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The Coagulation-flocculation Process of the Liquid Waste Treatment Plant at a Diagnostic Center in Yogyakarta, Indonesia

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Abstract: The study aimed to obtain the optimum dose of Al2(SO4)3 coagulant, which would be added to the coagulation-flocculation process to redesign a liquid waste treatment plant at a diagnostic center in Yogyakarta, Indonesia. The redesign aims to reduce the content of Chemical Oxygen Demand (COD) contaminants based on Provincial Decree number 65/Y1999 which concerns the Liquid Waste Quality Standards for Health Service Activities in the Province of the Special Region of Yogyakarta. The case was studied at the diagnostic center on Dr. Soetomo street, Bausasran Village, Yogyakarta City. The research method used is quantitative, with data collection techniques in the form of primary and secondary data through survey activities on the research objects in the field. The test and analysis were carried out at the environmental laboratory in Yogyakarta. Based on the jar-test analysis, the redesign process may significantly decrease the COD pollutant from 471.94 mg/liter to 140.763 mg/ liter or 70.17%. By getting the optimum dose of the Al2(SO4)3 coagulant.

Keywords: Redesign, coagulant, chemical oxygen demand, liquid waste, diagnostic center

1. Introduction

Nowadays, there are a lot of private clinical laboratories in Yogyakarta, as in Pramita Utama Diagnostic Center Yogyakartawhich is located on Jl. Dr. Soetomo No. 41, Rt 09 Rw 05, Bausasran Village, Danurejan District, Yogyakarta City, Special Region of Yogyakarta Province. Classification Pramita Utama Diagnostic Center Yogyakarta is a Primary Public Private Clinical Laboratory with a capacity of ± 200 patients/day and 50 full-time and part-time workers. Every day the activities that occur operate for 16 hours (06.00 - 21.00 WIB), namely: providing health examination services for patients supported by various types of laboratory service activities, including laboratory activities, laboratory support activities, and non-laboratory support activities [1].

The various laboratory service activities may produce a residual product as liquid waste. The liquid waste may result from the examination service activities, i.e., hematology, clinical chemistry, immunology, microbiology, and other clinical activities. Liquid waste is a potential source of water pollution because it contains inorganic, organic compounds, chemical compounds, and pathogenic microorganisms. The waste is Hazardous and Toxic Materials (B3) for the health of patients and staff at the hospital: Pramita Utama Diagnostic Center Yogyakarta, the surrounding community, and the environment.

To prevent environmental pollution, especially in receiving water bodies, all liquid waste is generated from each Clinical Laboratory activity located in the Special Region of Yogyakarta Province before being discharged into the environment. It must be treated first at Liquid Waste Treatment Plant so that the effluent produced meets the parameters in the liquid waste quality standard according to the Governor's Decree Special Region of Yogyakarta Number 65 of 1999. Concerning Liquid Waste Quality Standards for Health Service Activities in the Province of the Special Region of Yogyakarta.

Besides protecting human health, liquid waste treatment aims to maintain an ecological balance towards clean technology and processing technology to minimize pollution. It includes reducing significant negative impacts due to the entry or inclusion of physical, chemical, biological, and radioactive polluting elements that can cause pollution. Negative impacts on the environment, namely: health, tranquility, aesthetics, and environmental comfort [2].

So far, the liquid waste generated from the activities of Paramita Utama Diagnostic Center Yogyakarta is processed at the Liquid Waste Treatment Plant with a biological system that is placed underground and covered with a capacity of 6 m3/day and consists of several processing equipments: Inlet Control Tub, Sedimentation Tub 1, Sediment Tub 2, Sediment Tub 3, Control Tub Outlets, and Infiltration Wells. However, the effluent produced does not meet the parameters in the Liquid Waste Quality Standards, especially the COD pollutant content [3].

Based on the data from the results of tests on the effluent produced by The Paramita Utama Diagnostic Center Yogyakarta Liquid Waste Treatment Plant, which was taken on November 17, 2008, resulted in the pollutant content of COD = 471.94 mg/lt. It shows that the effluent produced by the Paramita Utama Diagnostic Center Yogyakarta Liquid Waste Treatment Plant, which is designed with a biological system, has not been able to reduce the COD pollutant content according to the Governor's Decree. Special Region of Yogyakarta Number 65 of 1999 concerning Liquid Waste Quality Standards for Health Service Activities in the Province of the Special Region of Yogyakarta, namely: the maximum requirement limit for the pollutant content parameter COD = 150 mg/lt.

