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INDUSTRIAL WASTE WATER ANALYSIS: A CASE STUDY OF CHASHMA SUGER MILLs, D.I KHAN

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Abstract **-** Sustainability is one of the most important concerns of the world today. The concept of sustainable development is gaining popularity of all around the world in day by day in economic sector like construction, architecture, agriculture, water resource & public health engineering. Water is life of all human activities so sustainable usage of water is very critical. Waste water generate from industries are to be reuse in other purposes to maintain circular economy. To reserve natural resources, reduce, reuse and recycling of waste water are very important. This research is about Industrial waste water analysis of Sugar Mills. The waste water generating form various processing units of the mill are discharged into a nearby canal. The water of this canal is further used for various purposes of economy and social purposes e.g. for agriculture, drinking (animals), construction and by other aquatic life. The purpose of the research is to analyze this waste water to know whether it is hazardous or advantageous for above social and economic activities. Un-treated sewage is also responsible for contaminating of environment with harmful micro-organisms called pathogenic bacteria. This pathogenic bacterium causes serious diseases like cholera, typhoid, dysentery, dangi etc. Also the floating sewage of untreated sewage decomposes & creates unpleasant smell & odors in waste water. Grab samples of water were together from all the units and particular areas at regular intervals inside Mills. They were analyzed for physical perimeters (color, taste, odor, turbidity, Total dissolved solid), chemical parameters (Hardness, chlorides, alkalinity, PH values) and for Biological perimeters (COD, BOD). We compare the results of physicals, chemicals and biological tests with the environmental standards CFWQG and NEQS. Some of the results are within range but some are positive. It is recommended that appropriate water treatment system is to be planned to treat the waste water before entering to the canal or river to make the environment free from pollution.

Keywords- *Sustainability, water quality, public health, social well-being, circular economy, Chashma sugar Mills D.I khan.*

1 INTRODUCTION

1.1 PROJECT PURPOSE

The concept of sustainable development is increasing day by day in all areas of economic sector like construction, architecture, agriculture, water resource & public health engineering. Water is life of all human activities so sustainable usage of water is very critical. Waste water generate from industries are to be reuse in other purposes to maintain circular economy. To reserve natural resources, reuse and recycling of waste water are very important. The current research is about waste water analysis of "Chashma sugar Mill D.I khan" to protect the environment from negative impact & reuse the waste water as circular economy and for social well-being. Grab samples were collected from various units of mill discharging waste at regular interval. These samples, composed periodically, were inspected in environmental lab for physical, chemical and bacteriological analysis/aspects. The tests conducted were turbidity, alkalinity, TDS, Hardness, Chlorides content, PH, Alkalinity, COD and BOD. The results so obtained from these tests were compared with NEQS (National Environmental Quality Standards) and CFWQG (Canadian Federation waste water Quality Guidelines), and suggestions/recommendations were made accordingly. There are some factors which are necessary to study & also adopt a necessary actions to control their negative impacts on environment, social and economic pillar of sustainability. i) The floating sewage of untreated water decomposes & creates unpleasant smell & odors in waste water. ii) The large Amount of organic matter present in un-treated water starts consuming the dissolved oxygen. Due to less amount of oxygen in water fish start dying, so determining of BOD & COD is prime important. The emitted CO2 may also causes to increasing the carbon foot print & effect the environment. iii) Untreated sewage is also responsible for contaminating the source water with harmful micro-organisms called pathogenic bacteria. This pathogenic bacteria causes serious diseases like cholera, typhoid, dysentery, dingy etc.

iv) These water may further uses for animal drinking. It create stomach problem & affect the digestion process in case of larger alkalis. v) Depletion of oxygen causes death of aquatic life which affects the social human attraction. vi) Hard water may cause washing & cleaning problem by more soap consumption. vii) The canal water may further use for local construction e.g. brick masonry, plastering, curing etc. viii) Use for agriculture purposes as good fertilizer [1] [2] [3]. Keeping in view the highly contaminated nature of waste water discharged from sugar industries and its consequent toxic effects on human health, domestic animals, aquatic life, construction and agricultural crops, current studies were performed to overview the strategies used for the treatment of waste water of sugar industries.

