Impact of Sugar Cane Industry Effluents on The Environment of its Surroundings

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Abstract

Pakistan's sweetener sector is mostly comprised of sugarcane cultivation, manufacturing and commercialization of white sugar. Pakistan is an agricultural country, with agriculture serving as the foundation of the economy. The sugar industry accounts for 4.2% of total manufacturing. Sugarcane is farmed on over a million hectares of land in Pakistan, providing raw material for the country's sugar mills, according to the Food and Agriculture Organization of the United Nations. Since many chemicals are employed during the processing, the effluent is frequently tainted with contaminants. Burnt sugar odor, low pH, black hue, high ash concentration, and 50 percent organic and inorganic particles are all present in this wastewater. Normally, sugar industrial effluents are not treated before discharge and hence pollute both land and aquatic habitats. When not adequately handled, they emit an unpleasant stench when released into the environment. The study's goal was to assess the effects of sugar mills' effluent on the ecology near the mills. Water effluent samples were collected from Layyah sugar mills, Multan, Punjab, Pakistan and evaluated for pH, total suspended solids (TSS), total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and several heavy metals for the current study. TSS, BOD, COD, pH, conductivity, nitrates, phosphates, chlorides, Ca, Mg, Hg, Cd, Ni, Zn, Cu, Fe, were all found to be greater than Pakistan's National Environmental Quality Standards (NEQS). The investigation discovered that the discharge of untreated effluents

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from sugar mills affected the surface water, groundwater, and soil, substantially degrading the ecosystem of the locations.

Key Words: BOD, COD, Pollutants, pH, Sugarcane, Wastewater.

Introduction

The sugar business in Pakistan is a seasonal sector that operates for 4 to 5 months and employs sugarcane as a raw material. The industry is critical to the economic growth of Pakistan. The sugar business contributes 3.2 percent to value addition, whereas it contributes up to 0.7 percent to GDP. Manufacturing accounts for 4.2 percent of the sugar sector. In previous decades, the sugar business primarily produced sugar; but, in the production of sugar, ethanol, and power new technology was introduced in the sugar industry (Ayyasamy et al., 2008)(Mijaylova Nacheva et al., 2009).

As a result of the many chemicals employed in the processing, the wastewater is frequently polluted with contaminants. This wastewater has a burned sugar odor, a low pH, a dark hue, a high ash concentration, and 50 percent organic and inorganic materials (Ingaramo et al., 2009). In terms of wastewater volume and characteristics, the sugar sector is one of the primary contributors of pollution (Mane et al., 2015). Due to various contaminants like low pH, biochemical oxygen demand, total dissolved solids, and Chemical oxygen demand Sugar industrial wastewaters is become risky in different cases. The discharge of effluent from the sugar industry without pretreatment causes contamination in both land and aquatic habitats (Al-Jayyousi, 2003)(Hamoda, 2004)(Cel et al., 2013).

Impurity coagulation), sulfur dioxide (to enhance sugar color), dilute sodium carbonate or sodium hydroxide followed by dilute hydrochloric acid (for episodic desalting of heaters), and the use of Lead sub-acetate are used. These substances work together to increase the suspended and dissolved solids, as well as the organic (Darilek et al., 2009). When sugar industrial effluents are applied to agricultural land, they have a wide range of negative impacts on crops (Adhikary, 2014). Farmers that use sugar factory effluent for irrigation and as a primary source of soil contamination have reported reduced plant growth and crop output(Al-Jayyousi, 2003)(Chavez-Rodriguez et al., 2013). Numerous air pollutants, such as CO and volatile organic carbons, are created when cane waste is burned and released into the atmosphere. These pollutants have a significant impact on the potential for photochemical ozone generation as well as eutrophication and acidification. (Jadhav, Vaidya, and Dethe, 2011)(Harush and Hampannavar, 2014). In addition to the contaminants and chemicals mentioned above, grease and oil for lubrication, detergents, nutrients, organic and inorganic elements, and more are present in wastewater having bagasse particles (Sassi, 2015)(Abbas et al., 2009).

