum,* and *Eichhornia crassipes*) were used separately. Two types of vessel (earthen vessel and glass jar) were used for each type of aquatic macrophytes cultivation. Every vessel was washed properly with tap water followed by rinsing with effluent. Two liters of effluent was taken in each container. The body and root part of the plants were washed very well to remove sediments and other impurities by tap water. Eight to ten fresh plants of *Salvinia cuculata* and *Pistia stratiotes,* and two fresh plants of *Nymphoides indicum* and *Eichhornia crassipes* were separately used for toxicity test. To evaluate the toxic effect of textile effluents on algae (*Nostoc*) two liters of settled effluent were taken into earthen vessel and glass jar. In earthen vessel and glass jar 400g *Nostoc* were allowed to grow. The effluent was shaken by a stick at two to three hours interval to maintain the equal distribution of algae all over the effluent.

Results and Discussion

Physicochemical parameters of textile industrial effluents

Results of physicochemical parameters of textile industrial effluent of different periods are presented in Table 1. It was observed from the result that the TSS value ranged from 100 to 336 mg/L, the lowest limit was within the acceptable limit (150 mg/L) but the upper limit was above the acceptable limit. Three fourth of the tested samples were above the standard value of DoE (150 mg/L) of wastewater permitted to emit in inland surface water (Haque, 2003). Conversely the TSS values were found 6.2 to 175 mg/L in the textile effluent in Dhaka Export Processing Zone (DEPZ) area (Ahmed, 2007).TSS values were found 200 to 1100 mg/L in the textile effluent in Lahore district in Pakistan (Mahmood *et al.,* 2005). Another study on the textile effluents in Pakistan found TSS value 150 to 1100 mg/L (Aslam *et al.*, 2001). A large volume of suspended sediment will reduce light penetration, thereby suppressing photosynthetic activity of phytoplankton, algae, and macrophytes. Reduced light penetration decreases photosynthetic rates of green aquatic macrophytes, algae and cells which are served as food sources for many invertebrates (Water quality parameters, 1995).

The TDS contents of the effluent were 1856 to 4356 mg/L. According to the standard of DoE (Haque, 2003), TDS content of the effluent must be within 2100 mg/l. TDS value of textile effluent was also recorded above the recommended level of DoE in Dhaka export processing zone (DPEZ) area's effluent (Kabir e*t al.*, 2002). The TDS values were reported 2380 mg/L in effluent of H.R. Textiles Mills Ltd. (Rahman *et al.*, 2008), 855 to 1315 mg/L in the textile effluent in DEPZ area (Ahmed, 2007), 1500 to 2200 mg/L in the textile effluent in Lahore, Pakistan (Mahmood *et al.*, 2005) and

Table I. Physicochemical parameters of H.R. Textile (Kornapara, Savar) industrial effluents collected at different time.

Parameters	Collection Period			
	December'07	February' 08	May' 08	July' 08
TSS (mg/L)	278	200	100	336
TDS (mg/L)	3392	3540	1856	4356
Salinity (%)	2.6	3.3	1.1	3.1
EC (µs/cm)	4820	6020	2210	5120
pH	9.8	9.6	10.7	11.2
Temperature (ºC)	41.2	43	40.5	42
DO (mg/L)	0.11	0.23	0.5	0.5
BOD (mg/L)	151.24	Not done	Not done	299.1
COD (mg/L)	2304	720	652.8	800
Color (PCU)	1890.75	5625	2250	3100
Lead (Pb) mg/L	0.0	0.0	0.0	0.0
Zinc (Zn) mg/L	0.0855	0.0838	0.1037	0.5960
Cadmium(Cd) mg/L	0.0006	0.0	0.0	0.0006
Copper (Cu) pmg/L	0.1546	0.0186	0.0586	0.1727

1888 to 4400 mg/L in textile effluent in Pakistan also (Aslam *et al.*, 2001).

