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WASTEWATER MANAGEMENT PRACTICES OF HEAVY INDUSTRIES IN LEYTE, PHILIPPINES

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ABSTRACT

The study was conducted to determine the wastewater management practices employed by six (6) identified heavy industries in Leyte for Calendar Year 2003 - 2007. Using descriptive method of research, particularly the case study approach, it utilized questionnaire, interview, inspection and document analysis to gather data from 12 pollution control officers or technicians from the industries and two (2) technical personnel from the Environmental Management Bureau of Leyte, Philippines.

The Industries produced huge amounts of wastewater, but maintained tolerable levels of wastewater characteristics and water quality after treatment.

The quantity of effluent discharges can be tolerable to the environment if their physical and chemical characteristics are within the allowable limits. The tolerability of wastewater effluent characteristics or qualities depends on the suitability of the available treatment technology and facilities. The sustainability of the industrial manufacturing operations depends on the capability of the utilized wastewater treatment facilities and technology to reduce or eliminate hazardous manufacturing by-products. The dynamic leadership of the Pollution Control Officers and full support from the Administration of the Industries could greatly advance the capabilities of their existing wastewater treatment technologies and could prevent the occurrence of wastewater management problems.

The quantity of effluent discharges did not measure the wastewater characteristics and qualities. Tolerability of wastewater effluent characteristics and qualities depended on the suitability of selected treatment plant and facilities. Sustainability of the industrial manufacturing operations depended on the capability of the utilized treatment plant type and technology in reducing or eliminating hazardous manufacturing by-products. Dynamic leadership could greatly improve the capabilities of the Industries' Pollution Control Offices.

KEYWORDS: heavy industries, industrial manufacturing operations, wastewater treatment technology, wastewater influent and effluent, pollution control officers, Environmental Management Bureau.

INTRODUCTION

Wastewater management encompasses a broad range of efforts that promote effective and responsible water use, treatment, and disposal and encourage the protection and restoration of our nation's watersheds. It also includes waste-water treatment plant designing, erection, commissioning and annual maintenance, sewage treatment, industrial effluent treatments and it requires general awareness (Sai BioCare Pvt. Ltd, 2008).

The rapid growths of the population, the technological and industrial boom have brought enormous problems and degradation of the environment. Effective collection and treatment of urban wastewater is a critical problem in a developing country. Water resource development has taken place all over the world and that protecting the surface water resources from wastewater pollution plays a vital role for the development. The disposal of wastewater into the surface water bodies leads to serious problems and affects the people in health aspects (Muthukumaran and Ambujam, 2003).

Metcalf and Eddy(1991) said that if untreated water is allowed to accumulate, the decomposition of the organic materials it contains lead to the production of large quantities of malodorous gases. Usually it contains numerous pathogenic or disease-causing microorganisms that dwell in the human intestinal tract or that may be present in certain waste. Wastewater also contains nutrients, which can stimulate the growth of aquatic plants, and it may contain toxic compounds. For these reasons, the immediate and nuisance-free removal of wastewater from its sources of generation, followed by the treatment and disposal, is not only desirable but also necessary in an industrialized society.

A study by the Japan International Cooperation Agency (JICA) conducted in 2001, as cited in National Economic Development Authority's Medium Term Philippine Development Plan 2004-2010, states that around 700 industrial establishments in the Philippines generate about 273,000 tons of hazardous wastes per annum. It was further estimated that with 5,000 potential hazardous waste generators, about 2.41 million tons of hazardous wastes will be generated (Greenpeace Report, 2007).

"Pollution prevention" and "waste minimization" practices are being introduced to address the problems on water pollution, especially chemical pollution. Traditionally, effluents and emissions discharged by most manufacturing firms in the country into the air, waterways, ground water and land are given end-of-pipe treatment characterized by the collection of waste material, and applying treatments such as dilution, detoxification, solidification, and in many cases, containment of the pollutants in barrels and placing them in landfills (USAID, 2000). Projects such as the Industrial Environmental Management Project (IEMP) are designed to reduce pollution at its source by improving "industrial housekeeping", or changing industrial production processes, and reducing and reclaiming industrial waste. These also promote the adoption of cost-effective pollution abatement technologies. The Department of Science and Technology, through its Integrated Program on Cleaner Production Technologies, encourages the adoption of clean technologies by providing support mechanisms for the industrial sector for the identification, evaluation, selection, and acquisition of cost-effective technologies for cleaner production. Part of government's response to the problem is the formulation of various policies, monitoring and analysis, researches, and capacity building among key stakeholders as part of their regular functions, and through the different programs implemented by concerned agencies (Greenpeace Report, 2007).

