Pak. J. Sci. Ind. Res. 2005 **48**(3) 209-211

Short Communication

Impact of Sugarcane Industry on Environment

Sajid Farid*[a], Musa Kaleem Baloch[a], Ahtsham Razaque[b] and Syed Amjad Ahmad[b]

[a] Department of Chemistry, Gomal University, Dera Ismail Khan, Pakistan

[b] NFC Institute of Engineering and Fertilizer Research, Faisalabad, Pakistan

(received June 19, 2003; revised May 16, 2005; accepted May 26, 2005)

Abstract. The environmental threat posed by the sugarcane industry is reported. Sixteen effluent samples, from four sites, were collected. These samples were analysed for pH, electrical conductivity (EC), total dissolved solids (TDS), Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, PO_4, BOD and COD. The results were compared with the National Environmental Quality Standards (NEQS) recommended for the industrial effluent discharge. These effluent samples were further evaluated for irrigation purposes by the TDS, SAR and RSC values and compared with the recommended irrigation water criteria. Results showed that the effluent samples neither met the standards outlined in the NEQS for pH, EC, BOD and COD, nor were they suitable for irrigation purposes due to the TDS values higher than those recommended for irrigation.

Keywords: sugar mills effluent, effluent quality, aquatic life, irrigation quality, environmental impact

Increased industrialization is a serious cause of water pollution. Inustrial effluents contain both the inorganic and organic hazardous materials. The discharge of these effluents on agricultural land, adversely affects the plant and animal life (Nabi and Aslam, 2001; Hamid, 1994). According to a rough estimate, 9,000 million gallons of wastewater is daily discharged into the water bodies by the industries in Pakistan (Saleemi, 1993). The number of sugar mills operating in Pakistan in 1999-2000 was 74 (ASP, 2000). These mills are discharging their effluents into the water bodies without any treatment. These effluents have been reported to have high COD and BOD values, which is harmful to the aquatic life (Bailly, 1997). Presently, the availability of data on the environmental pollution caused by the sugarcane industry is limited (Bailly, 1998). Also, the control being exercised to ward off the hazards caused by the disposal of untreated effluents is extremely lacking (Shah, 1987). The present investigation was carried out to assess whether the sugarcane industry effluents are within the limits of the NEQS in Pakistan (Gazette of Pakistan, 1993), and whether these effluents were suitable for irrigation purpose.

The effluent sampling was done from four sites, 220 ft apart from each other. The sampling was done on a weekly basis for one month, during the peak production period of the sugar industry. The total number of samples collected was 16. The samples were collected in plastic bottles, which were thoroughly rinsed with the effluent to be sampled. These samples were analysed immediately after the sampling for pH, electrical conductivity (EC), total dissolved solids (TDS), Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4 and PO_4 by following the standard methods (ASTM, 1993). The biochemical oxygen demand (BOD), and the chemical oxygen demand (COD) were determined by the standard methods (AOAC, 1984). The water suitability for irrigation purposes was evaluated in accordance with the methods described by USDA (1954).

*Author for correspondence

Physicochemical characterization of the effluents. The chemical characteristics of the sugar mills wastewaters investigated is given in Table 1. The mean pH values from the four sites were, respectively, 3.79, 4.32, 4.28 and 4.57, which were much below the lower limit of 6-10 of the NEQS in Pakistan. The highly acidic values of the effluents have harmful impact on the microflora and fauna. The low pH is indicative of the presence of acids and the hydrolysis of dissolved salts (Rump and Krist, 1992). Since pH effects the biological and chemical properties of the medium, the determination of the parameter in the wastewaters is, therefore, very significant (Banergi, 1993). The electrical conductivity (EC) values depend on the concentration and degree of dissolution of ions, as well as the temperature and migration velocity of ions in the electrical field. The mean EC values in the investigated effluents ranged between 1278.75 and 2121.25 $\mu s/cm^3$, which are higher than the NEQS of Pakistan (Table 1). The total dissolved solids (TDS) is a measure of the total inorganic and organic substances present in the effluent in the dissolved state. The TDS values of the investigated effluents ranged between 2250 and 3358.75 ppm, which were within the limits of the NEQS.

The Ca concentration ranged between 1247.5 2370.0 ppm, which was higher than 200 ppm suggested by Sharma and Lal (1998). The values of Na, 272.75-364.25 ppm, were also

Table 1. The physicochemical characterization of the sugar mill effluents collected from four sites, as compared with the national environmental quality standards for industrial effluents (NEQS)*

Parameters studied	Site-1	Site-2	Site-3	Site-4	NEQS** limits
pH	3.79	4.32	4.28	4.57	6-10
EC	2121.25	1679.25	1540.00	1278.75	1000
TDS	3358.75	2896.75	2808.75	2250.00	3500
Ca	2370.00	1717.50	1470.00	1247.50	-
Mg	599.40	467.11	369.17	237.88	-
Na	364.25	343.00	325.00	272.75	-
K	4.36	4.22	4.07	3.96	-
CO_3	0.00	0.00	0.00	0.00	-
HCO_3	1299.02	2060.25	1756.32	1262.70	-
Cl	890.56	790.40	680.00	575.25	1000
SO_4	233.76	171.48	170.17	119.46	-
PO_4	2.45	1.12	0.68	0.35	-
COD	1771.25	1730.75	1724.25	1676.25	150
BOD	1029.87	974.93	953.67	936.00	80

*EC values expressed in $\mu s/cm^3$, all other parameters as parts per million (ppm); **Gazette of Pakistan (1993); EC: electrical conductivity; TDS: total dissolved solids; COD: chemical oxygen demand; BOD: biological oxygen demand

Table 2. Quality of the sugar industry effluents for suitability for irrigation purposes