Salinity was found ranging from 1.1 to 3.3. Salinity has good relation with TDS and EC (Shah, 2007). From the result it was observed that the salinity value increased with increasing TDS and EC. High salinity may interfere with the growth of aquatic vegetation. Salt may decrease the osmotic pressure, causing water to flow out of the plant to achieve equilibrium. Less water can be absorbed by the plant, causing stunted growth and reduced yields. High salt concentrations may cause leaf tip and marginal leaf burn, bleaching, or defoliation (Perfetti and Terrel, 1989; CWT, 2004). EC was found ranging from 2210 to 6020 µs/cm; but the standard value is 1200 µs/cm (Haque, 2003). EC was also found 7650 µs/cm in the effluent of H. R. Textile Mills Ltd. (Rahman *et al*, 2008). In another report it was reported 2250 to 19000 µs/cm in the textile effluent in DEPZ area (Ahmed, 2007). Mahmood *et al*., (2005) noticed that the conductivity of wastes from CEBEE Textile Industries in Iran was 1884 µs/cm. High EC indicates that a large amount of ionic substances like sodium, potassium, iron etc are present in textile effluent (Kabir *et al.*, 2002).

pH was found in the range of 9.6 to 11.2 which is above the standard (pH 6-9) of DoE (Haque, 2003). Rahman *et al.*, (2008) found pH 11.9 in effluent of H.R. Textiles Mills Ltd. pH value was found 7.2 to 10.3 in the textile effluent in DEPZ area (Ahmed, 2007). pH value was found 5.5 to 10.5 in the textile effluent in Lahore district in Pakistan (Mahmood *et al*., 2005). Another study on the textile effluents in Pakistan found pH value 5.6 to 11.2 (Aslam *et al.*, 2004). High pH inhibits the growth of aquatic macrophytes by impairing iron (Fe) and phosphorus uptake (Agro, 2003) and pH >8.5 also reduced fish production (Edmund, 1998).

Temperature varied from 40.5^{O}C to 43^{O}C which is also above the standard (40^{O}C) (Haque, 2003). Temperature value was found 48^{O}C to 59^{O}C in the textile effluent in DEPZ area (Ahmed, 2007). Short term temperature fluctuations in streams near the textile and dying industries might lead fish to die, fish eggs that won't hatch or a total change in the fish population. For aquatic life, the temperature should not exceed 25^{O}C (77 ^{O}F) during the later half of October and the average temperature during that time period should be no higher than 22.2 (7^{O}C 2^{O}F) (Davis, 1998).

Dissolved oxygen (DO) values were found ranging from 0.11 to 0.5 mg/L. According to standard the effluent should content DO 4.8- 8 mg/L (Haque, 2003). DO value was found 2.15 to 5.90 mg/L in the textile effluent in DEPZ area (Ahmed, 2007). The composite textile mill release a lot of biochemical oxygen demanding waste. The BOD value found ranging from 151.24 to 299.1 mg/L which is 3 to 6 times higher than the acceptable value of wastewater permitted to release on the inland surface water (Haque, 2003).

BOD value was found 94.33 to 141.66 mg/L in the textile effluent in DEPZ area (Ahmed, 2007). BOD value was found 150 to 350 mg/L in the textile effluent in Lahore, Pakistan (Mahmood *et al*., 2005). Another study on the textile effluents in Pakistan found BOD value 145 to 236 mg/L (Aslam *et al.*, 2004).

Chemical oxygen demand (COD) values were found 2304, 720, 652.8 and 800 mg/L, respectively in four times collected samples which were very high above the standard (200 mg/L) of waste water permitted to disperse in inland surface water (Haque, 2003) . In December' 2007 COD value was the highest than in February, May, July' 2008. COD value was reported 170.88 to 854.4 mg/L in the textile effluent in DEPZ area (Ahmed, 2007). It was also reported 350 to 700 mg/L in the textile effluent in Lahore district in Pakistan by Mahmood *et al*. ,(2005). Another study on the textile effluents in Pakistan found COD value 370 to 618 mg/L (Aslam *et al*., 2004).