The Environment Management Bureau (EMB) of the Philippines under the Office of the Department of Natural Resources (DENR) monitored 196 inland surface waters for the period 2001 to 2005: 192 rivers and four lakes. Of the 196 monitored water bodies, only 127 met the required four sampling events and were included in the analysis. Forty percent recorded fair water quality, which means that the water bodies partially comply with the designated water quality criteria but do not support its intended beneficial use in 50 to 97.99 percent of sampling instances (Greenpeace Report, 2007).

Gaylican (2007) said that data in the Philippine Environment Monitor (PEM) 2004 issue, 15 rivers nationwide have dissolved-oxygen at or below zero, indicating that they are "dead" during the dry months. From the result of the 2005 Tapwatch Monitoring Program by the EMB, out of the 88 wells monitored in depressed areas in the country, the project found 21 sites with potable groundwater, while 27 sites were found to be contaminated with fecal coliform. The sampling sites found not potable are located in nine (9) Regions, one of which is in Leyte in Region VIII (EMB, 2006).

Eastern Visayas was dubbed as the geothermal capital of the Philippines for its abundant geothermal power reserves. The Tongonan Geothermal Plants in Tongonan, Ormoc City, also known as the Leyte Geothermal Power Field (LGPF), is the second geothermal power producer in the world. The region also houses two of the country's top dollar earners: the Philippine Phosphate Fertilizer Corporation (PHILPHOS) and the Philippine Associated Smelting and Refinery Corporation (PASAR) (NSCB-Regional Statistical Coordination Unit VIII, 2016).

Leyte shaped itself to become the center of commerce and industry in Region VIII. The presence of industries coupled by the tremendous increase in population caused evident water pollution, despite the issuance for quite considerable number of years of the Clean Water Act and other Anti-Pollution Legislations.

It was in this context that the researcher intended to assess the wastewater management practices of the identified heavy industries in Leyte, Philippines by looking into the profile of the Industries' wastewater and the availability of wastewater treatment technology or facilities. Problems the industries encountered related to wastewater management were also determined. The results of the study were the basis for forwarding recommendations to improve the wastewater management practices for the industries.

MATERIALS AND METHODS

The study utilized the descriptive method of research, particularly the case study approach. This involved an in-depth study of the wastewater management practices in heavy industries of Leyte. It involved description, recording, analysis and interpretation of the conditions that existed within a period of five years (2003 – 2007).This study was conducted in the identified heavy industries in Leyte. The companies were coded to protect their identities.

Company A was the leading producer of copper cathodes in the country. Company B had been producing phosphatic fertilizers. Company C was involved on the distribution and bottling services for soft drinks. Company D was another soft drink manufacturing company. Company E was one of the suppliers of sugar and molasses in the country. Company F was into alcohol production, supplying leading alcohol companies in Cebu.

The research respondents were the 12 wastewater engineers or pollution control technicians employed by C, D, E and F industries and two (2) EMB, DENR personnel. Industries A and B did not permit the researcher to conduct the study due to their standing company policy of prohibiting such kind of study. The data for the two (2) industries were taken from EMB documents and wastewater laboratory test results.

The questionnaire was the main tool used in the gathering of data which was already conducted and validated by Ceriaco (1996) in his study "Technology Applications and Management of Wastewater in Selected Industries of Cebu City". Part I was on the profile of the respondents. Part II was on the profile of the Industry in terms volume of effluent discharged per day, wastewater quality before and after treatment, and availability of wastewater treatment technology or facilities. Part III was the problems related to wastewater management encountered by the heavy industries in Leyte.

Before the full implementation of the study, the researcher personally asked permission from the Regional Director of the Department of Environment and Natural Resources (DENR) to conduct the study and to obtain laboratory test/analysis results for wastewaters from the heavy industries from its sub-Office, the EMB. Permission was then sought from the chief executives of the identified industries, with an attachment of authority from the Regional Director of the EMB, DENR, Region VIII. During the distribution of the questionnaires, interviews and/or discussions were undertaken with the Pollution Control Officer of each Industry; and inspection of the industries' sewage treatment plants were done to gather information regarding the condition and operations of wastewater management. The discussions or interviews were employed to gather firsthand information to validate answers to questions included in the questionnaire. Additional information were gathered from the EMB, DENR personnel and from their wastewater test/analysis reports for the heavy industries.

Descriptive statistics such as frequency and ranking were used to describe the problems related to wastewater management encountered by the six identified heavy industries in Leyte.

The study aimed to determine the profile of the Industries in terms of the volume of effluent discharged per day, wastewater quality before and after treatment, and the availability of wastewater treatment technology or facilities. It also looked into the problems related to wastewater management encountered by the six identified heavy industries. The results of the study were the basis for forwarding recommendations to improve the wastewater management practices for the industries.

