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Wastewater Treatment Facility of HIDECO Sugar Milling Company (HISUMCO) In Kananga, Leyte Philippines: A Key to Environmental Management

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Abstract: *A sugar manufacturing industry in Kananga Leyte, discharges 3020 m^3 of wastewater daily. The raw wastewater has a very high pH (12), contains a lot of suspended solids (1500 mg/L) and has a very high oxygen demand for biological degradation of organic and inorganic microorganism. This waste if discharged untreated would harm the environment. The BOD-COD ratio of the raw wastewater; it appears that the water is composed of highly biodegradable organic matters that an application of a biological treatment process like an activated sludge process is highly suitable. From the comparisons between the effluent parameters values and the respective DENR effluent standards, it was drawn out that HISUMCO effluent has passed the DENR's standards; therefore, HISUMCO wastewater treatment facility in the form of an activated sludge is efficient in treating their highly organic wastewater from sugar processing with an overall plant efficiency of 98.5%.*

Keywords: *Activated sludge, biological treatment, BOD, biological degradation, Philippines*

1. Introduction

In the 21st century of World Commission on Water affirmed “More than one-half of the world's major rivers are being seriously depleted and polluted, degrading and poisoning the surrounding ecosystems, thus threatening the health and livelihood of people who depend upon them for irrigation, drinking and industrial water.”

In the Philippines, the Committee on Ecology of the House of Representatives has drafted the “Philippine Clean Water Act” whose purpose is to prevent, control and abate water pollution by applying both command and control regulatory methods with economic instruments The new statute provides for a water quality management system, institutional mechanisms, incentives program and liability and penalty provisions including citizens suits.

The Clean Water Act mandates the Department of Environment and Natural Resources (DENR) to implement a comprehensive water quality management program to guarantee effective water utilization and conservation. The DENR will serve as the primary government agency responsible for the implementation and enforcement of the Act, in coordination with the local government units, and other government agencies.

Although the Phil. Clean Water Act of 2004 has come into existence, evaluation on the capability of the wastewater treatment facility is very important to effectively manage the operation. The choice was based on the existing waste water treatment facility inside the HISUMO Sugar Industry, which is the area of the study.

Wastewater is treated to stabilize the waste material, that is, to make it less putrescible. The effluent from the waste water treatment plant may be discharged into receiving body. In the case of HISUMCO wastewater treatment plant, effluent is the non-potable water source of locators after domestic wastewater has undergone several stages of treatment operations.

Thus, this study was made to assess the capability of the HISUMCO Wastewater Treatment Plant (WWTP) in treating raw wastewater in which effective and efficiency of the treatment process has to be known. The outcome of the study would provide baseline information about the capability of the industrial wastewater treatment facility.

2.1. Statement of the Problem

The researcher conducted a study to investigate the stages of wastewater treatment operation due to the need of understanding the capability of HISUMCO WWT Plant.

Specifically, the study sought to answer the following sub-problems:

a. Characterize wastewater going into the treatment facility (influent) and its effluent in terms of the following parameters: pH, TSS, BOD5 and COD

b. Evaluate the existing aeration tank capacity in terms of the following parameters: retention period, organic loading, and sludge loading treatment plant

c. Determine the efficiency of HISUMCO WWTP.

2.2. Significance of the Study

This study provided data and information to enhance operational controls. The findings provided also a better understanding of the process and documentation of HISUMCO WWT technology and generated insights and baseline data that helped other wastewater treatment facility in evaluating the capability of the treatment technology.

