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Mass Balance of Faridpur Sugar Mill, Bangladesh and the Effluents Impact on Chandana River

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Abstract: ***The inputs and outputs of sugar mill industries include different types of raw materials viz. sugarcane, water, bagasse and other chemicals which play important role in the sugar industry. This paper deals with the mass balance of input and output species in the Faridpursugar industry, Bangladesh and the impact of the output effluents in the Chandana River, Faridpur, Bangladesh. The study steps are: (1) The general modeling of the basic processes in the sugar industry was illustrated. (2) Then, the mass balance of the input and output species were calculated for a seasonal duration. (3) The water quality parameters of the effluents of the industry were tested at different distances in the river. (4) Finally, a sustainable solution of the effluents was recommended by analyzing the condition of the overall system. The results of the study are: (1) the basic modeling of the sugar industry has the potential key for the mass balance solution. (2) The mass balance of the mill was carried out in three different steps which show the system is almost accurate and matches with the basic modeling. (3) The water quality parameters were carried out in the laboratory to notice the effect of the effluents in Chandana River which was very tremendous for the ecosystem of that region. (4) Waste water stabilization pond system for the effluents can bring a sustainable solution to the sugar mills from the environmental hazards.***

Keywords: Mass Balance, Physicochemical Test, Sustainability, Water quality parameters.

1. Introduction

Water is the most precious natural resource which is essential for everything to grow and prosper in their way. Water bodies have been considered limitless dumping ground for different types of wastes such as industrial pollutants, raw sewage, garbage and oil spills. Faridpur Sugar Mill is a consumer of large quantities of water, discharging wastewater containing high levels of oil, suspended solids, organic matter, and chemicals. The Sugar Mill effluent is channeled to a set of canal located about 300 meters away from River Chandana. The effluents discharging from the canal into the river contain pollutants thus impacting on the downstream consumers and ecosystems.

The sugar factory design needs properly structured and definite processes of design procedure. The design steps becomes complex because of the physicochemical actions between the various ingredients of a sugar factory. To identify the processes, the model needs to be iterative and requires careful engineering judgments to make appropriate suppositions [1].

In Bangladesh, the sugar mills are opened seasonally, for 5-6 months which is called length of milling season (LOMS). The major processes and technologies for the mass balance can be represented as linear processwhich produces sucrose, non-sucrose and wastes. This model is used to calculate three types of mass balance viz. Milling, Purification and boiling. The milling system includes sugar cane, water as input while the outputs are mixed juice and bagasse. In secondary stage mixed juice, Calcium carbonate and Sulphur-di-oxide acts to produce clear juice and paste mud. Finally, the tertiary level includes the boiling of the clear juice to sugar, molasses and steam [2].

Material quantities are given to process operations and can be broaden by material balances whose principle is conservation of mass. Material balances are the key to the control of processing, mostly in the control of yields of the products. When any changes occur in a process then the material balances need to be determined again. The unit operation may be illustrated in Figure.1. The mass is input into the box must balance with the mass output [3].

Mass (Input) = Mass (Output) + Mass (Stored) (1)

Raw Materials = Products + Wastes Materials + Stored Materials (2)

$\Sigma mR = \Sigma mP + \Sigma mW + \Sigma mS$ (3)

$\Sigma mR = \Sigma mR1 + \Sigma mR2 + \ldots + \Sigma mRn$= Total Raw Materials (4)

$\Sigma mP = \Sigma mP1 + \Sigma mP2 + \ldots + \Sigma mPn$= Total Products (5)

$\Sigma mW = \Sigma mW1 + \Sigma mW2 + \ldots + \Sigma mWn$= Total Waste Materials (6)

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ΣmS= ΣmS1 + ΣmS2 + … + ΣmSn= Total Stored materials (7)

Note. Σ means the sum of the materials.