1.2 BRIEF HISTORY OF CHASHMA SUGAR MILLS, GEOLOGY AND HYDROLOGY

Sugar is extensively utilized in everyday human life as a basic source of sweeteners, preservatives and energy. To conduct water analysis study, a brief historic background, current status and expected new direction in the study area are required. In our country there are 78 sugar mills, out of which 40 are in Punjab, 32 in Sindh & 6 in KPK. Its total installment capacity of sugar production is 5 million tons. The Chashma sugar mill is one of the oldest mill in Pakistan. It is spread over an area of 1200 canals. It is situated on Multan road in district DI KHAN and have an easy access to the market. Its daily production is 4000 Bags per day. The waste water discharge from various units of mill is found to be ½ cusecs or 0.535 mgd. The mill and all around area consist of alluvial soil along with clay and to some extent the mix also contain sand. The water level is generally low and the water requirements for the various units are accomplished by tube wells installed inside the mill. The waste water generated from mill is discharged to a nearby canal.

The major raw material for production of sugar and gur are the sugar crop. It is cash crops having main economy of our country depend on a value of 6.7 & 1.7 in agriculture and GDP respectively. Sugarcane is one of the main source of founding sucrose. For extracting the most purest sucrose among all the raw material, there will require some chemicals in refinery which ultimately causes wasted water. In 1st step Ca(OH)2 which are produced by conversion of CaCO3 to CaO or by direct from CaO are to be uses in initial clarification known as defecation. It is necessary to coagulate all the precipitated impurities as insoluble mass which can be easily separated. Second step is carbonation in which CO2 from wet scrubbing unit of boiler or from calcination of lime kiln is bubbled through the liquid for precipitated the remain impurities. In third step of clarification phosphoric acid is added with sugar mixture for remove impurities. In sulphitation process the melt sugar are treated with SO2 for decolonization which is obtain through burning of sulphar in rotary kiln. Polyelectrolytes are further mix up with solution to coagulate the impurities separated during defection and clarification. Furthermost lead sub acetate a toxic chemical are used for analyze the sugar content.

A symbiotic frame work is established which contains the by-products of sugar industry and works as source of energy manufacture and sustainable building material [4]. There are some major by-product obtain during sugar production process like bagasse, mud or filter cake & molasses. Bagasse are the residue of sugarcane fiber which are 30% of total sugar constituent. Baggage contain approximately 50% of moisture. It is used as fuel in the mills up to 90% heating the boilers. Bagasse also used in paper making and production of pulp. Mud or filter cake are solid precipitate accumulated in base of vacuum chamber after result of clarification and carbonation process. Mud obtained by the process of sulphitation and carbonation are 3% and 7% of cane respectively. Mud generate from sulphitation are mainly use for fertilizer but their disposal creates some serious problem. Often it can be dump in low lying areas. The third by-product obtain from sugarcane industry are molasses which is about 4.85% of sugarcane amount. It is uses for sweetener for cattle feed and for produce industrial alcohol.

1.3 NEED OF WORK:

Sugar industries release a variety of contaminants which are toxic for the environment [5]. The production of sugar from sugar cane brings about alarming environmental changes due to extraordinary water usage and greater chances of eutrophication [6] [7]. Increasing numbers of deaths of domestic animals have also been reported due to this polluted water [8]. Sugar mills play a central role in water, land and air pollution [9]. The untreated sugar industry effluent contains high amounts of COD, BOD, TSS, TDS, and low contents of DO. Hence the effluents characteristics need to be properly monitored for better environmental protection and without proper treatment it is not directly dispose into canal that effect surface water body, pollute ground water & agriculture land [10]. Sugar industry effluent (SIE) is characterized as high organic load [11]. The waste water discharged from mill through open channel (drain) into a nearby canal. This canal water is used for agricultural and for other usual purposes like animal drinking, and masonry works of construction etc. As for sugar production various chemicals are used, which are either toxic or non-toxic. These chemicals also discharged with the waste water into the canal. Some undesirable characteristics of waste water are:

- Some organic matter soluble in canal water may seriously causes depletion of oxygen.
- Trace organics and phenols causes tastes and odors.
- Heavy metals, cyanides and toxic substances are harmful to living groups.
- Color and turbidity create unaesthetic conditions in water bodies. As a result, oxygen availability and photo synthesis are also affected. Suspended solids impair normal aquatic life
- Oil and floating matter return to reaeration.
- Hot water discharges from factories act on solubility and affect bacteriological action.
- Acids and alkalis affect aquatic life.
- Inorganic material may give rise to various problems such as hardness and corrosion.

