

SLUDGE CHARACTERISTICS IN JABABEKA INDUSTRIAL WASTEWATER TREATMENT PLANT

KARAKTERISTIK LUMPUR LIMBAH INDUSTRI DI IPAL JABABEKA

Imma Yuniar¹⁾ and Agus Jatnika Effendi²⁾

Environmental Engineering Study Program

Faculty of Civil and Environmental ITB, Jl.Ganesha 10 Bandung 40132

1) ima_imout@yahoo.com 2) agusje@tl.itb.ac.id

Abstract : Improper wastewater processing could decrease environment quality, whereas it is very potential polluting the environment. Wastewater in Jababeka Industrial area is processed by centralized method with biological treatment supported by physical and mechanical. Wastewater produces liquid and solid waste, which is sludge. This sludge came from units of treatment such as Grit chamber, Primary Settling Tank and Secondary Settling Tank. The objective of this study is to review the differences between each sludge characteristics to determine proper treatment if needed eventually. Sludge characteristics are very important for determining the right treatment, and so the wastewater characteristics. Sludge characteristic that could stated into treatment parameters are divided to physical, organic chemical and inorganic chemical treatment. Physical characteristics are including TSS, TDS, and color. Organic chemical characteristics are including BOD₅, COD, phenol, surfactant, oil and grease. Meanwhile, inorganic chemical characteristics are including Ammonia, Nitrate, Nitrite, Cadmium, Chrome, Copper, Cyanide, Fluoride, Iron, Manganese, Nickel and Zinc. Based on wastewater treatment plant configuration and existing characteristics, the inorganic sludge produced from Primary Settling Tank. The wastewater overflow is counted as biological flocs to treat on the next treatment unit. While the organic sludge produced from Secondary Settling Tank. Based on research conducted by Sucofindo wastewater sludge consists of heavy metals which could endanger the environment. Thus need sludge treatment to keep it safe for the environment.

Key words : Wastewater Treatment Plant, sludge characteristics, organic chemical, sludge treatment.

Abstrak : Pengolahan limbah yang tidak tepat dapat menurunkan kualitas lingkungan, mengingat potensinya dalam mencemari lingkungan. Air limbah yang berasal dari Kawasan Industri Jababeka diolah terpusat dengan menggunakan metode pengolahan secara biologis yang memanfaatkan mikroorganisme dibantu dengan proses fisik dan mekanik. Limbah yang dihasilkan dari IPAL ini selain limbah cair juga menghasilkan limbah padat berupa lumpur. Lumpur ini berasal dari unit Grit chamber, Primary Settling Tank dan Secondary Settling Tank. Tujuan dari studi ini adalah untuk mengetahui perbedaan karakteristik lumpur limbah industri sehingga dapat ditentukan pengolahan lumpur yang tepat apabila diperlukan. Selain karakteristik air limbah, karakteristik lumpur penting untuk menentukan pengolahan lumpur yang tepat. Karakteristik lumpur yang dapat dijadikan parameter pengolahan terbagi menjadi tiga yaitu fisik, kimia organik dan kimia anorganik. Karakteristik fisik antara lain TSS, TDS, warna. Karakteristik kimia organik antara lain BOD₅, COD, fenol, minyak lemak dan deterjen. Kimia anorganik antara lain Amonia, Nitrat, Nitrit, Kadmium, Krom, Tembaga, Sianida, Fluor, Besi, Timbal, Mangan, Nikel dan Seng. Berdasarkan konfigurasi IPAL dan karakteristik lumpur eksisting, lumpur yang dihasilkan dari Primary Settling Tank berupa lumpur anorganik. Overflow air limbah dari primary settling tank ke unit selanjutnya mengandung biological floc. Sedangkan lumpur yang berasal dari Secondary Settling Tank berupa lumpur organik. Hasil penelitian Sucofindo terhadap sludge cake IPAL Jababeka menunjukkan bahwa sludge cake ini mengandung logam berat yang bersifat B3. Pengolahan lumpur lebih lanjut diperlukan agar menghasilkan lumpur yang aman bagi lingkungan.

Kata kunci : Instalasi Pengolahan Air Limbah, karaktersitik lumpur, kimia organik, pengolahan lumpur

INTRODUCTION

Industrial activities produces various wastes depend on operating processes, type of raw material and chemicals added. Industrial wastewater could change the environment. Environmental change due to industrialization is important to be observed from the objectives, environmental risks and the effort to maintain for supporting sustainable development result.