If there are no physic-chemical changes in the plant, the law of conservation of mass for a component A:

mAin entering materials = mA in the exit materials + mA stored in plant (8)

Sugar is either being boiled or accumulating in the plant or else it is going unnoticed down the drain. [4]In this case:

MA = mAP + mAW + mAU (9)

Where, mAP= product of component A, mAW= waste materials of A and mAU = unknown loss for the conversion of A.

Raw Materials = Products + Waste Products + Stored Products + Losses (10)

Where, Losses = the unidentified substances.

The water of the river is polluted due to the effluents of the mill and the physicochemical parameters are determined at different intervals of the river. This is very much effective for the determination of the effectiveness and the strength of theeffluents over the river water.

The work flow determines the three types of uncertainties in the decision making process: (1) uncertainty of the effects of the chemicals and effluents to be constant in whole year (2) uncertainty of the fixed environmental effect of the pollutants (3) uncertainty of the sustainable solution of the pollution in the sugar mill.

The study on sugar mill mass balance and its impact on Chandana River due to effluents having the following objectives which are: (1) To study on the mass balance of the sugar mill (2) To study on the river water due to effluents (3) To notice a sustainable solution to the effluents before throwing it in the river.

2. Study Area & Data

2.1 Study Area

Faridpur Sugar Mill is in Modhupur, Faridpur district and in the division of Dhaka. Faridpur sugar mill's construction was started during 1974 and it was ended during 1978. The production of sugar was started during 1976-1977. About 1016 TCD cane can be crushed daily and yearly production is 10,160 M. Ton. The factory area covers on an about 56.50 Acre. Faridpur Sugar Mill stands at Modhukhali of Faridpur district. The machinery and equipment are brought from M/S.StrokWerks Poor of Holland. At an average the sugar recovery rate is 7.73% per annum. The average wind speed is 18 Mile/hour and the average temperature of the region is on an about 32°C.

2.1 Data

The mass balance of the sugar industry is given below which is according to the flow chart of the study (Table - 1).

The various water quality parameters at different distances ofChandana River give the right idea on the intensity of the pollution in the river water. The different water quality parameters are pH, color, turbidity; Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD) and dissolve solids tests were done. On the basis of the velocity of streams the great change in the water quality parameters enhances the pollution of the river water and its intensity of pollution and effect on environmental species and food chain is great.

Legend: Black Rectangle is milling; Red one is purification and Blue is boiling. 3D hatch boxes denote the material is taken out from the system.

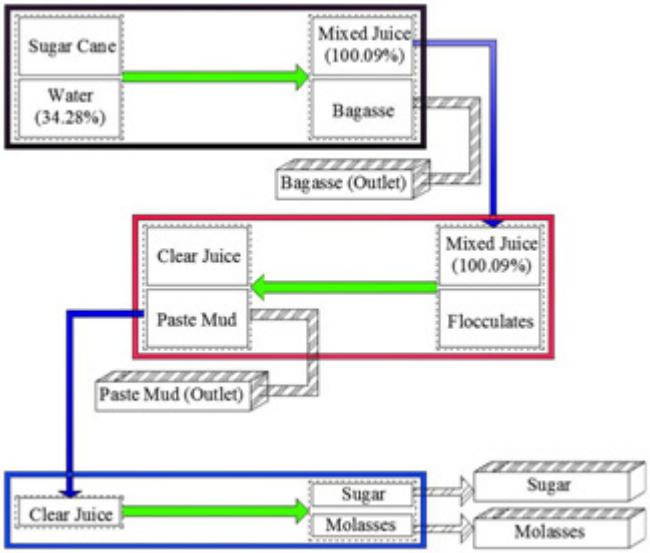

Figure 1: Flow Chart of the study

Figure 2: Study Area

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Table 1: The mass balance of the Faridpur Sugar Mill, Modhukhali, Faridpur, Dhaka