RESULTS AND DISCUSSION

This section presents the profile of heavy industries in Leyte in terms of the volume of wastewater generated per day, wastewater quality before and after treatment, and the availability of wastewater treatment facilities.

Profile of Industry:Volume of Wastewater. The data presented in Table 1 below divulge the condition of wastewater effluents of the six identified industries in terms of volume in cubic meters per day. These data were obtained from the questionnaire, which were accomplished by the respondents, and were also found in the Monitoring Report prepared by EMB, DENR from January to December of Calendar Years 2003-2007. The standards used in rating wastewater quantity was the Revised Effluent Regulations of 1990, revising and amending the Effluent Regulations of 1982 of the Department of Environment and Natural Resources, Environmental Management Bureau. Where specific type of Industry was unknown, an allowance of 50 cu.m./day/hectare was often used, however the Effluent Standards apply to industrial manufacturing plants and municipal treatment plants discharging more than 30 cubic meters per day.

Table 1. The Profile of Industries in Terms of Volume

Name of Industry	**Wastewater Effluent Generated Per Day in Cubic Meter**	**Condition**
A	362, 147	AA
B	5.728 x 10^8	AA
C	524, 826	AA
D	358, 674	AA
E	2, 840.35	AA
F	240	AA

Legend:

AA – Above the Allowable Effluent Discharge of 50 cu.m./hectare

Among the six (6) Industries, Industry B discharged the biggest volume of effluent or otherwise known as the treated wastewater, at an average rate of 5.728 x 10^8 cu. m. per day; while the lowest effluent discharge was that of Industry F which was at an average rate of 240 cu. m. per day. It was noted that all the Industries had discharges above the allowable effluent discharge of 50 cu. m. per day; thus all of them needs to have their wastewater effluent characteristics be within the allowable limits stipulated in the said Effluent Standards for industrial manufacturing plants.

Physical Wastewater Quality before and after Treatment. The wastewater qualities before and after treatment were also analyzed. All the data were based on the answers given on the questionnaire and were being attested by the latest EMB, DENR Industrial Influent/Effluent Monitoring Report and from the heavy industries' River Monitoring Reports. The EMB, DENR Technical Staff made the Influent and Effluent Monitoring Report by performing laboratory tests on the wastewaters of the six identified heavy industries in the respective wastewater laboratories of the said industries. Other tests not performed by the Industries and were required by DENR were tested by either the EMB, DENR Regional No. 7 Standards and Testing Laboratory in Banilad, Mandaue City or by the DOST Region No. 8 Standards and Testing Laboratory in Tacloban City.

The physical wastewater qualities before and after treatment were the physical characteristics of the influent and effluent, as shown in Table 2; and they were in terms of temperature, solid total, suspended colloids, and settleable solids.

Table 2.The Physical Wastewater Quality Before and After Treatment

Unit of Mea-sures	**Industry A**		**Industry B**		**Industry C**		**Industry D**		**Industry E**		**Industry F**		**Stan-dard Qua n-tity**
	Be-for e	**Afte r**	**Be-fore**	**Afte r**	**Be-for e**	**After**	**Be-fore**	**After**	**Be-for e**	**After**	**Be-fore**	**Af-ter**	
Tempe ra-ture in ^{0}C	30. 4	30.8 *	30.9	33.4 *	32. 2	32.0*	31.2	28.9*	48	29.3*	NA D	28. 8	• 3 ^{0}C rise

Solids, total(TS) in mg/L	43	33*	NAD	NAD	90	65*	78	21*	NAD	NAD	NAD	NAD	☼ 720 mg/L ♣ 1,200 mg/L
Suspended Solids (SS)	NAD	NAD	NAD	NAD	NAD	NAD	NAD	NAD	300	40	NAD	NAD	☼ 90 mg/L ♣ 70 mg/L
Settleable Solids	NAD	NAD	NAD	NAD	NAD	NAD	164	21*	NAD	NAD	NAD	NAD	☼ 0.5 mg/L ♣ 0.3mg /L

Legend: * Tolerable; mg/L = milligrams per liter ; NAD = no available data
☼ Class C Industry; ♣ Class SB Industry; ● Class C and Class SB Industries

Table Notations: Class C Industries (discharging effluent to inland waters): Industry C, Industry D, Industry E, and Industry F; Class SB Industries (discharging effluent to coastal and marine waters): Industry A and Industry B**.**