2.3. Schematic Diagram

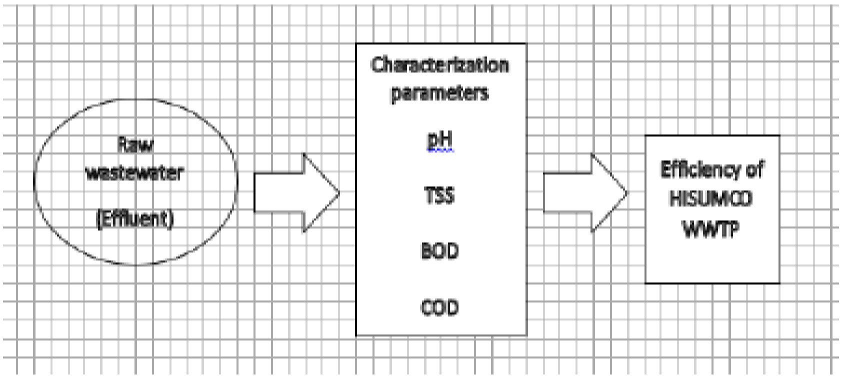

Fig1. *Schematic diagram in determination of the efficiency of HISUMCO WWTP*

2. METHODOLOGY

a. A letter of request submitted to the Management of HIDECO Sugar Co., allowing the researchers to conduct a study related wastewater treatment facility.

b. Conduct and perform a laboratory experiments on the characterization of wastewater

c. Gather necessary data and information relevant to the study

d. Have an ocular inspection on the site and perform other trials to gain more accurate and precise data.

e. Tabulate, analyze and interpret the data obtained

f. Made a conclusion and recommendation

3. RESULTS AND DISCUSSIONS

The wastewater from different industrial plants must be treated and the characteristics of the treated effluent should meet the following DENR standards.

As shown from the Table 1.1, there is no exact standard for the color of the effluent provided that it doesn’t cause abnormal discoloration on the receiving waters outside of the mixing zone. It should be noted that the DENR does not have standards for the primary treatment of wastewater. This might be due to the fact that it is the effluent, which is considered as the final product of wastewater treatment that mixes and combines with the receiving body of water. If not treated well, this becomes a serious threat to public health and safety and to the environment as a whole. Aside from requirement, these effluent standards are also very important to all wastewater treatment plant operators since this will serve as the basis for their desired effluent quality.

Table 1.1 **DENR LIST OF EFFLUENT STANDARDS**: Conventional and other Pollutants in Island waters (Class D), Coastal Waters (Class SC), and SD and other Coastal Waters (Class SC), and SD and other Coastal Water not yet classified.

Parameters	Unit	Island Waters (Class D)		Coastal Waters (Class SC)		Class SD and other Coastal waters not classified	
		OEI	NPI	OEI	NPI	OEI	NPI
Color	---	---	----	A	A	A	a
Temperature (max. rise in °C in RBW)	°C	3	3	3	3	3	3
COD	mg/L	250	200	250	200	300	200
5-day BOD at 20°C	mg/L	105	120	120	100	150	120
TSS	mg/L	200	150	200	150	B	c
pH	---	5-9	6-9	6-9	6-9	5-9	5-9

Legend:

a – Discharge shall not cause abnormal discoloration in the receiving waters outside the mixing zone.
b –not more than 60 mg/L increase (dry season)
c – not more than 30 mg/L increase (dry season)
OEI – refers to Old or Existing Industry
NPI – means New/ proposed Industry or Wastewater Treatment plants
RBW – receiving body of water

As shown in Table 1.2, the comparison between HISUMCO effluent and DENR effluent standards, it can be drawn out the plant's wastewater treatment have passed the requirements.

Table 1.2 Comparison of values of the parameters analyzed with the DENR standards.