Steps	*Inlet (M. Ton)*		*Outlet (M. Ton)*	
A. Milling	Sugar Cane	72987	Mixed Juice (100.09%)	73052.69
	Water Adding	25020	Bagasse	24954.31
	Inlet Total	**98007**	Outlet Total	**98007**
B. Purification	Mixed Juice	73052	Clear Juice	71108
	$CaCO_3$ (0.184%)	135	Paste Mud (2.89%)	2116
	SO_2 (0.05%)	37	-	-
	Inlet Total	**73224**	Outlet Total	**73224**
C. Boiling	Clear Juice	71108	Sugar (6.85%)	5000
			Molasses (3.776%)	2756
			Evaporation (86.80%)	63352
	Inlet Total	**71108**	Outlet Total	**71108**

3. Methodology

3.1 Mass balance of the sugar mill

The mass balance of the Faridpur Sugar mill involves with the three consecutive linear steps which are: Milling, Purification and Boiling. In the milling there are two steps in the inlet sections viz. sugar cane and water adding and outlet section comprising of mixed juice and bagasse. Next, the purification section having mixed juice and the flocculants to be added to give the output as clear juice and the paste mud. Finally the boiling section heats the clear juice to give sugar, molasses and the steam. This description is as stated in the Table 1 and as directed in the Figure 1.

3.2 Water quality parameters of the Chandana River

The water quality parameters of the Chandana River are based on the following experiments viz. pH, Color, turbidity, BOD_5, COD and Dissolve Solids. The above parameters as stated above are controlled on the basis of the stream velocity of the rivers which lessened the strangeness of the effluents. (Table 2)

The pH of the water is done by membrane electrolyte method which is a modern technology to show 98.9% accuracy of the sample. The color of the samples is determined on the spectrometer photometry by Pt. Co. unit. The turbidity is as usual on the basis of the spectrometer photometry.

Table 2: The water quality parameters of the Chandana River at different intervals prior and after the disposal of sugar mill waste (bracketed values)

Location	1	2	3	4	5	6
Location Point	Mothurapur	Officers Quarter	Mill Gate Bridge	West Garakhola	Modhukhali Bazar Bridge	Baikanthapur
Distance from the point 3 (ft.)	1857	852	0	654	1329	2154
Stream Type	Up	Up	-	Down	Down	Down
Velocity (ft/sec.)	0.837 (0.192)	0.836 (0.178)	1.161 (0.213)	0.732 (0.156)	0.778 (0.198)	0.630 (0.132)
pH	7.61 (7.29)	7.96 (7.21)	7.59 (7.02)	7.69 (6.76)	6.99 (6.84)	6.77 (6.94)
Color (Pt.Co.)	67 (235)	63 (221)	68 (648)	80 (478)	80 (592)	66 (425)
Turbidity (NTU)	2.00 (5.31)	2.21 (5.17)	3.00 (19.60)	5.75 (14.66)	4.68 (17.91)	4.72 (15.22)
BOD_5 (mg./L)	78.7 (103.40)	64.3 (96.30)	61.9 (169.40)	19.8 (133.50)	71.2 (168.70)	21.4 (146.70)
COD (mg./L)	192 (493.60)	160 (449.80)	128 (1093.40)	96 (876.60)	160 (986.40)	96 (926.80)
TS (mg./L)	260 (388)	120 (180)	180 (614)	180 (429)	90 (602)	170 (670)
DS (mg./L)	110 (242)	20 (180)	80 (614)	30 (429)	10 (602)	60 (505)

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4. Results

4.1 Mass balance of Faridpur sugar mill

The mass balance of sugar mill depends on the three main steps viz. milling, purification and boiling. The mass balance of the milling step having inlet and outlet with some methods of the processing is shown below in Figure3. The next mother steps are also same.

4.2 Water quality parameters of Chandana River

The Water quality parameters of the Chandana River depend mainly on the variation of the stream velocity. On the basis of the stream velocity different parameters like pH, Color, Turbidity, Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD) and dissolve solids are calculated and are shown in graphical form(Figure 4).