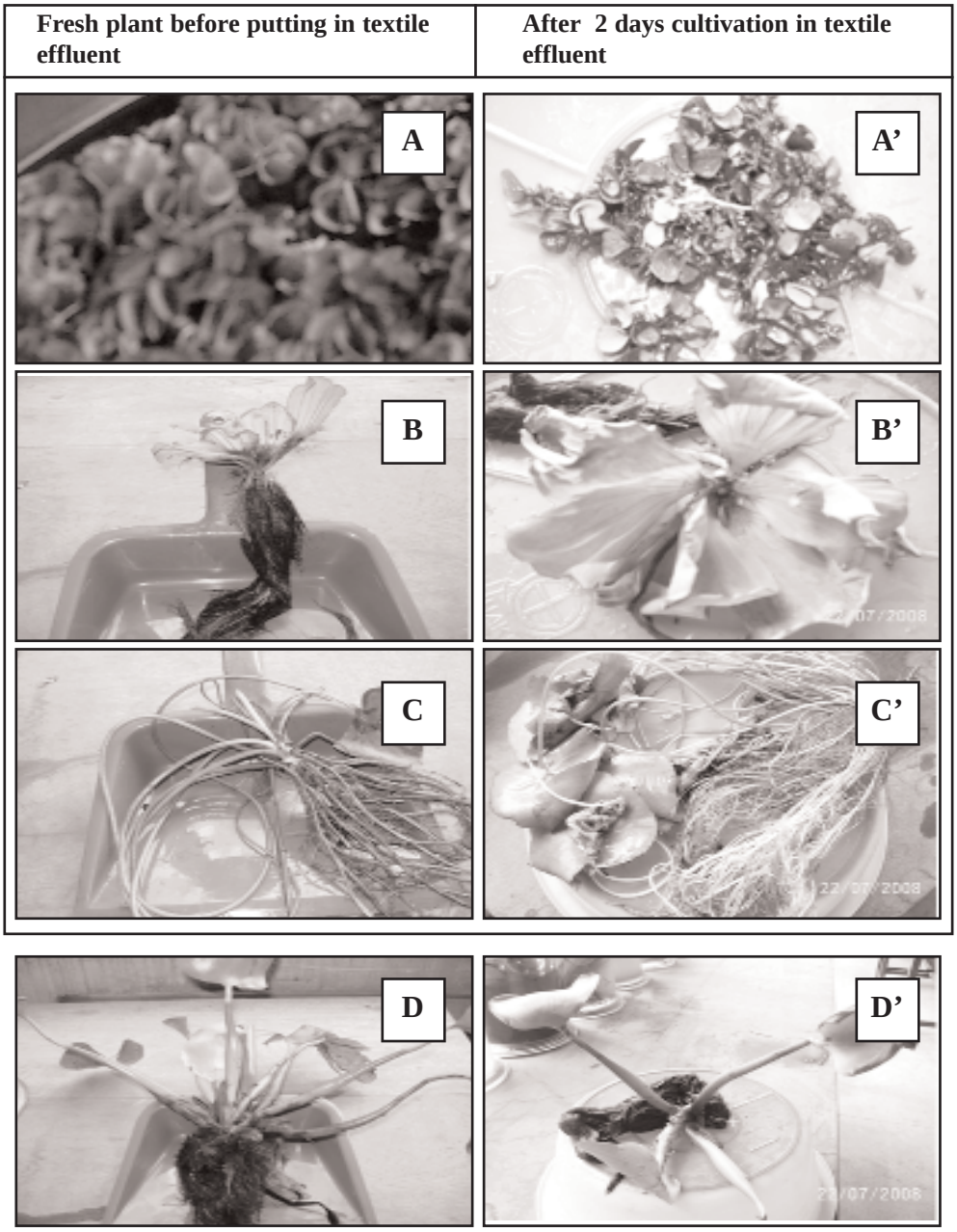

Fig. 1. Condition of *Salvinia cuculata* (A, A'), *Pistia stratiotes* (B, B')s, *Nymphoides indicum* (C,C ') and Eichhornia *crassipes* (D,D') before and after cultivation in textile effluent in the laboratory

Table II. Reduction of algal weight during the cultivation in textile effluents in different type of culture vessels under laboratory condition

Sample	Vessel	Volume of sample (ml)	Initial weight (g)	Weight after 4 days (g)	Weight reduced (g)	Reduction (%)
Algae (Nostoc)	Earthen	2000	400	280	120	30
Algae (Nostoc)	Glass	2000	400	345	55	13.75