Parameters	Units	HISUMCO Effluent	DENR Standard	Remarks
Color	-	Cloudy white	It must not cause abnormal discoloration in the receiving water outside the mixing zone	PASSED
Temperature	°C	30	Max. of 3°C rise in the receiving body of water	PASSED
pH	-	7.0	6 – 9	PASSED
BOD_5	mg/L	65	120 – 150	PASSED
COD	mg/L	200	250	PASSED
TSS	mg/L	55	200	PASSED

Analysis of the raw wastewater

A. Data for COD, BOD_5, Temperature, pH and color

Sample	Temperature, °C	Color	pH	COD, mg/L	BOD_5, mg/L
Raw wastewater	60	Coffee brown	12	10,000	4348.33

B. Data for TSS

Sample	Volume (ml)	Constant weight of filter paper (mg)	
		Before	After
Raw wastewater	15	9.5	35

		Low	med	high	DAO 35, Class D
Reference	BOD (ppm)	100	200	300	105
	COD (ppm)	250	500	1000	250
	TSS (ppm)	200	500	1000	200
	pH		6.5 – 8.5		6.0 – 9.0

Analysis of the wastewater samples inside the Aerator Tank

A. Data for BOD_5, COD, Temperature, pH and Color

Sample	Temp., °C	Color	pH		BOD_5		COD	
			Before	After	Before	After	Before	After
Processed wastewater	30	Light brown	8.4	7.6	710	213	1000	450

Determination of rate constant, k for the wastewater inside the Aerator Tank and Clarifier

As shown in Tables 1.3 and 1.4 are used to evaluate the rate constant k inside the aerator tank and clarifier. Its values are computed from the COD values measured at various times using the Thomas method. These data, along with the COD values are plotted in the Figure 1.3.

Table 1.3 Data results from the samples in **COD (mg/L)**

Sample	COD (mg/L)			
	Day 1	Day 2	Day 3	Day 4
Influent	800	960	980	1000
Effluent	305	360	400	450

Table 1.4 Data results from the samples in **$[Time/COD]^{1/3}$**

Sample	$[Time/COD]^{1/3}$			
	Day 1	Day 2	Day 3	Day 4
Influent	0.1077	0.1014	0.1006	0.1000
Effluent	0.1486	0.1406	0.1357	0.1305

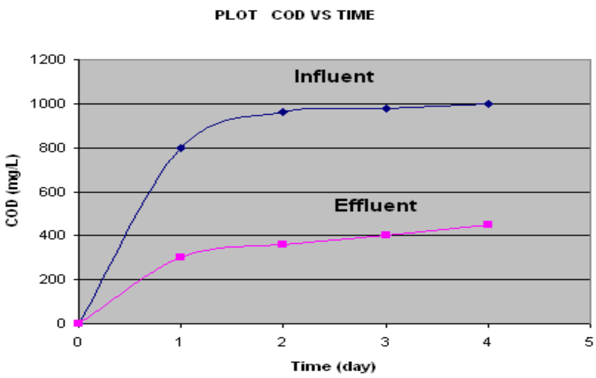

Fig1.2. *Graphical Analysis of COD (mg/L) vs Time (day)*

As shown in Figure 1.3 illustrates a graphical method for determining the value of k (1 /day) by plotting the values of the cube root of time in days over COD in mg/L, which are used to obtain from figures and the corresponding time. A line from these points is used to calculate the k-value. It was found out that the results of the calculations of the k-value from the aerator is 0.05778 and is almost 50% lower than the k-value of the clarifier which is 0.1001/day.