Basically waste is residual material from human activities and natural processes neither with negative economical value. One of produce waste is liquid waste. This waste water treatment is divided into physical, chemical and biological treatment. Physical treatment is separation process by particle size, consist of flotation, sedimentation and screening. Chemical treatment is wastewater mix with certain amount and type of chemical, consist of absorption and disinfection. Biological treatment is microorganisms employed to decomposed waste. Microorganisms obtain by activated sludge.

Activated sludge method is commonly used in industrial including Jababeka Wastewater Treatment Plant. This method can be employed for wastewater treatment which produced by various industrial wastes such as food and beverages, textiles, plastics, metals industries, etc. Meanwhile, activated sludge method field operation is often tripped in difficulties, for example (1) the requirement of large area due to extra time needed, (2) the occurrence of sludge which is caused by the increasing of microorganisms amount. This sludge is produced from several treatment units, for instance screening, sedimentation, chemical treatment and biological treatment.

Sludge is the accumulation of pollutant's residue after passing the vaporization process at 103-105°C (Sugiharto, 2005). The amount of water that is contained in sludge causing high level of volume and weight that will harden the treatment and storage process (Qasim, 1985). The involved problems in sludge treatments are very complex and improper treatment process might endanger the environment. Thus, sludge characteristic research is very important to generate proper treatment process. Evaluation of sludge characteristic from existing sludge treatment facility is very crucial as it will provide basic information to enhance the performance of sludge-treatment. Due to the regulation, industrial sludge is categorized as hazardous waste, so that it requires a serious handling, in order to keep it safe for the environment and sanitation.

Wastewater that is derived from industrial activity contains heavy metals such as As, Zn, Cu, Cr, Co, Pb and Ni. For that reason, industrial wastewater should be taken care very carefully, regarding its possibility of becoming hazardous. Advance treatment for the sludge is needed to avoid dangerous impact for the environment.

As an organizer for environmental aspect, PT Jababeka Infrastruktur has established and operated a wastewater treatment plant, equipped with sludge treatment installation. The available units in the treatment plant are grit chamber, primary settling tank, oxidation ditch, secondary settling tank, distribution box, sludge drying bed and belt filter press.

METHODOLOGY

The methodology used during the research is by sludge sampling at three different points. The first sludge sampling point is at transfer point between primary settling tank and sludge drying bed. Second point is at transfer point between secondary settling tank and belt filter press. Meanwhile, the last sampling point is sludge cake produced by belt filter press. And then laboratory test to research and collect the physical and chemical

characteristics. Physical parameters are used on gravimetric methods to acquire the TSS and TDS. The chemical parameter analysis is conducted by TCLP (Toxicity Characteristic Leaching Procedure). Physical and chemical characteristics of the sludge will be evaluated due to government regulation.

RESULT AND DISCUSSIONS

The total of industry operated in Jababeka Industrial Area reaches 1235 industries. Considering such condition, the characteristic of wastewater to be treated is various, depends on the type of industry, the material used during the production process and the process itself. Most of wastes are derived from food and detergent industry.

Varying characteristic of wastewater to be treated makes it hard for the area organizer to apply wastewater treatment. Due to such condition, to ease the operation of treatment process, standard criteria is applied, and it is an obligation for the industries to fulfill the standard. In defend industries whose wastewater surpass standard criteria a preliminary treatment should be applied.

Effluent yield from the treatment plant must be actuated by the standard criteria. KepMen LH No 03/MENLH/I/1998 related to wastewater standard for industrial area in Indonesia shows in Tabel 1 and KepGub West Java No. 06/ 1999 related to wastewater standard for industrial activities in West Java. The picture of Jababeka Water Treatment Plant is shown in Figure 1.



Figure 1. Jababeka Wastewater Treatment Plant

The basic concept of this wastewater treatment system is biological aerobic treatment, completed by physical and mechanical process. Industrial wastewater is wasted to the channel along the street in the area, through control chamber that is available in each industry building, to the lifting pump. The wastewater then pumped to the waste water treatment central through influent pump. The influent and effluent quality can be seen in Table 2. The influent physical characteristics are still below the standard, but the average influent chemical characteristics are higher it. High level of chemicals compounds are caused by the accumulation of effluent from industrial wastewater since the area is dominated by textiles, electroplating industries and some food industries. The treatment plant treated the wastewater to decrease the contents until reaching below the effluent standard criteria as shows in Tabel 1. The Jababeka wastewater treatment plant efficiency is around 73% to reduce the constituent of wastewater.