2.0 RESEARCH METHODOLOGY

The common parameters are presented for analysis so as to understand the basic procedures. Generally, physic-chemical and biological treatments are used to treat the sugar industry wastewaters [12].

2.1 PHYSICAL PERIMETERS

Physical parameters may be turbidity and total dissolved solids

Turbidity is the quantity of occupancy of colloidal particles. It may due to silt, clay and presence of microorganism. The amount of turbidity depends upon the type of soil over which this water has run and the velocity of water. **TDS** are the mixture of all organic and inorganic substances which are present in a molecular, ionized or micro-granular suspended form contained in a liquid.

2.2 CHEMICAL PERIMETERS

The chemical parameters to be analyzed are pH, Alkalinity, Hardness, Chlorides.

PH is defined as the logarithm of the reciprocal of the hydrogen ion concentration expressed in moles / liters. More simple, the pH value of water sample expresses its tendency to accept or donate Hydrogen ion on a scale of 0 (very acidic)-14 (very basic) and 7 (neutral or mineral water). The pH value represents the instantaneous hydrogen ion concentration rather than the buffering capacity or the total reserved as an acidity and alkalinity test. **Hardness** in water is the presence of multivalent cations that cause to form scales and resistance to soap. It has two types i.e. temporary hardness and permanent hardness. **Alkalinity** raises to the competency of water to neutralize acids. In the waste water the most common cause of alkalinity are due to presence of carbonates, bicarbonates and hydroxide. The type and level of alkalinity are directly consequence on the source of industrial waste water. A high level of alkalinity indicates the presence of strongly alkaline industrial waste. **Chloride** has a number of commercial and industrial applications and is used in the form of sodium chloride (NaCl) and calcium chloride ($CaCl_2$) are extensively used in industries. It is available in ionic and molecular form in waste water depending on the discharging unit.

2.3 BIOLOGICAL PERIMETERS

These paremeters are Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD).

COD is the amount of oxygen required by the strong oxidizing agent to completely oxidize the organic matter under acidic conditions. The BOD, the organic matter is not completely oxidized. Biologically degradable organic matter is only oxidized. But in COD both the bio-logically degradable and biologically inactive organic matter is oxidized, so COD is always more than BOD. **BOD** is the oxygen amount required for the microorganism (bacteria) existing in the waste water to convert the organic substance to stable inorganic compounds i.e. H2O and CO2. Its determination is very much important because it will give you the oxygen consumed. So if it is more it will have adverse effects on the aquatic life. i.e. Organic Substance + Oxygen +Bacteria ---------→ CO2 + H2O

2.4 SAMPLING

Sampling means collecting a representative portion of waste water from an area to ascertain its quality and characteristics. Waste water samples may be taken from treatment plants, disposal sites and in polluted rivers or soils. Grab samples were taken for analysis from the following selected localities of mill; i) Mill Water ii) Injection Water iii) Feed Water. ***Mill Water*** is coming from crushing unit of the Mill. It is that water which has been used in removing mud and clay attached to sugar cane also carrying oil and grease. It is usually sprinkled over the sugar cane in crushing plant. ***Injection water*** is used for cooling of boilers and after two or three cycles when it becomes dirty and hot, is discharged to the main drain of Mill. During circulation through boilers in pipes, it gets polluted due to leaching and corrosion of pipes. ***Feed water*** is mixture of distilled water in combination with various chemicals like NaCl and NaOH etc, used for purification purpose. All the drains carrying these three types of water, combined together in a single drain leading to the nearby canal.

Sampling is one of the most basic & very important phase/aspect for analysis of waste water. The significance of waste water analysis mostly depends on sampling procedure. Samples should be collected sensibly for analysis to make sure that the most representative model is obtained. As possible to minimize the effects of drainage system the samples should be taken as closely to source of discharge. The sample container should be filled slowly, to avoid air bubbles. Generally as little time as possible should elapse between collecting the sample and making analysis. Depending on the nature of test, special precautionary measures in handling the sample also may be necessary to prevent natural interference such as organic growth or loss or gain of dissolved gases. Waste water samples are taken in glass bottles or in plastic bottles pre- cleaned with vim or washed many times with tape water, dipped with HCl (conc.) and again washed with tape water and finally with distilled water before the bottles were dried. Different sampling procedures were employed for different types of water and all necessary precautions were taken. To obtain an accurate results the samples should be analyzed on the same day.