As shown from the Table, the wastewater temperatures of Industries A and B rose after the treatment by 0.40^{0}C and 2.5 ^{0}C, respectively; while that of Industries C, D, and E decreased for 0.2 ^{0}C, 2.3^{0}C, and 18.7 ^{0}C, respectively. The rise or fall in the effluents' temperatures depended on the type of wastewater unit operations and processes the industries utilized. As shown from the Table, all of the Industries' wastewater temperatures after treatment were tolerable, except for Industry E whose wastewater temperature before treatment was not available. From the Philippine Revised Effluent Standards, the standard temperature rise of 3 ^{0}C is acceptable. Also, all these temperatures did not fall within the critical range of 25 to 35 ^{0}C wherein bacterial activity likely occurs; none of the industries' temperatures reached 50^{0}C wherein aerobic digestion and nitrification stop; and none of their temperatures dropped to about 15 ^{0}C wherein methane-producing bacteria become quite inactive (DENR-AO35,1990).

DENR-AO 35 (1990) stipulated that wastewater temperature affects chemical reaction and reaction rates, on aquatic life, and on the suitability of the water for beneficial uses. Increased temperature, for example, can cause a change in the species of fish that can exist in the receiving water body.

On the tolerable total solids (TS) conditions of the heavy industries, Industry A, C and D TS values, respectively decreased by 10, 25, and 57 mg/L after treatment. Industries B, E and F did not have available TS data on their wastewaters which means that TS is not present. Industry A's TS was very much below the allowable value for class SB industries of 1, 200 mg/L. This Industry belonged to class SB because it discharged its effluent to the nearby marine waters. Industry C and D effluents' TS values after treatment were below the allowable 720 mg/L for class C industries, the class where these Industries belonged because they discharged their effluents to inland waters. Excessive quantity of TS in the wastewaters causes slow biological decomposition and thereby adding organic load to receiving waters (DENR-AO35, 1990).

For suspended solids (SS), the Table shows that only Industry E had available data on SS, which incurred 260 mg/L decrease after treatment. This value fell below the allowable value of 90 mg/L and therefore tolerable to the environment. High TSS can block light from reaching submerged vegetation. As the amount of light passing through the water is reduced, photosynthesis slows down, causing less dissolved oxygen to be released into the water by plants. If light is completely blocked from bottom dwelling plants, the plants will stop producing oxygen and will die. As the plants are decomposed, bacteria will use up even more oxygen from the water. Low dissolved oxygen can lead to fish kills. High TSS can also cause an increase in surface water temperature, because the suspended particles absorb heat from sunlight. This can cause dissolved oxygen levels to fall even further (because warmer waters can hold less DO), and can harm aquatic life in many other ways, as discussed in the temperature section (Mitchell and Stapp, 1992).

Finally, for settleable solids, only Industry D had available data. The settleable solids for Industry D incurred a total decrease of 143 mg/L which fell below the allowable value of 0.5mg/L. Therefore, it was safe to the environment. Settleable solids can cause slow biological decomposition in the receiving waters (DENR-AO35, 1990).

From these findings, it was noted that all the available physical wastewater qualities of the Industries were found tolerable to the environment.

Chemical Qualities of Wastewater. Chemical wastewater qualities before and after treatment refer to the chemical constituents' characteristics of the influent and effluent. The chemical analysis is shown on the following Table.

Table 3. The Chemical Qualities of Wastewater

Unit of Measures	**Industry A**		**Industry B**		**Industry C**		**Industry D**		**Industry E**		**Industry F**		**Standard Quantity**
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	
5-day BOD in mg/L	NAD	NAD	NAD	NAD	400	15	280	18	900	2	70	24	☼ 80 mg/L ♣50 mg/L
COD in mg/L	NAD	NAD	NAD	NAD	1,647.05	84.7	310	185	NAD	NAD	NAD	NAD	☼150 ♣100
pH	8.15	7.45*	NAD	NAD	8.35	7.76*	12.1	7.85*	12	7-8*	NAD	6.51*	● 6-9
Gases		SO_2: 86.9 mg/NCM*	**SO_2:** 497.73 mg/CM* **Ammonia:**35.02 mg/CM* **Nitrogen:** bdc* **NPK**: nil*	**SO_2:** 497.73 mg/CM* **Ammonia:**35.02 mg/CM* **Nitrogen:** bdc* NPK: nil*									**SO_2**: ● 200 mg/CM **Ammonia**: ● 400mg/CM **Nitrogen**: ● 20-30 mg/L **NPK**: ● 6-10 mg/L **P_2O_5**: ● 200mg/CM