Tabel 1. KepMen LH No 03/MENLH/I/1998

Parameters	Max content (mg/l)	mass loading (kg/days.Ha)
BOD	50	4.3
COD	100	8.6
TSS	200	17.2

Table 2. The wastewater characteristic

No.	Parameters	Standard (*)	Influent	Effluent	Unit
Physical					
1	TSS	400	121.4	14.8	mg/l
2	TDS	2000	1534.2	1488.4	mg/l
3	Color	300	294.2	149.52	Scale of PtCo
Organic Chemical					
4	BOD5	500	467	35.51	mg/l
5	COD	800	1105.6	71.92	mg/l
6	Phenol	0.5	752.5	0.97	mg/l
7	Surfactant	5	1.74	0.9	mg/l
Inorganic Chemical					
8	Ammonium (N-H3)	10	38.52	10.18	mg/l
9	Nitrate (NO ₃)	30	1.33	0.66	mg/l
10	Nitrite (NO ₂)	2	1.3	0.36	mg/l
11	Cadmium (Ca)	0.05	0.02	0.006	mg/l
12	Total Chrome (Cr)	0.5	4.27	0.081	mg/l
13	Chrome hexavalent (Cr 6+)	0.1	0.05	0.011	mg/l
14	Copper (Cu)	2	1.31	0.048	mg/l
15	Cyanide (CN)	0.05	0.008	0.008	mg/l
16	Fluoride (F)	2	0.87	0.49	mg/l
17	Iron (Fe)	5	6.8	0.46	mg/l
18	Lead (Pb)	0.1	0.15	0.044	mg/l
19	Manganese (Mn)	2	0.26	0.12	mg/l
20	Nickel (Ni)	0.2	0.84	0.19	mg/l
21	Zinc (Zn)	5	16.77	1.92	mg/l

(*) estate regulation of Jababeka Industrial area, June 2005

Before entering the treatment unit, wastewater is filtered using mechanical bar screen to retain solid things such as plastics or other kind of solid pollutant that is brought along the flow. The wastewater then pumped to the grit chamber through venture meter, to calculate wastewater discharge flowing to the installation. The flow of the wastewater shows in figure 2.

The wastewater then flow gravitationally to the primary settling tank (PST). At primary settling tank, suspended with specific gravity 1.03 g/ml or more density will be settling in 1.5-5 hours. Foam and other suspended matter that use to be contained in

wastewater will be separated and collected in scum collector to be pumped to sludge drying bed unit (SDB), together with settling sludge at the bottom of primary settling tank unit.