Figure 1: Feed water sprinkling in Mill

Figure 2: Injecting water for cooling in atmosphere

Figure 3: Mill water discharging from Mill

Figure 4: Combine (Feed + Mill + Injecting) water discharging from Mill

2.5 EXPERIMENTAL TESTING*:*

a) Physical test (Turbidity & Total Dissolved solid)
b) Chemical test (PH, Hardness, Alkalinity, Chlorides)
c) Biological test (BOD and COD)

3.0 RESULTS & FINDINGS

In this chapter we compare the results of each parameter with international Canadian Federation Waste Water Quality Guidelines (CFWQG) and also with National Environmental Quality Standards (NEQS) of Pakistan.

3.1 PHYSICAL PARAMETERS

Turbidity level of waste water of Chashma Sugar Mill is presented in Table 1. Its value is maximum for mill water i.e. 106 NTU and minimum for feed water i.e. 12.8 NTU, and the combined average result of all the three samples is within the range of both NEQS and CFWQG standard. If the value is not in standard range it will affect the process of photosynthesis (plants, algae & bacteria). The value of this TDS is listed in table 2. The value was found to be maximum for mill water i.e. 800 mg/lit and minimum for Feed water i.e. 340 mg/lit. The average result is 535 mg/lit which lies under the range of both standards. The higher value cause the following affects.

- Dissolved solids forming a scum on the water surface affecting reaeration.
- Oil and grease also clog and interfere in treatment units.

Table 1-Result of Turbidity test

Sample	Turbidity (NTU)	Combine drain (NTU)	CFWWQG (NTU)	NEQS
Feed water	12.8			
Mill water	106	71.9	20-140	15-2000
Injection water	97			

Table 2-Result of Total dissolved solid (TDS) test

Sample	TDS (mg/lit)	Combine drain (mg/lit)	CFWWQG (mg/lit)	NEQS (mg/lit)
Feed water	340			
Mill water	800	535	1500-2000	3500
Injection water	465			

3.2 CHEMICALS PARAMETERS

The PH values of different samples are written in table 3. The maximum value was 9.16 for Feed water and 7.06 for mill water. The average value lies within the range of mentioned guidelines. pH is important parameter to be found for waste water due to corrosion control, biological process , seal formation in boilers, disinfection and Chemical coagulation . In Table 4 the total Hardness values of the samples are found to be maximum for Mill water i.e. 480 mg/lit as CaCO3 and minimum for Feed water i.e. 160 mg/lit as CaCO3. Hardness of all the samples examined and was found well within acceptable level of NEQS but don't satisfy CFWQG standards. Higher values will cause scale formation in hot water boilers and also effect skin. The Alkalinity value is found in table 5 & its maximum value for Feed water i.e. 260 mg/lit and minimum for Injection water i.e. 180 mg/lit. The average result (220 mg/lit) is out of range of both NEQS (200 mg/lit). Alkalinity value in standard range is required for proper chemical reaction in WWTP and having same effects like acids. The values of different chloride samples are written in table 6. The maximum value is found 675.11 mg/lit for Mill water & minimum for Feed water which is 410.94 mg/lit. The avg: result is 538.13 mg/lit which is in well accepted range of NEQS i.e. 1000 mg/lit. If it exceeds the standard value, causes corrosion of various metals used in water handling systems.

Table 3-Result of PH test

Sample	PH	Combine drain	CFWWQG	NEQS
Feed water	9.16			
Mill water	7.06	7.87	6-9	6-10
Injection water	7.41			

Table 4-Result of Hardness test

Sample	Hardness (mg/lit)	Combine drain (mg/lit)	CFWWQG (mg/lit)	NEQS (mg/lit)
Feed water	160			
Mill water	480	346.76	112-152	368-1050
Injection water	400			

Table 5-Result of Alkalinity test

Sample	Alkalinity (mg/lit)	Combine drain (mg/lit)	CFWWQG (mg/lit)	NEQS (mg/lit)
Feed water	260			
Mill water	220	220	NA	200
Injection water	180			