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			P_2O_5: 9mg/CM **Flourine:** 12.13mg/Nm*	**P_2O_5:** 12mg/CM* **Flourine:** 12.13mg/Nm*									**Flourine**: ● 47.5 mg/CM
Heavy Metals	**As**: 0.19 (Infl.) **Cd**: 0.011 **Hg**: 0.055ppb	**As**: 0.289 **Cd**: 0.023* **Hg**: 0.33*	**As**: bdc **Cd**: bdc **Hg**: bdc ppb	**As**: bdc **Cd**: bdc **Hg**: bdc ppb									**As:** ☼ 0.5mg/l ♣0.2 mg/L **Cd:** ☼ 0.5mg/l ♣0.2 mg/L ***Hg:*** ● *0.005mg/L*
Oil and Grease in mg/L					1.5	3.0	21.65	3.81	0.3	0.001			☼ 10 mg/L ♣ 5 mg/L

Legend: ☼ Class C Industry; ♣ Class SB Industry; ● Class C and Class SB Industries; * Tolerable; mg/L = milligrams per liter ; NAD = no available data

Table Notations: Class C Industries (discharging effluent to inland waters): Industry C, Industry D, Industry E, and Industry F; Class SB Industries (discharging effluent to coastal and marine waters): Industry A and Industry B.

As reflected in Table 3, the chemical qualities used in determining the quality of wastewater for the Industries were BOD, COD, pH, gases, metals, and oil and grease. The 5-Day Biological Oxygen Demand or BOD for all Industries, except Industries A and B who had no available data, made tremendous amount of reductions by 385, 262, 898, and 46 mg/L for Industries C, D, E, and F, respectively. From the Table, the allowable value of BOD for Class SB industries was 50 mg/L. This implies that these Industries had tolerable wastewater BOD after treatment. Excess BOD, according to Abdel-Raouf et al. (2012) can deplete the dissolved oxygen of receiving water leading to fish kill and anerobiosis, hence its removal is a primary aim of wastewater treatment.

BOD is based on the principle that if sufficient oxygen is available, aerobic biological decomposition (i.e., stabilization of organic waste) by microorganisms will continue until all waste is consumed. BOD is also used in determining the size of wastewater treatment facilities and in measuring the efficiency of some treatment processes. Exceeding the allowable values stipulated in the standards for effluents means renovation and/or additional treatment processes and facilities for the Industry's wastewater treatment plant (UGA Extension Circular 922, 2013; DENR-AO35, 1990). Excess BOD can deplete the dissolved oxygen of receiving water leading to fish kills and anaerobiosis, hence its removal is a primary aim of wastewater treatment.

Among the six (6) industries, only Industries C and D had Chemical Oxygen Demand or COD test results. Industries C and D had greatly reduced their wastewater COD content -were 1,562.35 mg/L and 125 mg/L, respectively. From the Table, the maximum tolerable COD value for class SB industries was 100 mg/L. All the COD values for Industries C and D were below the maximum allowable value. COD test is used to measure the content of organic matter found in industrial wastewaters. These organic matters may consist of hazardous compounds detrimental to biological life. It is therefore frequently desirable to measure and control the concentration for COD (http://science.jrank.org/pages/1388/Chemical-Oxygen-Demand.html#ixzz4HH0EwhQw, retrieved Aug. 14, 2016).

For pH values of wastewaters, the total reduction of pH values after treatment for the Industries were as follows: Industry A – 0.70, Industry C – 0.59, Industry D – 4.25, and Industry E – 4.5 (average). All of these Industries' effluent pH values were tolerable since the allowable range of 6 to 9. The pH analyses are important for neutralization, precipitation, coagulation and other biological treatment process. pH analyses are probably the most recommended method for waste water treatment (vlab.amrita.edu,2012).

Among the industries, only Industries A and B had gas contents on their wastewaters. The wastewater of Industry A contained tolerable amount of sulfur dioxide or SO_2 after treatment which was below the allowable value as indicated from the Table. Industry B's wastewater contained the $SO_{2;}$ ammonia (NH_3); nitrogen (N), phosphorus (P), and potassium (K) or NPK; pentoxide (P_2O_5)), and fluorine (F). Among these gases, only P_2O_5 changed after treatment was undertaken, having increased by 3 mg/CM after treatment. All values were below the standard quality which means that both wastewaters of Industries A and B had tolerable gas contents.

Trace of heavy metals were only present in Industry A and Industry B. Industry A's traces of metals fell below the allowable values. On the other hand, Industry B had below detectable concentration (bdc) for all its wastewater contents' heavy metals. This implies that the trace of heavy metals found in Industries' A and B wastewater were found safe to the environment.

The last chemical quality found in the Industries' wastewaters was oil and/or grease. Only Industries C, D, and E had available test results because these Industries produced oil and/or grease as by-product of their operations. The amounts of oil and/or grease in the Industries' effluents were all found to be below the allowable values which means that they are safe to the environment.