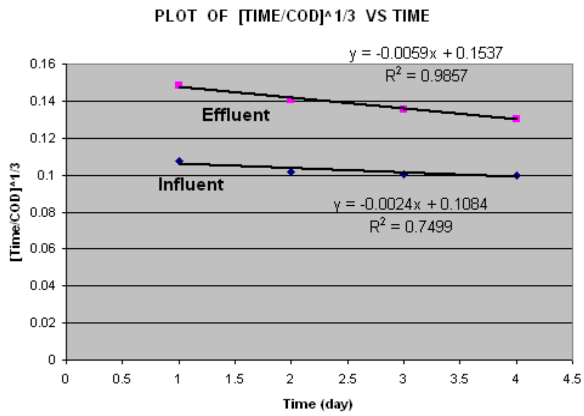

Fig1.3. *Graphical methods for determining the value of K (1/day)*

Thus summary of aeration tank parameter results as shown in Table 1.5

Table 1.5: Summary of Aeration Tank Parameter Results

Item	Parameter	HIDECO	REFERENCE
	pH	7.6	6.5 – 8.5
	Temperature , °C	30	3° max. rise
	DO	5.7	2
	COD (mg/L)	450	250
	BOD_5 (mg/L)	213	105
Aeration Tank	Retention Period (hr)	12.96	6 - 8
	TSS (ppm)	64	200
	Sludge work (Kg-hr/m^3)	0.829	8 -12
	Organic Loading (Kg BOD_5 /m^3-d)	0.120	1 - 2
	Sludge Loading (Kg/Kg-d)	1.88	0.1 – 0.4
	Efficiency, %	69.48	

Retention Period. Typical activated sludge process is usually designed 6 to 8 hours retention period. BOD removal is not further increase with increasing retention time beyond 8 hours. HISUMCO aerator's tank retention period of 12.96 hrs appears to be 2 times longer than required aeration time. This clearly indicates that it can handle 2 times more volume of incoming wastewater.

Organic Loading. Organic loading shows the daily BOD load per reactor volume with the computed value in Appendix D of 0.120 is approximately 12 -13 times lower than the reference data of 1 – 2 Kg BOD / m^3*d. Typical design capacity of an activated wastewater plant would have an organic loading value of approximately 1 - 2 Kg BOD/ m^3*d so that the size of the aerator tank would be balance with the incoming organic load. HISUMCO organic loading result also indicates that the WTP is not fully utilized to its designed wastewater treatment performance. The low organic loading is due to low strength wastewater and the large aerator tank volume capacity.

TSS. Fundamentally, high concentration of bacteria is needed for the fast breakdown of organics in the water. Figure shows that the higher TSS value; the better will be the BOD removal. HISUMCO's TSS value of 64 mg/L is 3 times lower than the reference of 200 ppm which is the target to maintain the best possible activated sludge performance in terms of BOD removal. The low sludge concentration is due to low strength wastewater.

Sludge Loading. Sludge loading which shows the daily BOD load per sludge TSS in aerator tank with the computed value in Appendix of 1.88 is considerably higher than reference of 0.1 to 0.4. Even though the incoming wastewater is low strength and with enough supply of DO, a high sludge loading value has resulted due to low TSS that would relate to the poor BOD removal efficiency of 69.48% as computed in Appendix. The sludge loading result would correlate also to the relatively high BOD effluent.

Sludge Work. Sludge work of 0.829 Kg h /m^3 as computed in Appendix is below the typical target of around 8 to 12 Kg h /m^3 to achieve about 90% removal of pollution BOD as shown in figure. While the aeration time is found to be long at 12.96 hours, the very low sludge concentration is the cause for low sludge work.

Dissolved Oxygen. This measured to ensure that DO is not limiting factor on the performance of the treatment process. DO inside aerator tank with an average value of 5.7 is approximately 3 times higher than reference of 2 ppm. The result explains that the aeration tank has more than enough amount of DO to prevent oxygen deficiencies form the limiting the rate of substrate removal.

The wastewater parameters inside the aerator tank are presented in Table 3.5

Table 3.5: Average values of the wastewater parameters inside the aerator tank.

Parameters	Unit	Influent	Effluent
Color	-	Light brown	Cloudy colorless
Temperature	^{0}C	60	30
pH	-	8.4	7.0
COD	mg/L	450	350
BOD_5	mg/L	213	65
TSS	mg/L	64	55
k	1/day	0.05778	0.1001

In Table 3.5, it summarizes the performance of the wastewater treatment facility inside the aerator tank. It reduces the strength of highly organic waste from an initial BOD_5 of 213 mg/L; it reduces to 65 mg/L.