The purpose of the current study was to check impurities due to wastewater and understand its impacts on the environment, as well as to estimate the effects of effluent on wheat crop yield.

Materials and Method

Samples were taken from the Layyah sugar mill and subjected to a laboratory of tests for physico-chemical characteristics, including arsenic, nitrate, and microbiological contamination. Three drinking water samples were taken from three separate sources: a hand pump, a motor, and a tube well. The technique employed are described below.

Odor, Taste and Color (TCU) were measured by sing Sensory Test (Simat et al., 2017), Sensory Test (Simat et al., 2017) and Sensory Test (Sarkar et al., 2022), respectively. Whereas Conductivity (µS/cm) was estimated by employing EC meter, Instrument by Hanna with Model HI 991301, Italy (Meter, n.d.). pH was obtained through pH Meter, Italy (Tds, n.d.) Turbidity was confirmed through Turbidity Meter, Instrument by Hanna with Model HI 93703, Italy (Microprocessor and Meter 2005). Carbonate, Bicarbonate and Alkalinity (m. mol/l as $CaCO_3$) was measured by 2320, Standard Method (1992) (Federation, Pollution, and Federation 2012). TDS by 2540C, Standard Method (1992) (Holstege et al. 2010)Calcium by 3500-Ca-D, Standard Method (1992) (Gilcreas 1967) and hardness by EDTA Titration, Standard Method (1992) (American Public Health Association 2018). Chloride was measured by Titrating silver Nitrate, Standard Method (1992) (Korkmaz 2011) Sodium, and Potassium using Flame Photometer PFP7, UK (Cole-Parmer Ltd 2021).

Fluoride and Sulfate were obtained by Sulphonic acid azochromotrop reagent using Colorimeter, Model DR/890, HACH, USA (“Portable Datalogging Colorimeter Instrument Manual” 1999) and SO_4 4500 by the use of turbidity meter, (1992) SM (Standard Method). SPECORD 200, Analytikjena(“Portable Datalogging Colorimeter Instrument Manual” 1999) UV- Visible Spectrophotometer, , respectively. Magnesium and Arsenic and Iron by using 2340-C, Standard Method (1992) (American Public Health Association 2018) and Atomic Absorption Spectrometer, novAA 300, Analytikjena(Perkin 1996), respectively. Nitrate-N by using 4500 $NO_{3,}$ Standard Method (1992), UV- Visible Spectrophotometer, SPECORD 200, Analytikjena (“Portable Datalogging Colorimeter Instrument Manual” 1999). Were as Microbiological Analysis was carried out by a) contamination of Bacteria in the sample was confirmed by the two types of test;

(a)(Semi Quantitative) (b) 10 % QC Analysis, 9221, (1992) SM (Standard Methods) (APHA-AWWA-WEF 2006)

Principle for Measurement of COD

A detected intemperance of potassium dichromate ($K_2Cr_2O_7$) in flute ampoules or cap tubes refluxes the ordeal in a strong acidic solution. After that, a colorimeter is used to determine how much oxygen has been ingested (Cel et al., 2013).

Principle for Measurement of BOD

Samples are filled in airtight bottles and incubating it at the specified temp for 5 days at 20 ^{0}C in BOD sensor cap.

Sample size taken

BOD Range Sample Volume

a) 80 milligram/ dm^3 400 milliliter sample
b) 300 milligram/ dm^3 250 milliliter sample
c) 550 milligram/ dm^3 150 milliliter sample
d) 1000 milligram/ dm^3 100 milliliter sample

The alkalinity was determined using the 2320 Standard Method (1992). This technique included a variety of substances, including sodium carbonate, HCl, and indicators. By using EDTA with help of sodium hydroxide (to obtain the PH 12-13), murexide indicator and standard EDTA titrant calcium was analyzed.

Calcium concentration in (milligram/dm^3) = Ax Bx 400.8 / V

Chloride was determined in the sample by following prescribed procedure. Sample of pH 7 -10 titrated against standard solution of $AgNO_3$ till the appearance of pinkish yellow color as end point by adding few drops of K_2CrO_4 indicator.