For this reason, a redesign will be carried out at The Paramita Utama Diagnostic Center Yogyakarta Liquid Waste Treatment Plant, especially in the liquid waste treatment system. One of the alternative liquid waste treatment systems that can be used to treat the resulting liquid wasteClinical laboratory is a chemical system using a coagulation-flocculation process. The main consideration in selecting a chemical system using the coagulation-flocculation process is the high processing efficiency, namely; BOD = 40 -50%, COD = 30 – 70%, Total Organic = 85%, SS = 99%, Detergent = 55%, Total Phosphate = 95%, Total Nitrogen = 50% [4].

According to previous research [3,4], flocculation coagulation is the addition of a floc-forming chemical reagent (coagulant) into clean water or liquid waste to combine colloidal solids (not precipitated) and suspended solids to form a floc that settles rapidly. The coagulant to be used is Aluminum Sulfate ($Al_2(SO_4)_3$) 10% with various doses of 10, 15, 20, 25, 30, 35, 40, 45, and 50 ml. The Environmental Laboratory analyzed the Jar Test to find the optimum coagulant dose. The result of the processing is usually a residue or remnants of solid particles, which will then be separated from the clear through a filtration process using a Rapid Sand Filter.

This study aims to evaluate and suggest a system for liquid waste generated from every activity of the clinical laboratory. Also, it may suggest the right treatment system at the appropriate Liquid Waste Treatment Plant level that saves the environment.

2. Materials and Methods

2.1 Object of research

The object of research is redesigning The Paramita Utama Diagnostic Center Yogyakarta Liquid Waste Treatment Plant, located in Danurejan District, Yogyakarta City, Yogyakarta Province. For the data collection in this study, it uses the Quantitative Research method with data collection techniques in the form of primary and secondary data.

Primary data, namely: data obtained directly from research objects in the field through survey activities, including data on the quality and quantity of liquid waste produced, and Jar Test analysis carried out at the Environmental Technology Laboratory of Harjoko STTL "YLH" Yogyakarta. Secondary data is obtained through library survey activities on the field's research object.

2.2 Research stages

Determining the chemical system using the flocculation coagulation process at Paramita Utama Liquid Waste Treatment Plant Diagnostic Center Yogyakarta consists of several stages of research, including:

1. Primary and secondary data collection: activities carried out directly to collect the primary data. It includes data on the quality and quantity of liquid waste produced and secondary data on the research object.
2. System evaluation, namely: activities carried out for sampling liquid waste on effluent produced by the Paramita Utama Liquid Waste Treatment Plant Diagnostic Center Yogyakarta with a biological system which is placed underground and covered with a capacity of 6 m3/day consisting of several processing equipments: Inlet Control Tub, Sedimentation Tub 1, Sedimentation Tub 2, Sedimentation Tub 3, Outlet Control Tub, and Infiltration Well. Then the COD pollutant content was analyzed at the Yogyakarta Environmental Health Engineering Center so that performance could be known Liquid Waste Treatment Plantworking properly or not.
3. Determination of the system: activities carried out to establish a liquid waste treatment system that can reduce the content of COD pollutants. It follows the Governor's Decree Special Region of Yogyakarta Number 65 of 1999 concerning Liquid Waste Quality Standards for Health Service Activities in the Special Province of Yogyakarta, the approach in redesigning the Paramita Utama Diagnostic Center Yogyakarta Liquid Waste Treatment Installation as follows [4,5]:
   a. Liquid Waste Discharge (Q) is calculated from the estimated amount of clean water needed for drinking water, laboratory activities, the needs of patients and patient's families, and the needs of employees (Qab), namely: Q = 50 - 80% x Qab. It is generally taken Q = 70% x Qab.
   b. The inlet and outlet control tubs that have been owned are still used. This is intended so that it is not redundant and can still be used, besides saving the cost of diversion and creating a new piping system in the building to dispose of liquid waste.
   c. The basic principles of wastewater treatment are using chemical systems using the process of flocculation coagulation followed by a filtration process using a Rapid Sand Filter.
   d. Jar Test, namely, an approximation method to obtain the optimum dose of coagulant Aluminum Sulfate ($Al_2(SO_4)_3$) 10%, which can reduce the COD pollutant content so that it can be used in the calculation of the redesigned tool for Liquid Waste Treatment Plant.
   e. Calculation of tools: Coagulation Tub, Flocculation Tub, and Filtration Tub.

3. Results and Discussion

3.1 3.1 Research result

The results of a survey conducted at Paramita Utama Diagnostic Center Yogyakarta obtained the following data, as follows:

1. Liquid Waste Discharge (Q) is calculated from the clean water needed for drinking and laboratory activities. Also, the needs of patients and patients' families and the needs of employees (Qab), namely: Q = 70% x 10.7 m3/hr = 7.5 m3/hr, are presented in Table 1.
2. Every day, the activities that occur operate for 16 hours, from 6 am to 9 pm, and this time is used as a reference for the average length of liquid waste flow per day.

The survey results were then inventoried, as presented in Table 1 below.