From the above findings, it was noted that the available chemical wastewater qualities were found tolerable to the environment.

Availability of Wastewater Treatment Technology or Facilities. The profile of the industries in terms of the availability of wastewater treatment technology for a period of five years (2003-2007) are shown in Table 4 below. Wastewater unit operations are the methods of wastewater treatment where physical forces predominate. Methods of treatment in which the removal of contaminants is brought about by chemical or biological reactions are known as unit processes. Unit operations and processes are grouped together to have the primary, secondary, and advanced (or tertiary) treatment. In the Industries' treatment plants, primary treatment involved physical unit operations, such as screening and sedimentation, to remove the floating and settleable solids found in the wastewater. In the secondary treatment, biological and chemical processes were removing most of the organic matter. In advanced or tertiary treatment, additional combinations of unit operations and processes were used to remove other constituents, such as nitrogen and phosphorus that were not reduced significantly by secondary treatment.

Table 4. The Wastewater Treatment Technology of Industries

Wastewater Unit Opera-tions and Processes	**Industry A**	**Industry B**	**Industry C**	**Industry. D**	**Industry E**	**Industry F**
Primary wastewater	Screens,	Screens, sedimentation tank	Parabolic screens, oil	screens, oil sepa-arator, primary sedimentatio	screens, settling tank, primary sedimentation tank,	sedimen-

managemen t facilities	Sedimentatio n tank		separator, sedimentatio n tank	n tank, sedimenta-tion tank, settling tank	sedimentation tank, oil-water separation tank	tation tank
Secondary wastewater managemen t facilities	waste heat boiler, electro-static precipita-tor, flow measu-ring device, settling tank, primary flow equalization basin, pH neu-trallization tank, fish pool	Waste heat boiler, electro-static precipi-tators, sludge collectors Neutralizatio n plant, carbide sludge facility, Calcine decanta-tion tank, fish pool	Nutrient & sump feed tanks, aeration tank, polishing pond, stabili-zer, sludge bed Equalization pond, neutraliza tion pond, Filter beds, filter pump, solar drying beds, fish pool	flow equaliza-tionsludge collectors, aeration basin, clarifier, digester, Equa-lization/neutr ali-zation tank, fish pool	filter pump, filtration tanks, aeration tank, sludge collectors sludge drying beds, fish pool	Aeratio n tank, Stabiliz er, fish pool
Advanced wastewater managemen t facilities	-	-	FABCON PER Rapid Clarifier	-	Flocculator	-

Industry A had a chemical wastewater treatment plant type utilizing screens and sedimentation tank as its primary wastewater facilities. Waste heat boiler, electrostatic precipitator, flow measuring device, settling tank, flow equalization basin, pH neutralization tank and fish pool served as its secondary treatment. Industry A had no advanced wastewater treatment facility. Gases containing sulfur passed through the gas ducts to the waste heat boiler, electrostatic precipitator, and acid plant for conversion into sulfuric acid. Waste acid from the acid plant was treated in a neutralization plant to produce gypsum. Waste heat boiler was designed to burn gas/tail gases to generate stream for process and/or power. Copper smelting was one of the typical processes that made use of a waste heat boiler.

The electrostatic precipitator used by this Industry was a device used for separating precious metals such as gold and other saleable byproducts, aside from removing solid particles from the gases containing sulfur dioxide that passes through the gas ducts. It used a field produced by static electricity to ionize (electrically charge) the particles and then precipitated (deposit) them onto a plate with an opposite electric charge.

The primary and secondary treatment facilities used by Industry A were sufficient to make the wastewater quality tolerable to the environment.

The types of wastewater treatment plants/facilities utilized by Industry B were lime neutralization system, carbide sludge facility, and calcine decantation tank. Screens and sedimentation tank were the Industry's primary treatment facilities; while its secondary treatment facilities which were used to treat wastewater from various sources (domestic, phosphatic acid, old sulfuric acid plant, granulation plant, utilities, and ammosul plant) were waste heat boiler, electrostatic precipitators, sludge collectors, neutralization plant, carbide sludge facility, calcine decantation tank, and fish pool. It had no advanced wastewater management facility.

Industry C had physical and chemical types of wastewater treatment plants or facilities such as parabolic screens, oil separator, and sedimentation tank to treat its wastewater primarily. The Industry used the following secondary wastewater treatment facilities: nutrient & sump feed tanks, aeration tank, polishing pond, stabilizer, sludge bed, equalization pond, neutralization pond, filter beds, filter pump, and fish pool. It used the latest FPR for its advanced wastewater management facility to ensure faster flocculation and clarification of water and for the efficient separation and removal of sludge. The oil separator de-oiled the wastewater mostly coming from washing bottles, spillages, and acid carbon filters. The nutrient feed tank biologically treated the wastewater with the Fabcon Micro 110 after it had been neutralized. The sump tank is the tank where the wastewater, after being treated biologically and aerated at the aeration pond, was being pumped out to the FABCON PER Rapid Clarifier (PFR).