Chlorine concentration in (milligram/dm^3) = (A-B) x M x 35.45 x 1000 / V

Fluoride, Iron and Magnesium

The fluoride content of the samples was determined using the SPADNS technique. The fluoride content was evaluated using a DR/890 colorimeter. Photometric method was used to analyze the iron(Meloche and Martin 1956). The concentration of iron was measured by spectrophotometer at wavelength of 510 nm for suitable calibration curve at 3-4 pH. The magnesium concentration was determined using the

Standard Method 2340-C. (1992). $CaCO_3$ was used for the confirmation and calculation of magnesium by the difference between hardness and calcium.

*Magnesium concentration in (*milligram/ dm^3) = *[hardness of $CaCO_3$ (*milligram/ dm^3*) – hardness of calcium (as magnesium calcium carbonate per liter) x 0.243]*

System of Atomic Absorption Spectrophotometer was used for Mercury Hydride System novAA 300, Analytikjena and Ar (argon) gas with purity of 99.999 percent were used to determine arsenic pollution in drinking water. Argon was adjusted to 4to 6 bar by dissolving 10 g sodium borohydride and 3.5 g NaOH in 1 dm^3 deionized water (reducing agent for arsenic). A 7 ml sample was placed in the reaction cell, and 1.5 ml of concentrated HCl was added. A calibration curve was created using arsenic calibration standards with values of 0, 5, 10, 15, 20, 25, and 30 ppb.

Physical Parameters

The pH of water was determined using the electrometric technique. Suspended solids such as clay, fine organic and inorganic compounds, and micro-organism were the basic purpose of Turbidity in water. Visual impressions were used to check for turbidity in the wastewater, and American Public Health Association (1992) bacteriological testing was used to look for microorganisms.

Results and Discussions

The detail analysis of te samples is provided in Table-1 and Table-2 and discssed below.

BOD and COD

The biochemical oxygen demand and chemical oxygen demand levels in the seven samples taken from the Layyah sugar mill were measred and fond tobe different. The biochemical oxygen demand levels varied between 160 and 220 miligram/ dm^3. chemical oxygen demand levels, on the other hand, ranged from 241 to 301 miligram/ dm^3 (Fig. 1). The BOD and COD levels was elevated due to presence of biodegradable compounds in the analyte with very huge amount The BOD and COD ranges discovered in waste water were substantially higher than the National Environmental Quality Standards (NEQs), which were 85 and 160 miligram/ dm^3, respectively. Because of the high biodegradability of the waste water, it was required to purify it before it can be sed for irrigation purpose. (Figure 1 & 2).

Carbonate and Bicarbonates and Total Coli form MPN/100mL

$CaCO_3$ was found in all of the water samples tested. Carbonate levels in waste water were found to be 370 mg/L. Pure water, on the other hand, had 0.03 to 0.04 mg/L of carbonates level. According to WHO, the Total Coli form MPN/100ml of waste water expected to be 280/100ml, whereas the permitted limit was 20.

TDS and TSS

The TDS level was found to be 581 mg/L. Untreated effluent had suspended particles ranging from 243 to 283 mg/l (permissible value is 200 mg/l). Turbidity can be caused by a little higher TSS value than the allowed limit. TDS levels in potable water ranged from 549 to 563 mg/L (Fi. 2) much below the WHO's. acceptable limit of 1000 mg/L. (Figure 3)

Chlorides, Sulphates,Ammonium Nitrates, Potassium and Arsenic

The chlorides value of wastewater effluent was 63mg/L (standards value 250 mg/L), sulphates were 75 mg/L (WHO standards value is 250 mg/L), and ammonium nitrate was 8.46mg/L (standards value 5mg/L) in the current study.

Potassium was 24 mg/L, which is somewhat more than the allowable threshold and may have beneficial when used for irrigation. The wastewater from Sugar Mill Layyah had 59 mg/L of arsenic, according to an arsenic content examination (Fig. 4).