Table 1. Clean Water Needs at Pramita Utama Diagnostic Center Yogyakarta

No	Activity	Source	Types of Liquid Waste	Volume (m3/hr)
1.	Drinking water	PDAM	Non-medical	0.1
2.	Laboratory Activities	PDAM	Medical, Non-Medical, and Toxic	0.6
3.	Patient and Family Needs	Groundwater	Medical	5
4.	Employee needs	Groundwater	Non-medical	5
Total				**10.7**

3. The results of the tests on the resulting effluent In the Paramita Utama Diagnostic Center Yogyakarta Liquid Waste Treatment Plant and the following data were obtained as in Table 2.

Table 2. Test results on the effluent produced by the Installation Pramita Utama Liquid Waste Treatment Diagnostic Center Yogyakarta

No	Parameter	Satuan	Hasil Uji	Kadar max. gol mutu limbah cair III
1.	Suhu	^{0}C	28	30
2.	COD	Mg/l	471,94	100
3.	pH	-	8	6 - 9

Table 2. above shows that The Paramita Utama Diagnostic Center Yogyakarta Liquid Waste Treatment Plant with a biological system has been unable to reduce the COD pollutant content. According to the Governor's Decree Special Region of Yogyakarta Number 65 of 1999 concerning Liquid Waste Quality Standards for Health Service Activities in the Province of the Special Region of Yogyakarta, namely: the maximum requirement limit for the pollutant content parameter COD = 150 mg/lt [6].

4. The results of the Jar Test analysis of the resulting effluent In the Paramita Utama Diagnostic Center Yogyakarta Liquid Waste Treatment Plant, the following data were obtained as in figure 2 [6,7].

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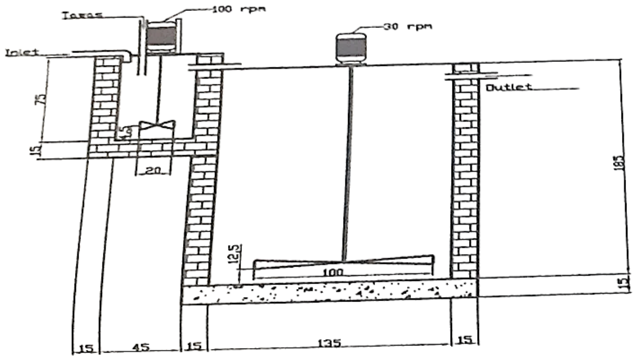

Figure 2. Jar Test analysis results

Based on fig. 2 above, it can be seen the relationship between variations in coagulant doseAluminum Sulfate (Al2(SO4)3) 10% with the efficiency of reducing the COD pollutant content based on the equation (1) and presented in table 3 and figure 3.

$$E = \frac{\text{Initial Concentration} - \text{Late Concentration}}{\text{Initial Concentration}} \times 100\% \quad (1)$$

Table 3. The relationship between coagulant dose variation and efficiency Decrease in the content of COD

No	Dose $Al_2(SO_4)_3$ 10% (ml)	COD (mg/lt)			Effisiency (%)
		Beginning	End	Decrease	
1	10	471,94	413,605	58,335	12,36
2	15	471,94	207,175	264,765	56,10
3	20	471,94	178,459	293,481	62,19
4	25	471,94	152,428	319,512	67,70
5	30	471,94	140,763	331,177	70,17
6	35	471,94	148,721	323,219	68,49
7	40	471,94	153,095	318,845	67,56
8	45	471,94	156,919	315,021	66,75
9	50	471,94	172,906	299,034	63,36

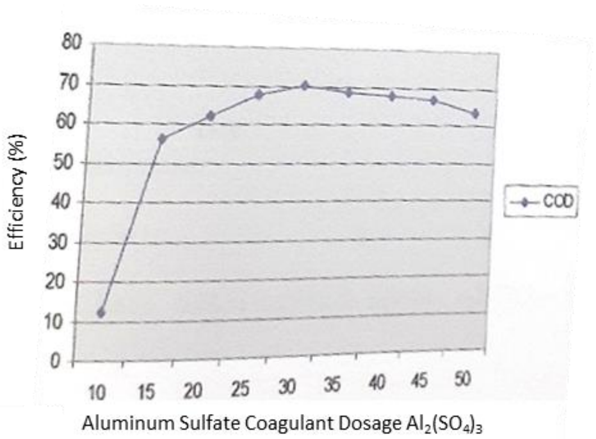

Figure 3. Graph of the relationship of coagulant dose variation to the reduction of COD pollutant content

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From the table and graph above, it is clear that there is a significant decrease at a dose of 30 ml, namely: for COD of 471.94 mg/ltr 140.763 mg/lt or a decrease of 70.17%.