The aeration of inoculated wastewater for Industry C was done through activated sludge process with the modern Aire-02 guns, which allowed below surface horizontal induction of surface air at high velocity. Oxygen was dispersed rapidly allowing high oxygen transfer and thorough mixing of the water in the pond. Biological activity was greatly increased and digestion of organic pollutants was effected, with formation of less sludge and removal of odor. The horizontal high velocity flow pattern created by Aire-02 aeration kept the water moving and organic solids suspended allowing more bacteriological breakdown to lower energy cost. The sludge bed was actually the sludge drying bed, where the sludge was dried up and sold to private farmers.

It was observed that Industry C's influent first passed through a parabolic screen for deposit at the pump pit. From the pump pit it went directly to the oil separator where oil was being effectively removed. The oil free wastewater then passed to the equalization pond, then to the neutralization pond where hydrochloric acid (H_2SO_4) was being injected for pH control purposes, then to the aeration pond where nutrients and sump were being feed for biological treatment, and to the Plug-Flow Reactor (PFR) where fluid particles retained their identity and remained in the tank for a time equal to the theoretical detention time. It was in the PFR where the zuclar was being mixed with the treated wastewater to stabilize D_2O. From the PFR, the treated wastewater then passed to the polishing pond for the purpose of complete treatment by rapid stabilization of strong organic wastes. Finally the completely treated wastewater was being deposited in a weir box and fishpond before being disposed to Cancabato Bay.

Industry D used an Activated Sludge Type (biological type) of wastewater treatment plant/facility which used primary - screens, oil separator, primary sedimentation tank, sedimentation tank, and settling tank; secondary - flow equalization, sludge collectors, aeration basin, clarifier, digester, equalization/neutralization tank, and fish pool; advance – none. Activated-sludge process utilized by Industry D, according to its PCO, involved the production of an activated mass of microorganisms capable of stabilizing waste aerobically. It had eliminated the use of biocides, scale inhibitors, and rust treatments, which had been traditionally used to treat the water used in cooling towers, in order to maintain and protect the equipment and protect employees. Instead, it treated the water with ozone generated on site, which degrades to oxygen after it killed any harmful bacteria in the water. The Industry's PCO stressed, aside from the wastewater management facilities used by Industry D, the main office provided copies of Material Safety Data Sheets (MSDS) to all its bottlers worldwide so they understood proper handling procedures for concentrates, and how to deal with them if they were spilled. Further, in order to assure worker and environmental safety, the main office supplied these MSDS to all other bottlers even in countries where this information were not required.

Industry E had physical and biological types of wastewater treatment plants/facilities. It used primary treatment facilities such as screens, settling tank, primary sedimentation tank, sedimentation tank, and oil-water separation tank. Its secondary treatment facilities were the filter pump, filtration tanks, aeration tank, sludge collectors, sludge drying beds, and fish pool; advance – flocculator. Being a sugar Industry was an important consumer of both drinking and industrial waters used in the refining process. Wastewaters produced had high organic load and, initially in the refining process, also had high particulate load. Thus, treatment of these wastewaters required a process that combined mechanical, chemical, and biological treatment measures. The principle element of the purification process was based upon the aerobic activated sludge technology with one or more aeration stages.

For this Industry, sugar processing wastewater was collected and transported through pipelines to a collection facility, where it was passed through a series of screens to remove coarse contaminants like sand, stalks, leaves, etc. From the screens, the wastewater went to the settling tank, and then to the primary sedimentation tank by gravity flow to the sedimentation tank, which was equipped with hydraulic devices for collecting the separated sludge and the foam. The flocculator was utilized to form aggregates, or flocs, from the finely divided matter. The flocculation of wastewater by mechanical or air agitation was used to increase the removal of suspended solids and BOD in primary settling facilities, conditions wastewater containing certain industrial wastes, and improve the performance of secondary settling tanks following the activated-sludge process.

The separated sludge was removed, drained, and dried in sludge drying beds. The water passed from the sedimentation tank into the oil-water separation tank to remove the oil and grease content, and then to the first stage aeration tank, which was equipped with devices for aerating the effluent and adding the nutrients in order to promote the growth of active sludge bacteria which metabolize up to 75 percent of the organic pollutants in the wastewater. In the next phase, the water passed into the second stage filtration tanks, through the filter pump, from which the excess sludge was pumped to the drying areas, and the supernatant was pumped into an aeration tank, which further purified the effluent by removing up to 95 percent of the initial organic load.