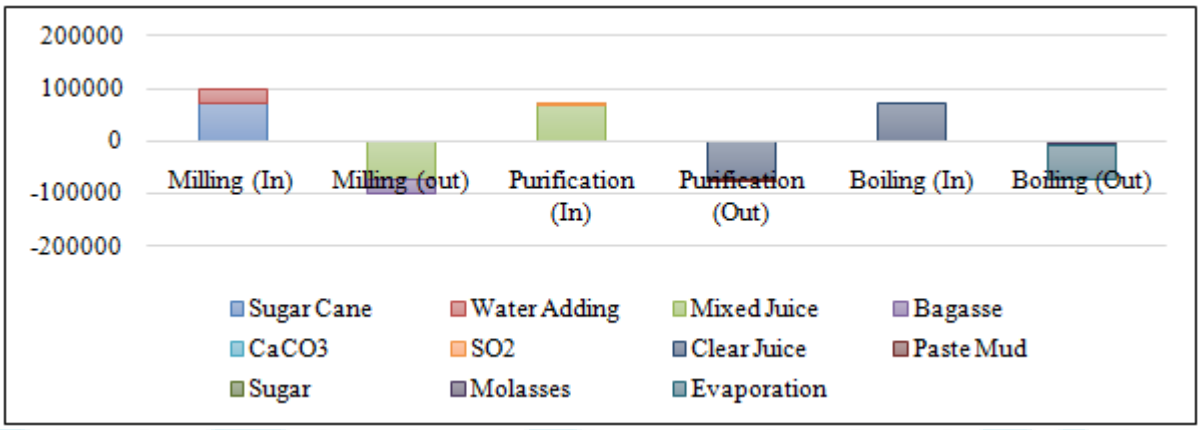
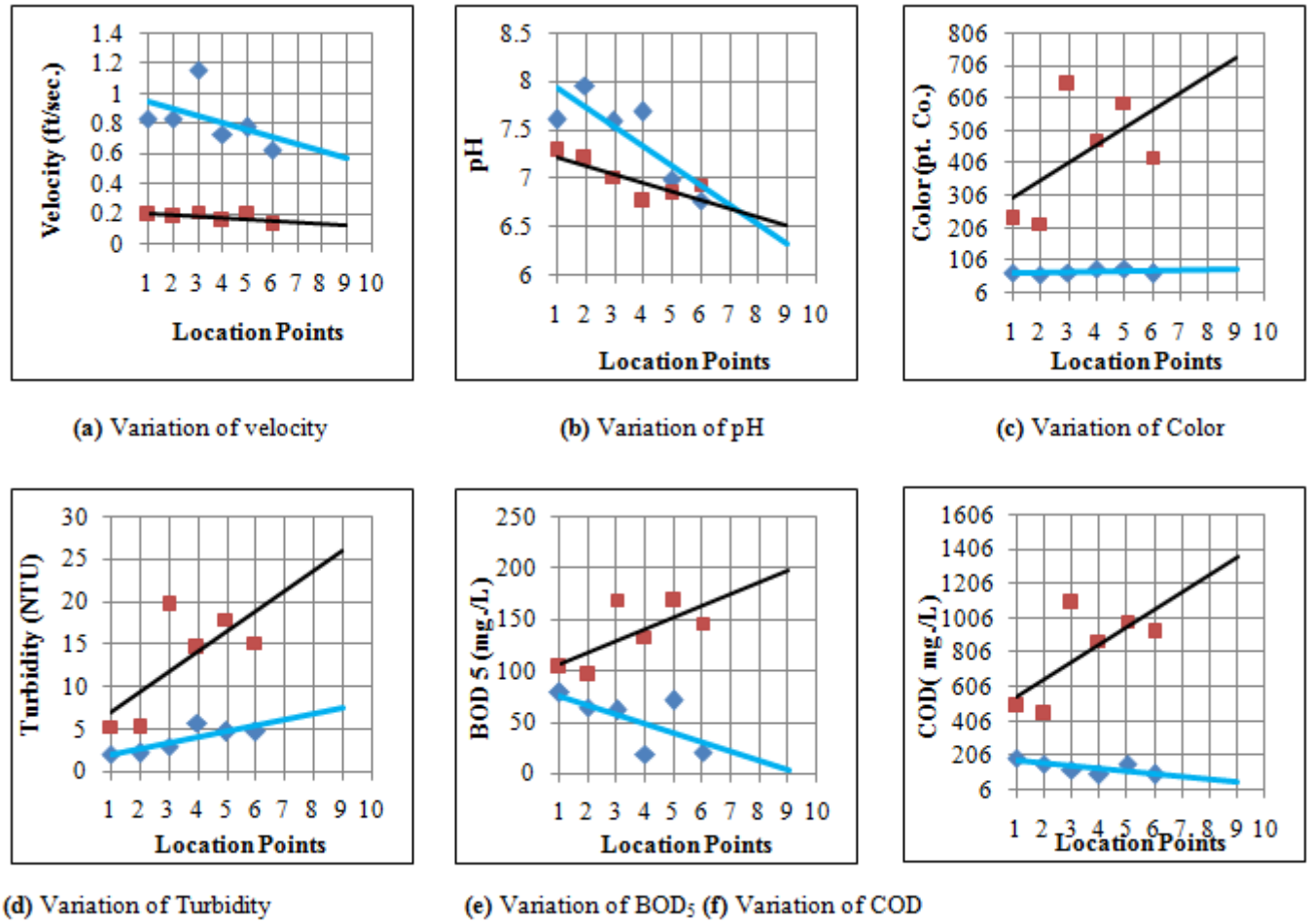