Parameters*	Site-1	Site-2	Site-3	Site-4	Critical levels (marginal fitness)
TDS (ppm)	3358.75	2896.75	2808.75	2250.00	1000-1800
SAR (mmol/1)	2.44	2.67	2.77	2.61	7.50-15.00
RSC (mmol/1)	<zero	<zero	<zero	<zero	2.00-4.00

* suitable for irrigation if values below the critical levels; unfit, if values above the critical levels; TDS: total dissolved solids; SAR: sodium adsorption ratio; RSC: residual sodium carbonate

on the higher side. Against the NEQS limits of 1000 and 600 ppm, respectively for Cl and SO_4, the effluent values of 575.25-890.56 and 119.46-233.76 ppm in the four effluent samples were within limits. Carbonates and bicarbonates are naturelly present in water, with the values of the latter higher than the former (Ghanlour *et al.,* 1985). No carbonates were detected in the studied effluents, which may be due to their conversion to bicarbonates at the acidic pH in the presence of excess H^+ present in the wastewaters.

The chemical oxygen demand (COD) is the parameter that signifies the amount of oxygen required by the organic matter present in the effluent for its oxidation by strong chemical oxidants. This value gives the measure of the organic matter load. The COD in the studied effluents was observed to be 1676.25-1771.25 ppm, which was higher than the limit of 150 ppm prescribed in NEQS. Similarly, the biological oxygen demand (BOD) of the effluents was determined to be 936.0-1029.87 ppm, which was rather high against the NEQS limit of 80 ppm. The very high COD and BOD values indicate that the effluents contained high contents of organic matter.

Assessment of the effluents for irrigation quality. The parameters used for the assessment of the effluents for irrigation quality included TDS, sodium adsorption ratio (SAR) and residual sodium carbonate (RSC), and the values obtained during the present investigation are given in Table 2. The TDS values, as already noted above, were quite high in all the four effluents. It has been suggested by Sharma and Lal (1998) that the utilization of such a water for irrigation may cause salinity. As such, the effluents from sugar industry were not fit for irrigation. The classification of water with respect to SAR is primarily based on the effect of exchangeable Na on the physical conditions of the soil. The SAR range of 2.44-2.77 mmol/l was well below the critical level. The RSC values in all the effluents were below zero. From these observations it may be noted that though the SAR and RSC values were within the suitabi-lity limits, the effluents were not suitable for use as irrigation water due to high TDS.

Conclusions. The physicochemical characterization revealed that the values of pH, TDS, EC and Na in all the four effluents were not within the NEQS limits. The effluents, furthermore, were not suitable for irrigation purposes due to high TDS values. It is required, therefore, that the sugar mills must treat their effluents to the acceptable limits of NEQS before their discharge. Some of the treatment methods suggested for the purpose are lagoon construction, trickling filler, upflow anaerobic sludge blanket reactor, and activated sludge treatment (sequential batch reactor).

References

AOAC. 1984. *Official Methods of Analysis of the Association of Official Analytical Chemists,* 14th edition, AOAC Inc., 1111-North, 19th Street, Suite 210, Arlington, Virginia 22209, USA.

ASP. 2000. *Agriculture Statistics of Pakistan, 1999-2000,* Government of Pakistan, Ministry of Food, Agriculture and Livestocks (Economic Wing), Islamabad, Pakistan.

ASTM. 1993. *Annual Book of ASTM Standards, Water and Environmental Technology,* ASTM 1916, Race Street,

Philadelphia, PA 19103-1187, USA.

Bailly, H. 1998. *A Guidebook: End of Pipe Treatment for Sugar Mill Effluents,* pp. 1-49, Ref. R8MO2Sid, Sustainable Development Policy Institute (SDPI), Islamabad, Pakistan.

Bailly, H. 1997. *Pollution and In-Plant Control Measures in Sugar Mills,* pp. 1- 42, Ref. R71PSSID, Sustainable Development Policy Institute (SDPI), Islamabad, Pakistan.

Banergi, K. S. 1993. *Environmental Chemistry,* pp. 2-4, Prentice Hall of India (Pvt.) Ltd., New Delhi, India.

Gazette of Pakistan. 1993. *National Environmental Quality Standards*, pp. 2-3, Government of Pakistan, Islamabad, Pakistan.

Ghanlour, El. M.F.M., Khalid, J.B., Atta, S.A. 1985. Distribution of carbonates, bicarbonates and pH values in groundwater, Nile Delta Region, Egypt. *Ground Water* **23:** 35-41.

Hamid, S.M.R. 1994. *Fundamentals of Environmental Pollution*, CBS Publishers and Distributors, Delhi, India.

Nabi, G.M.A., Aslam, M.R. 2001. Heavy metal contamination of agricultural soils irrigated with industrial effluents. Sci. Tech. Develop. **20:** 32-36.

Rump, H., Krist, H.T. 1992. *Laboratory Manual for Examination of Water, Wastewater and Soil,* pp. 90-110, VCH Publishers, New York, USA.

Saleemi, M.A. 1993. *Environmental Assessment and Management of Irrigation and Drainage Scheme for Sustainable Agriculture Growth,* Environmental Protection Authority, Lahore, Pakistan.

Shah, A.A. 1987. State of the environment in Pakistan in environmental management for sustainable socioeconomic development. In: *Proceedings of the National Seminar on Environmental Management for Administrators,* Lahore, Pakistan.

Sharma, H.C., Lal, C. 1998. Sugar mill effluent-quality and its suitability for irrigation. In: *Procedings of International Symposium on Agroenvironment,* pp. 159-163, University of Agriculture, Faisalabad, Pakistan.

USDA. 1954. *Diagnosis and Improvement of Saline and Alkali Soils*, Handbook No.64, US Salinity Laboratory Staff, California, USA.