The sizing of the aeration tanks was carefully selected such that these were adequate to handle the hydraulic charge and the appropriate concentration of the recirculated sludge, and provide sufficient aeration and sludge contact time. From the aeration tank, the water passed in devices that collected the sludge, which was dried in sludge stabilization ponds, and removed the foam. Following this treatment, the treated effluent was discharged to the fish pool before being discharged to the nearby river.

Industry F had biological type of wastewater treatment plant/facility using the sedimentation tank as its primary treatment facility and aeration tank, stabilizer, and fish pool for its secondary treatment facilities. It had no advanced wastewater management facility. There were only few processes involved in the wastewater treatment for Industry F. This was due to the fact that its alcohol production utilized few processes, and the process chemicals used were only few. Iodine was used, in small quantities, for sterilization of process equipment. Lime was used for water treatment. Bleaching powder was used for effluent treatment.

The processes involved in ethyl alcohol production for Industry F were fermentation process additives, steam distillation, condensation and cooling, and finally the alcohol product. The success of this process largely depended on batchwise preparation of fungal amylase bacteria culture using seed tanks to grow in column, which was initially started in the laboratory. The process chemicals used albeit in small quantities to maintain effective and ideal fermentation were sulfuric acid and salt constituents and antifoaming agents. Industry F generated waste solvents that must be either shipped away for disposal or recovered. A number of separation technologies could be used for solvent recovery depending on the composition of the waste. The technique used by the Industry was distillation, since the solvents were mixed, recovered, and purified. Distillation, sometimes referred to as fractionation or rectification, is a process whereby two or more liquids are separated. The process utilizes the varying differences in vapor pressures to produce the separation. Distillation facility was not one of the wastewater treatment management facilities used by the Industry. Being one of the processes involved in the production of alcohol, solvents were at the same time recovered during the distillation process in the manufacturing of alcohol.

Problems Encountered by the Industries

Table 5 presents the problems related to wastewater management encountered by the six identified heavy industries in Leyte as perceived by the two groups of respondents.

Table 5. The Problems Encountered by the Industries

Problems Encountered	Frequency	Rank
Irregular supply of chemicals.	12	1
Lack of facilities, equipment and supplies	9	2
Absence of permanent expert personnel in the wastewater treatment plant.	8	3
No ready provision of defective equipment or facility parts for immediate replacement.	6	4
Absence of modern facilities and equipment.	3	5
*Multiple response		

Table 5 shows that the prevailing problem encountered by the Industries was the irregular supply of chemicals. These chemicals were used as reagents in obtaining laboratory tests for wastewaters' physical and chemical characteristics as being required of the industries by the EMB, DENR. This was the reason why all the Industries were not capable of obtaining complete wastewater characteristic tests for the two mentioned areas. The next problem was the lack of facilities, equipment and supplies. The PCOs and Technicians of the Industries said they were obliged to have some of the wastewater characteristic parameters be tested at the DENR and DOST Regional Testing Laboratories because of this problem. The third problem was the absence of permanent expert personnel in the wastewater treatment plant. As per interview with the respondents, personnel at the Pollution Control Office of the Industries "just come and go". In fact the highest number of years one PCO worked in one Industry was 8 years. This was because, being chemical engineers by profession, they looked for greener pastures in other companies.

The fourth problem encountered by the Industries was the absence of ready provisions for defective equipment or facility parts for immediate replacement. Although some of the Industries made measures to solve this problem, it was in the requisition process that delayed the purchase of these spare equipment or equipment parts. The last problem encountered by the industries was the absence of modern facilities and equipment. Two respondents from EMB exposed this problem, and it referred to Industry A. The external technical personnel said, although the present wastewater treatment facilities and equipment were sustainable to render the Industry's wastewater sustainable to the environment, it really needed more updated or modern facilities and equipment to further reduce, if not totally eliminate, the sulfuric acid wastes generated during the production process.

CONCLUSIONS

The quantity of effluent discharges can be tolerable to the environment if their physical and chemical characteristics are within the allowable limits. The tolerability of wastewater effluent characteristics or qualities depends on the suitability of the available treatment technology and facilities. The sustainability of the industrial manufacturing operations depends on the capability of the utilized wastewater treatment facilities and technology to reduce or eliminate hazardous manufacturing by-products. The dynamic leadership of the Pollution Control Officers and full support from the Administration of the Industries could greatly advance the capabilities of their existing wastewater treatment technologies and could prevent the occurrence of wastewater management problems.

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