Table 6-Result of Chlorides test

Sample	Chlorides (mg/lit)	Combine drain (mg/lit)	CFWWQG (mg/lit)	NEQS (mg/lit)
Feed water	410.94			
Mill water	675.11	538.13	NA	1000
Injection water	528.35			

3.3 BIOLOGICAL PARAMETERS

The COD value is found maximum for Injection i.e. 184 mg/lit and minimum for Feed water i.e. 143mg/lit in table 7. The average result (165.66 mg/lit) is out of range of both NEQS (150 mg/lit) and CFWQG (80mg/lit), its excess will cause more oxygen consumption and will cause danger for aquatic life. Hence proper treatment must be done to bring it with in the permissible limits. The BOD value is found maximum for Mill water i.e. 152 mg/lit and minimum for Feed water i.e. 70 mg/lit in table 8. The average result (112.33 mg/lit) is out of range of both NEQS (80 mg/lit) and CFWQG (20mg/lit), Hence the water must be recommended for proper treatment before being disposed into the canal.

Table 7-Result of COD test

Sample	COD (mg/lit)	Combine drain (mg/lit)	CFWWQG (mg/lit)	NEQS (mg/lit)
Feed water	143			
Mill water	170	165.66	80	150
Injection water	184			

Table 8-Result of BOD test

Sample	BOD (mg/lit)	Combine drain (mg/lit)	CFWWQG (mg/lit)	NEQS (mg/lit)
Feed water	70			
Mill water	152	112.33	20	80
Injection water	115			

4.0 DISCUSSION:

The reduction of 75.6% of COD and 79.2% of color content of sugar industry waste water with thermal treatment, and 97.8% of COD and 99.7% of color with combined thermal and electrocoagulation treatments under optimum conditions [13]. Sugar industry does not produce harmful chemical materials, which alter the physicochemical and biological property of the surrounding environment if proper technology can be implemented. Therefore industry is considered as a zero discharge system. The outcome of the study is that from raw to end product of sugar processes have many challenges and require proper management, otherwise causes a major effect on the environment [14]. It has been proved experimentally that adding ferric salt which works as chemical coagulant, 98% reduction in COD and 99.7% color removal in sugar waste water were noted [15].
The present research was undertaken with a view to study the extent of hazards contaminants in the waste water of chashma sugar mills. The residence of area around chashma sugar mill used this contaminated water for agriculture, animal drinking and for masonry work. The people of area are unaware whether the canal water is suitable for the above mentioned usage or not. So we planned to conduct the waste water analysis, discharging from various units of the mill, leading to the canal. For this purpose three locations in the Sugar Mill were selected which were Boilers (discharging Feed water), injection system (discharging injection water, used for cooling the boilers, circulating during the sugar processing) and from crushing plant (discharging Mill water). The parameters monitored were turbidity, TDS, PH, hardness, alkalinity, chlorides, COD and BOD. In current research work the physical aspects (Turbidity & Total dissolved solid) are found within range of CFWQG & NEQS. In chemical perimeters PH, hardness and chloride are found within standards, only alkalinity is found out of range. Biological aspects (BOD & COD) both are found out of standards.

5.0 CONCLUSIONS & RECOMMENDATION*:*

An experimental research has been conducted to know about quantitative measurement of waste water contamination of chashma sugar mills DI khan. All the physical and chemical parameters are found within the permissible range of NEQS and CFWQG guidelines values. However both the bacteriological (COD and BOD) and also one chemical (alkalinity) parameters were found in excess from standards. It is however concluded that the water used for agricultural and masonry works have no worst affect, but it is dangerous for aquatic life. Excess alkali in water causes dysentery and stomach problem for animal. Keeping in view all the results, some impotent suggestion/recommendation are made.

- Tests should be conducted on regular basis or at equal intervals so that the cause is known and remedial measures are taken.
- Local waste water treatment plants should be installed to treat the water before discharging into canal.
- Old or rusted pipes in water handling system inside the mill should be replaced by new one.
- Residents of the area should be educated to use the canal water for agricultural and other purposes.
- The use of oil and grease should be according to the requirements; otherwise skimming tanks should be used if affordable.
- Flow meter is also necessary for inlet and outlet discharge of waste water.
- Required amount of chemicals should be used for sugar processing in each unit.
- Circular economy will enable the earth for continue support human life of coming generation.

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