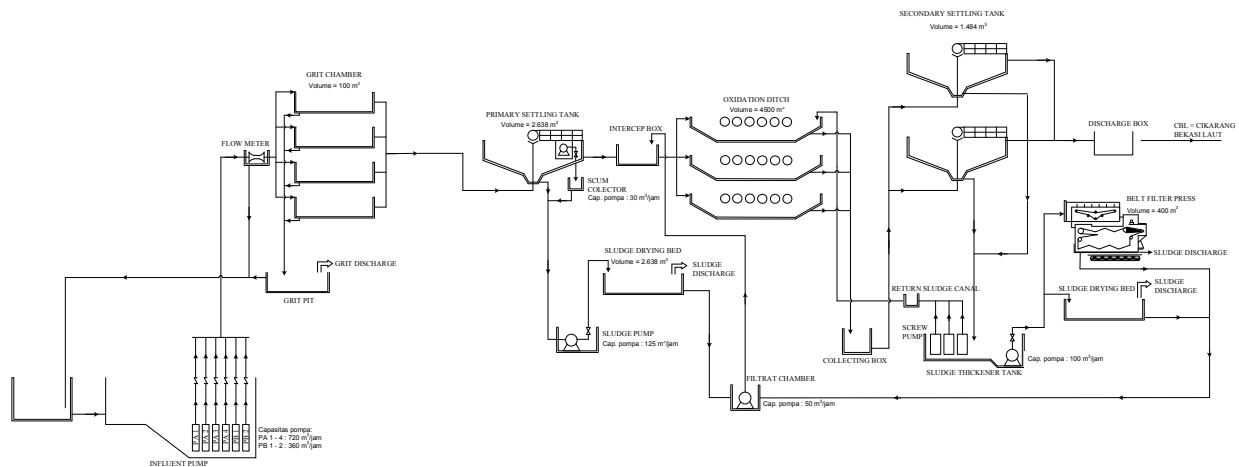


Figure 2. Schematic Diagram Wastewater Flow

The next treatment stage is biological process in aeration lagoon with Oxidation Ditch system (OD). Wastewater is flowing via overflow to this unit through V-notch weir to be aerated. Aeration process is conducted with *Mammoth Reactor* that is able to transfer oxygen, to fulfill the need of oxygen during biological process that involves microorganism in wastewater to transform polluting compounds, dissolved or suspended, to become *biological flocs*.

Aerated wastewater flows to the first part of distribution box. This unit has 3 functions:

1. Flowing waste water from OD to secondary settling tank (SST)
2. Returning activated sludge from SST to OD
3. Flowing unused sludge to belt filter press

Secondary settling tank is used as the last settling to separate water and biological floc. This process is aimed to get the supernatant that will have already fulfill wastewater standard issued by the local government, to be wasted directly to the CBL river (Cikarang Bekasi Laut), 4 km far from the industrial area and treatment plant. On the other hand, sludge that is formed during sedimentation process and spread at the bottom of the tank, scraped with scraper and collected in *Sludge Hooper* that lies in the middle of the unit, and hydrostatically re-flowed to the second part of distribution box to be re-circulated to the oxidation ditch as returned activated sludge. The excess of the process will be pumped to belt filter press to be drained.

In the direction of wastewater, sludge became one of the most problems. Sludge yielded from treatment plant as grit chamber, primary settling tank and secondary settling tank. The most important thing need to considerate is hazardous waste initiate from the sludge. Thus, sludge treatment is essential.

Sludge from grit chamber is separately processed in a special sludge drying bed lies on the left side of the unit. This special unit is built as the sludge, unlike those that are derived from other units, only consists of grit and large-size particle. Sludge wasting from this unit is held once a week as the sludge generated from grit chamber is not much around 0,6 m³/day. This special sludge drying bed consists of layers, for fastening the grit

drying process. Sludge derived from grit chamber is not dangerous for the environment, so that open dumping wasting is applied. The sludge is wasted directly to the open area on the waste water treatment plant's surrounding.

The sludge that is generated from primary settling tank unit will be drained in sludge drying bed. Average concentration of BOD removed is about 273.7 kg/day or 24.3 mg/L, and suspended solid removed concentration is about 404.6 kg/day or 34 mg/L. Sludge generated from PST is about 33.87 m³ per day, with 5% solid concentration. Average concentration of removed BOD in secondary settling is approximately 1459.55 kg/day, while removed TSS concentration is 2255.7 kg/day. Sludge generated from SST is about 58.25 m³ per day.

Daily flowrate in Jababeka wastewater treatment plant is about 11900 m³/day and the average discharge 10100 m³/day. That's conclude the disposal of the sludge around 1800 m³/day with the total produced sludge from primary settling tank and secondary settling tank around 5.71 m³/day. As much as 1794.29 m³/day filtrate from dewatering process and activated sludge will be pumped to oxidation ditch.

Sludge consists of organic and inorganic solids. Primary sludge contains solids exist in the raw wastewater, while secondary sludge contains chemical or biological solids which produced during the treatment processes (Qasim, 1985). The selected processes mainly depend on the characteristics and final disposal method of the sludge. The affecting characteristics are particle density, particle size distribution, surface charge, degree of hydration and compressibility.

Particle density is very important in sludge thickening since it affects the subsidence rate. Particle size distribution affects both thickening and dewatering. As the average particle size decreases, the surface volume ratio increases exponentially. Increased surface area will cause greater hydration, higher chemical requirement, and increased resistance to dewatering. Particle size distribution is also affects compressibility (Modern Pollution Control Technology, 1978).

The characteristics of sludge produces in wastewater treatment can vary greatly. It is important to be able to measure some characteristics that can be used in design and operation. Because of the complex nature of sludge, basic parameters are of only limited value, and it has been necessary to develop some operational parameters (Vesilind, 1975). The sludge characteristics divided into physical and chemical characteristics.