5. Tool calculation
   a. Coagulation Tub
      - Length (P) = 0.45 m
      - Width (L) = 0.45 m
      - Water Height (Tair) = 0.395 m
      - Body Height (Tbak) = 0.75 m
      - Stirrer Motor Power (P) = 31.85 Watt
      - Stirring Arm Length (Impeller) = 0.20 m
      - Impeller Height Distance from the bottom of the body = 0.045 m
   b. Flocculation Tub
      - Length (P) = 1.35 m
      - Width (L) = 1.35 m
      - Water Height (Tair) = 1,285 m
      - Body Height (Tbak) = 1,855 m
      - Stirrer Motor Power (P) = 19.5 Watt
      - Stirring Arm Length (Impeller) = 1.0 m
      - Impeller Height Distance from the bottom of the body = 0.125 m
   c. Filter Body
      - Number of Filters = 1 Piece
      - Area/Filter = 1 m^2
      - Filter Diameter = 3.7 m
      - Filter Height = 2.5 m

The above calculation shows that the flocculation coagulation may be designed as presented in figure 4, based on others [8,9].

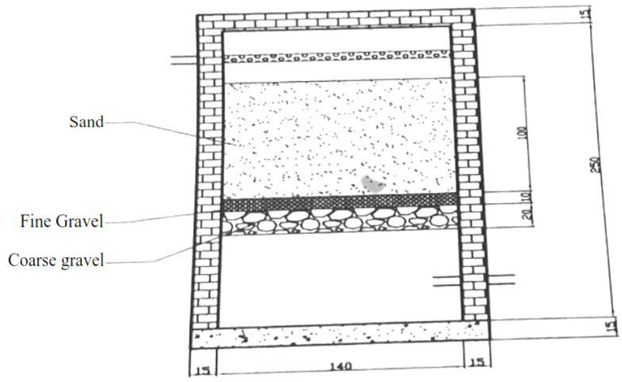

Figure 4. Flocculation Coagulation Tub

4. Conclusions

The various types of laboratory service activities in Pramita Utama Diagnostic Center Yogyakarta residual products are produced in liquid waste channeled to the Inlet Control Tub (BKI), where its function is to accommodate and homogenize the liquid waste before further processing. Then, by gravity, the liquid waste flows into the Coagulation Flocculation Tank (BKF) and Filtration Tank (BF). In BKF, there is the addition of coagulant Aluminum Sulfate (Al2(SO4)3) 10% with a dose of 30 ml into wastewater to reduce the COD pollutant content, namely: from 471.94 mg/lt to 140.763 mg/liter or a decrease of 70.17%. The coagulation-flocculation process occurs mechanically in the presence of fast and slow stirring. The BKF is planned to be square with an impeller and motor as the driving force and equipped with a coagulant affixing tub. From the BKF, the liquid waste has flowed to the BF, where a filtration process occurs using a Rapid Sand Filter whose function is to filter, separate, and hold residues or the remnants of solid particles giving coagulant to the BKF so that the liquid waste becomes clear. Furthermore, the liquid waste is channeled to the Outlet Control Tub (BKO) and then to the Infiltration Well as an effluent.

References

[1] Fair, Geyer and Okun. (1968) *Water and Waste Engineering*, John Wiley & Sons, New York, London, Sydney.
[2] Johannes, (1973) *Pengantar Kimia Koloid dan Kimia Permukaan*, UGM, Yogyakarta.
[3] Laboratorium Klinik Utama "PRAMITA" Cabang Yogyakarta, (2003) *Upaya Pengelolaan Lingkungan (UKL) dan Upaya Pemantauan Lingkungan (UPL) Pengembangan Laboratorium Klinik Utama "PRAMITA" Cabang Yogyakarta*, Yogyakarta.
[4] Met Calf and Eddy, (1972) *Waste Water Enginering Treatment Disposal Reuse*, Second Edition, Mc. Graw Hill Publishing Company, New York, 2 nd Ed.
[5] Reynold, (1982) *Unit Operation and Processes Environmental Engineering*, Brock/Cole Engineering Division, Monterey, California.
[6] Sudaryati, (1993) *Koagulasi Flokulasi*, Kursus Teknik Pengolahan Limbah Cair Secara Fisika, Kimia, dan Biologi, Puslitbang Kimia Terapan, LIPI, Jakarta.
[7] Sugiharto, (1987) *Dasar-Dasar Pengelolaan Air Limbah*, Universitas Indonesia Press, Jakarta.
[8] Syamsiah, (1995) *Teknologi Pengolahan Limbah Cair Rumah Sakit*, Kumpulan Makalah Kursus Pengelolaan Limbah Cair Rumah Sakit, PPLH, UGM, Yogyakarta.
[9] Tjokrokusumo, (1998), *Pengantar Enjinering Lingkungan*, STTL "YLH" Yogyakarta, Yogyakarta.