Color was found 1890.75 PCU, 5625 PCU, 2250 PCU, and 3100 PCU respectively in four cycles. The permissible limit of color in waste water to discharge is 15 PCU (IWS, 2002). The observed values of color was126 to 375 times higher than recommended value. Due to inefficiencies of the industrial dyeing process, 10- 15% of the dyes are lost in the effluents of textile units, rendering them highly colored (Vaidya and Date 1982; Boer *et al*., 2004; Jin *et al.*, 2007). The efficient removal of dyes from textile industry effluents is still a major environmental challenge (Baldrian and Gabriel, 2003). However, all of tested heavy metals e.g. cadmium (Cd), Lead (Pb), Copper (Cu), Zinc (Zn) were found very less which complied with the permissible level (Table I).

Toxic effect of textile effluents on aquatic macrophytes:

Salvinia cuculata could hardly survive 2 days on textile effluents in laboratory culture conditions. It lost the roots from the rest of the body parts. Leaves turned to brownish color as shown Fig.1. A similar situation was also observed for *Pistia stratiotes* and *Nymphoides indicum*. In Fig. 1, shows that the root part of *Nymphoides indicum* turned green to white color. The roots of Eichhornia crassipes was observed bright and strong in lake water and same as in the preserved form in artificial pond in BCSIR. The roots turned to dark and become weak in effluent on treatment after two days (Fig.1). Sooknah and Wilkie (2004) reported the growth inhibition of water hyacinth (*Eichhornia crassipes*), pennywort (*Hydrocotyle umbellata*) and water lettuce (*Pistia stratiotes*) by textile effluents. Toxic effect of textile effluents on water hyacinth (*Eichhornia crassipes*) was also observed by Qaisar *et al*., (2005). They observed the effects of pollutants from textile wastewater on the anatomy of the water hyacinth and noticed that textile waste significantly affected the size of root cells..

Toxic effect of textile effluents on Algae (Nostoc)

The weight of *Nostoc* reduced after four days. Table II shows the amount of reduction of weight of Nostoc in the effluent. Weight reduction in earthen vessel was more than in glass vessel. Weight reduction may be due to the toxic effect of textile effluents and consequently, death of certain portion of algal cells. *Noticeable reduction* of algal concentration in the pond was also reported by Assadi (1979). Toxicity of textile effluents on algae was also reported by Sponaza (2002), among the tested effluents samples, 18 effluents showed toxicity while 5 effluents were found not to be toxic.

Conclusion

* The studied physicochemical parameters such as TSS, TDS, TS, pH, color, salinity, EC, DO, BOD, COD of H.R. Textiles Mills effluents were quite higher than the recommended values set by DoE.
* Metals like Cd, Zn, Pb, Cu, and Fe were present in trace amount. These complied with the permissible limit.
* Concentration of the post discharge of equalization tank of H.R. Textile (Kornapara, Savar) industrial effluents showed the toxic effects on tested aquatic macrophytes and algae in laboratory culture conditions.

References

Argo B. (2003) Understanding pH management and plant nutrition part 1: Introduction. *Int. Phalaenopsis Alliance. J.,* **12**(4): 1-2

Assadi M. (1979) Application of stabilization pond for purification of textile wastewater in Esfahan, Iran. *Water, Air and Soil Pollution. J.*, **11**: 247-252

Ahmed T. (2007) Characterization of textile effluent from selected industries in DEPZ and their treatment by adsorption- filtration process. M. Sc. Thesis, pp 1-132, Department of Environmental Sciences, Jahangirnagar University, Saver, Dhaka.

APHA (1998) Aggregate organic constituents. In Standard method for the examination of water and waste (Greenberg, A. E., Clesceri, L. S. & Eaton, A. D. eds), 20th (Ed), (pp 5.13- 5.17). APHA, AWWA & WEF.

Aslam M. M., Baig A. M., Hassan I., Qazi A. I., Malik M. and Saeed H. (2001) Textile wastewater characterization and reduction of its COD and BOD by oxidation. Electron. *J. Environ. Agric. Food Chem.*, **3** (6) : 804 - 811.

Baldrian P., and Gabriel J. (2003) Lignocellulose degradation by Pleurotus ostreatus in the presence of cadmium. *Federation of Europian Microbiological Society (FEMS) Microbiol Letters* **220**:235-240.