Concentration of Zinc, Copper, Iron, Phosphate and Nitrate

According to NEQs, the maximum allowable value of zinc is 5 mg/L 3.9mg/L, with 4.7 mg/L found in wastewater. Iron level in wastewater was found to be 3.9mg/L (the NEQs allowable maximum for Fe in wastewater is 2 miligram/ dm^3). Similarly, copper levels in wastewater varied from 0.40 to 0.65 miligram/ dm^3, while the allowable limit set by NEQs was miligram/ dm^3 (Fig. 4). As a result, the higher value in wastewater may not be suitable for irrigation.

In the current investigation, 1.56 miligram/ dm^3 phosphate content was found in wastewater. Although in small amounts, it may be beneficial on crops when used for irrigation. The nitrate content in wastewater was determined to be 8.46 miligram/ dm^3. The allowable value, according to the NEQs, is in the range of 10 miligram/ dm^3. Based on the given findings, it is summarized that this wastewater is recommended for agricultural lands as it contains nitrates content which can be useful for irrigation purposes. (Figure 5)

Table 1
Wastewater Quality Parameters of the Layyah sugar mill

Sr. No.	Parameter for water quality (milligram/dm^3)	Allowed range	Results Analyte 1	Analyte 2	Analyte 3	Analyte 4	Analyte 5	Analyte 6
1	BOD (Biochemical oxygen demand)	85(NEQs)	192	185	210	225	205	220
2	COD (Chemical oxygen demand)	160 (NEQs)	240	262	300	280	300	291
3	TSS (Total suspended solid)	200(NEQs)	255	240	270	260	277	282
4	Arsenic	1000(NEQs)	45	50	52	60	51	56
5	Chloride	1000 (NEQs)	42	48	55	52	60	62
6	Conductivity (micro-S/cm)	NGVS(NEQs)	870	864	876	859	881	843
	TDS	3500(NEQs)	550	570	561	572	557	582
7	Ph	6-9 (NEQs)	6.9	6.96	7.1	7.33	7.19	6.86
8								
9	Phosphate as P	(NEQs)	1.55	1.36	1.20	1.38	1.40	1.28
10	Nitrate as N	10 (NEQs)	8.45	6.72	6.37	6.08	7.92	7.10
11	Bicarbonate	NGVS(NEQs)	349	356	370	347	364	338
12	Sulfate	600 (NEQs)	66	70	72	70	62	76
13	Fe	2 (NEQs)	3	3.5	3.7	3.3	3.9	3.8
14	Total Coli form MPN/100 ml	0(NEQs)	More then 230	More then 236	More then 248	More then 245	More then 260	More then 280
15	Zn	5 (NEQs)	4.5	4.1	4.4	4	4.7	4.2
16	Cu	1 (NEQs)	0.43	0.40	0.51	0.64	0.56	0.55
17	Potassium as K	(NEQs)	24	18	19	21	20	23

Table 2
Standards and Results of Chemical Investigation of Drinking Water of Layyah Sugar Mill Colony

Sr. No.	Parameters for Quality of Water (mg/dm^3)	Permissible Limits	Sample 1	sample 2	Sample 3
1	Arsenic	10 (WHO)	2.72	2.11	2.92
2	Chloride	250 (WHO)	38	36	38
3	Conductivity (micro-Second/centimeter)	NGVS	881	876	868
4	Potassium	12 (EC)	0.9	0.94	1.11
5	Sodium	200 (WHO)	85	86	82
6	Sulfate	250 (WHO)	77	70	63
7	Nitrate as N	10 (WHO)	0.50	0.55	0.48
8	TDS	1000 (WHO)	561	550	560
9	Total Coli form MPN/100 Ml	0 (WHO)	15	14	18
10	Bicarbonate	NGVS	390	396	391