Figure 3: The Mass Balance of the Sugar Mill in Bar Diagram



(a) Variation of velocity **(b)** Variation of pH **(c)** Variation of Color

(d) Variation of Turbidity **(e)** Variation of BOD_5 **(f)** Variation of COD

Figure 4: Variation of parameters with respect to Location Points

From Figure 4, the point no. 3 is the main point of the origination and the point 1 and 2 are upstream and 4, 5 and 6 are in downstream. The blue colored points of the graph are of prior to dispose of the waste to the river while the red mark goes to after the dispose of the waste on to the river. From data it is to be observed that the point no. 5 of Modhukhali Bazar Bridge having an abrupt change of the water quality parameters due to market waste. The graphs are linearly drawn to show the change of the quality parameters in a linear way. Since the channel is prismatic and non-meandering thus the linear regression method is used.

5. Conclusion

The results can be concluded by:

1. The mass balance of the sugar mill is completely equals both input and output of all the systems viz. milling, purification and boiling. In the milling section, addition of water increases the volume of the of the sugar juice into 0.09%. In this section the bagasse are taken out for the further treatment to suck the rest of the juice from it. The purification step helps by the addition of limestone and sulphur-di-oxide to pure the mixed juice and the byproduct as paste mud. This paste mud is used as timber for the cooking. Finally in boiling section, the clear juice is made to sugar and molasses by evaporating 86.80% of its total mass.

2. The water quality parameters of the Chandana River show the effluents plays very important role to destroy the environment of the Faridpur. The ejection point of all the effluents is Mill Gate Bridge. So from this point, two points are taken from upstream and three are from downstream to compare the output in the Figure 4. Here both data are displayed to compare the change of the parameters in both prior and after the dispose of the materials. The huge amount of change in all parameters of the water quality really makes the environment to be polluted. This rigorous evaluation was very much essential to judge the condition of the environment before and after the dispose of the effluents.

3. Since, any effluent is very much dangerous to the environment thus, its disposal is most necessary to have a good environment. The bagasse is used as biomass or raw materials to the paper industry to recycle it further. The paste mud is used as timber to the household works. The other effluents are the liquid effluents which can be treatments by sedimentation, filtration or coagulation and then, thrown to the river water so that the environment is less affected.

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Authors Profile

Sm. Arifur Rahman is now an undergraduate student of Department of Civil Engineering at Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh. During 2011-2013 he was researching on different types of biomass as a renewable energy for electricity generation and influence of treated water on early age autogenous shrinkage of cement paste. Currently, he is the leading research engineer of Basha Research Corporation (BRCROP).

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