Bangladesh Textile Mills Association (BTMA) Annual report. 2007. (pp. 14, 35).

Boer CG, Obici L, Souza CG, and Peralta RM (2004) Decolourization of synthetic dyes by solid state cultures of Lentinula (Lentinus) edodes producing manganese peroxidase as the main lignolytic enzyme. *Bioresour Techno*l **94**:107-112.

Clean water team (CWT) (2004) Electrical conductivity/ salinity fate sheet, FS- 3.1.3.0 (EC). In The clean water team guidance compendium for water monitoring and assessment, Version 2, Division of water quality, California State Water Resources Control Board (SWRCB), Sacramento, CA. URL: www.swcrb. ca.gov/ nps/volunteer.html accessed on16th August, 2008.

Davis B. (1998) River assessment monitoring project (RAMP) of Kentucky water watch. URL: http://water.nr.state.ky.us/ww/ramp/.html accessed on 20th June, 2007.

Edmund M. J. (1998). Understanding Factors that affect pH and guide to alkalinity and pH control. Sea scope. Aquarium System, 5.

Gurnham F. C. (1965). Industrial work control (Academic press, New York). pp 5-6.

Haque M. E. (2003) A compilation of environmental laws of Bangladesh, Administrated by the Department of Environment (DoE).

Industrial wastewater standard (IWS) (2002) Discharge limit set by Jordan Specification.

Xian-Chun J., Gao-Qiang L., Zheng-Hong X. and Wen-Yi T. (2007). Decolorization of a dye industry effluent by Aspergillus fumigatus XC6. *Appl Microbiol Biotechnol* **74**:239-243.

Kabir E. S., Kabir M., Islam S. M., Mia C. M., Begum N., Chowdhury D. A., Sultana S. M. and Rahman S. M. (2002) Assessment of effluent quality of Dhaka export processing zone with special emphasis to the textile and dying industries. *Jahangirnagar Uni. J. Sci.*, **25**: 137-138.

Mahmood Q., Zheng P., Islam E., Hayet Y., Hassan M. J., Jilani G. and Jin R. C. (2005) Lab scale studies on Water Hyacinth (*Eichhornia crassipes Marte Sloms*) for biotreatment of textile waste water. *Caspian J. Env. Sci.*, **3**: 83-88.

Qaisar M., Ping Z., Rehan Q.M., Ejal Ul I., Rashid A. M. and Yousaf H. (2005). Anatomical studies of water hyacinth (Eichhornia crassipes Marte Sloms) under influence of textile waste water. *J. Zhejiang Univ SCI* **20056B** (10): 991-998.

Rahman H. S., Neelormi S. and Tareq M. S. (2008) Environmental impact assessment of textile and dying industries on ecosystem of Karnopara canal at Savar, *Bangladesh. Jahangirnagar Uni. J. Sci*., **31**: 18-32.

Saha R. (2007) Impact of the effluents of textile dying industries on the water quality of D.N.D. embankment area, Narayangang. M. Sc. Thesis, pp 1- 50, Jahangirnagar University, Saver, Dhaka.

Sooknah R.D., and Wilkie A.C. (2004). Nutrient removal by floating aquatic macrophytes cultured in anaerobically digested flushed dairy manure wastewater. *J.Ecological Engineering*, **22** (1, 1): 27-42.

Sponaza D. T. (2002) Necessity of toxicity assessment in Turkish industrial discharges (examples from metal and textile industry effluents). *Environmental Monitoring and Assessment* **73**: 41-66.

Tufekci N., San H.A., Aydin S., Ucar S. and Barlas H. (1998) Wastewater Treatment Problems in the Operation of Woven and Knit Fabric Industry, *Federation of Europian Biochemical Society (FEB)*, **7** : 795-802.

Vaidya A. A., and Date K.V. (1982) Environmental pollution during chemical processing of synthetic fibers. *Colourage* **14**: 3-10.

Water quality parameters. (1994). In River management monitoring project Kentucky water watch, 1994. URL: http://kywater.org/ww/ramp/rmtss.htm accessed on 16th August, 2008.

Received : January 26, 2009;
Accepted : August 25, 2009