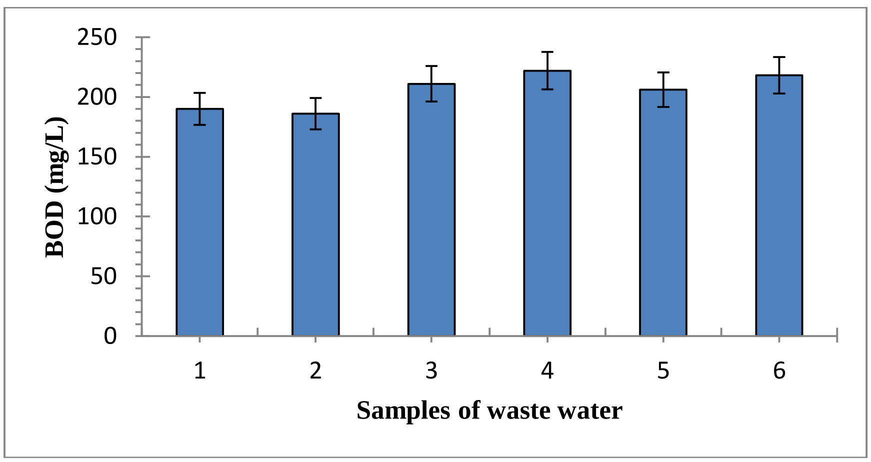

Figure 1. BOD values of waste water obtained from Sugar mills

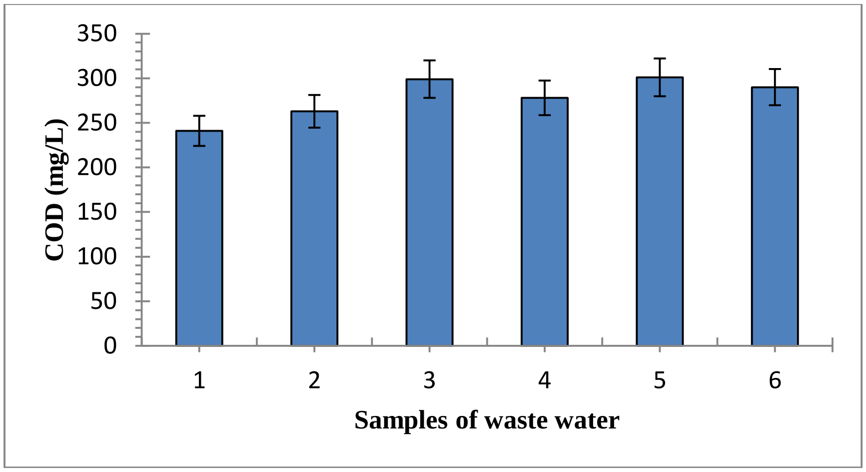

Figure 2. COD values of waste water obtained from Sugar mills

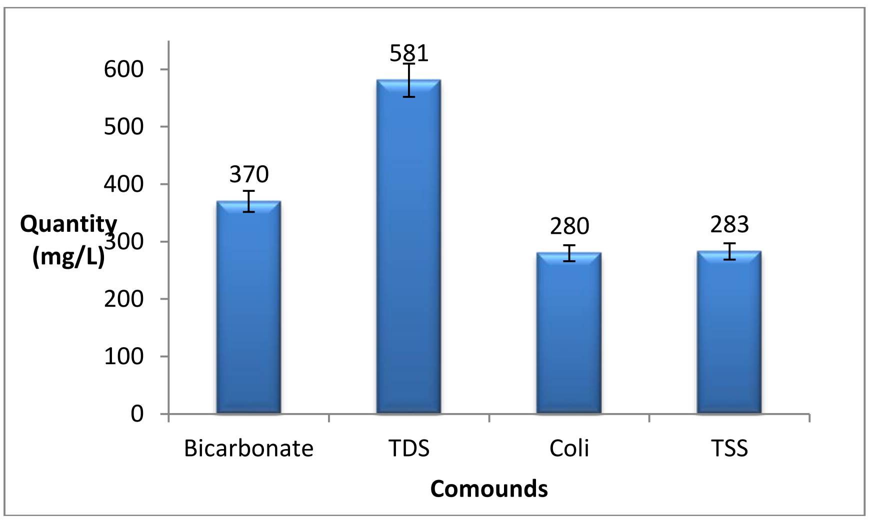

Figure 3. Amount of carbonates, TDS, Coli and TSS in waste water and Pure Water.