From the original pH of 12, it decreases to 8.4 and finally 7.0. The color also improves form coffee brown to light brown then to cloudy white effluent. The final color is more or less the same as that of the receiving body of water. This would mean that the effluent, when discharged would not cause severe discoloration to the receiving body of water. And also, temperature change from the effluent does not exceed 3^{0}C rise from the receiving body of water. The temperature range is within the range of 29 – 30^{0}C.

COD is also reduced from 10,000 mg/L to 450 mg/L and to a final concentration of 350 mg/L. This is how relatively high % removal of 55 in the final effluent.

TSS also decreases from an initial wastewater concentration of 1,500 mg/L to 200 mg/L and a final concentration of 55 mg/L.

4. Summary, Conclusions and Recommendations

4.1. Summary

1. There are several effluent standards set by the DENR that should be met by all existing and /or newly proposed plants. This is shown in Table 3.1. These standards are the basis for the designed effluent quality of a plant.
2. The raw wastewater of HISUMCO was found to a very high, contains considerably large amount of suspended solids and demands a lot of oxygen for biological degradation. It was also found out that this raw wastewater is biodegradable that an application of a biological treatment process is highly suitable.
3. From Table 1.2, it was found out that the effluent of HISUMCO has passed the DENR's maximum effluent standards.

4.2. Conclusion

There are several wastewater parameters that are used in determining the strength of an industrial waste. The common ones are the Biological Oxygen Demand, the Chemical Oxygen Demand, color, temperature, pH, and the total suspended solids (TSS).

Several effluent standards are set by the government through the Department of Environment and Natural resources (DENR) that should be followed by all existing and/or newly existing plants.

The effluent standards for the existing plants are the ff.

BOD_5 – not more than 120 mg/L

COD – not more than 250 mg/L

Color – shall not cause abnormal discoloration in the receiving waters outside of the mixing zone.

Temperature – a maximum of 3 ^{0}C rise in the receiving body of water.

pH – within the range of 6.0 – 9.0

TSS – not more than 200 mg/L

HISUMCO, a sugar manufacturing industry in Kananga Leyte, discharges 3020 m^3 of wastewater daily. The raw wastewater has a very high pH (12), contains a lot of suspended solids (1500 mg/L) and has a very high oxygen demand for biological degradation of organic and inorganic microorganism. This waste if discharged untreated would harm the environment.

From BOD-COD ratio of the raw wastewater; it appears that the water is composed of highly biodegradable organic matters that an application of a biological treatment process like an activated sludge process is highly suitable.

The treatment of the raw wastewater in the reactor system greatly decreases the strength of the waste with the aid of the microbial activity. The biological oxygen demand decreases from an initial value of 710 mg/L to 213 mg/L and final concentration of 65 mg/L or a 69 % BOD removal efficiency. The pH, color, total suspended solid and the chemical oxygen demand also decreases.

From the comparisons between the effluent parameters values and the respective DENR effluent standards as listed in Table 3.6, it can be drawn out that HISUMCO effluent has passed the DENR's standards; therefore, HISUMCO wastewater treatment facility in the form of an activated sludge is efficient in treating their highly organic wastewater from sugar processing with an overall plant efficiency of 98.5%.

4.3. Recommendations

Since activated sludge process is efficient as wastewater treatment, it is therefore recommend that the system should be well maintained by desludging it once every 4 to 5 years, cleaning the surroundings of the system and removing any scum's present. The system should also be well maintained by inspecting it every now and then, and fixing it if necessary.

Inefficiency of the system could be caused by overloading the system with wastewater. It is therefore recommend that the discharge waste should not exceed the capacity of the system.

Overabundance of filamentous organisms present in the mixed liquor in the activate sludge process can cause biological flocs in the reactor to be bulky and loosely packed. But to control of filamentous organisms can be accomplished in several ways. 1. addition of chlorine or hydrogen peroxide to the return waste-activated sludge; 2. alteration of the dissolved oxygen concentration in the aeration tank 3. addition of major nutrients (i.e. nitrogen and phosphorus).

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