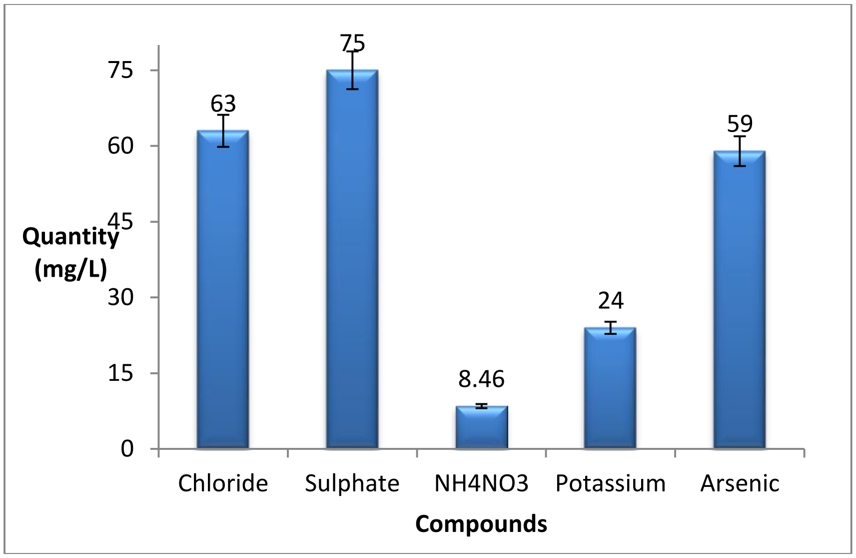

Figure 4. Amount of Chloride, sulphate, ammonium nitrate, potassium and arsenic in waste water

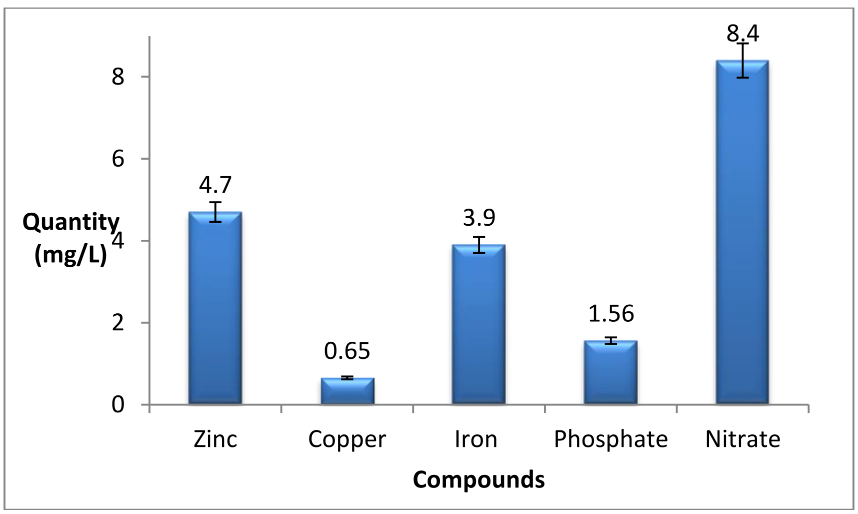

Figure 5. Amount of zinc, copper, iron, phasphate and nitrate in waste water

pH

The pH of the land irrigated with Layyah sugar mills waste water ranged from 8.1 to 8.5. The pH of Pakistani soils is often in the same range. The soil was somewhat alkaline, and phosphate and other micronutrient availability became insufficient in this range. Different organic stuff was also found in wastewater, which is particularly deteriorating to the soil and limits the growth of many plants.

Conclusion

Industrial wastewaters from the sugar industry have high levels of total soluble solids, pH, chemical oxygen demand (COD), and biological oxygen demand (BOD). There are also nutrients, sulphates, chlorides, carbonates, oil, grease, and heavy metals. Untreated wastewater from the sugar industry that is discharged pollutes both land and aquatic environments. It releases a foul odour into the atmosphere if improperly handled.

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