The most important physical characteristics of wastewater is its total solids content, which is composed of floating matter, settleable matter, colloidal matter, and matter in solution. TSS is one of the two universally used effluent standards (along with BOD) by which the performance of treatment plant is judged for regulatory control purposes (Metcalf, 2004). In Jababeka Wastewater Treatment Plant they measure Total suspended solid, total dissolved solid and color. Color is the describe condition of composition and concentration wastewater.

Chemical characteristics consist of organic and inorganic chemical. Organic compounds are normally composed of combinations of carbon, hydrogen, and oxygen. Organic matters in wastewater include BOD, COD, surfactant, oil and grease and Phenols. The most widely used parameter of organic pollution applied to both wastewater and surface water is BOD (Metcalf, 2004). Inorganic chemical characteristics include nutrients, nonmetallic constituents, metals, and gases. Many metals are classified as priority pollutants such as Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni), And Zinc (Zn). These metals are important characteristics of the most waters.

The primary settling tank is simply operated by allowing heavier solids to settle to the bottom and lighter solids to float to the top. The solids removed from the bottom of the primary settling tank are known as *raw primary sludge*. Raw primary sludge is quite objectionable and has a high percentage of water, two characteristics which make further handling difficult (Vesilind, 1975). Raw primary sludge could not drain well on sludge drying bed, this sludge is often digested to make it less objectionable and reduce the volatile solids until 50%. In Jababeka wastewater treatment plant the raw primary sludge directly drained on the sludge drying bed.

Sludge from secondary settling tank is classified as inorganic whereas the high level of metals compound. This occasion is happen because unsettled metals compound from the accumulation and non reductive metals stick with microbe. In addition sampling time is also affecting the level of sludge chemical compound. The high level inorganic chemicals matter are Cd, Cr, Cu, Pb, Mn, Ni and Zn. Sludge characteristics of primary settling tank and secondary settling tank are shows in Table 3.

Sludge that is generated from secondary settling tank will pass the process in belt filter press. This sludge drying process will generate a solid matter with above 15% solid concentration, called *sludge cake*.

Table 3 Sludge characteristics in primary setting tank and secondary settling tank

No.	Parameters	PST	SST	Unit
Physical				
1	TSS	12052	667	mg/l
Organic Chemical				
2	BOD5	8523,7	764	mg/l
3	Phenol	3.63	0.0407	mg/l
Inorganic Chemical				
4	Cadmium (Cd)	0.00665	0.0293	mg/l
5	Chromium (Cr)	1.29	150	mg/l
6	Copper (Cu)	0.867	108	mg/l
7	Lead (Pb)	0.0504	0.0987	mg/l
8	Manganese (Mn)	0.236	4.74	mg/l
9	Nickel (Ni)	0.648	19.5	mg/l
10	Zinc (Zn)	9.79	247	mg/l

Table 4 shows the characteristics from the sludge cake and the secondary sludge. Before dewatered, secondary sludge must have further treatment to decrease metals concentration. Metals concentration at sludge cake is still higher than the standard. The standard conducted by KABAPEDAL No 04/ BAPEDAL/ 09/ 1995 related to total maximum untreated hazardous wastes content and landfill determined for A column. Sludge cake is approved for direct disposal to landfill category 1 which is vacuum-packed site with clay double layer bottom soil (Damanhuri, 2004).

Table 4. The characteristics of sludge in sludge transfer tank and sludge cake

No.	Parameter	Standard	Sludge Cake	Unit
Metals				
1	Cd	50	5.2	mg/kg
2	As	300	48.3	mg/kg
3	Cr	2500	12050	mg/kg
4	Co	500	33	mg/kg
5	Sn	500	1600	mg/kg
6	Pb	3000	98.7	mg/kg
7	Cu	1000	5980	mg/kg
8	Mn	-	290	mg/kg
9	Hg	20	10	mg/kg
10	Ni	1000	1720	mg/kg
11	Se	100	8.5	mg/kg
12	Zn	5000	16270	mg/kg
Organic Chemical				
13	Phenol	10	0.009	mg/kg

(*) KABAPEDAL No 04/ BAPEDAL/ 09/ 1995

SUMMARY

Sludge from Primary Settling Tank and Secondary Settling Tank have different characteristics. Sludge from Primary Settling Tank is counted as raw primary sludge. Raw primary sludge could not drain well on sludge drying bed. Meanwhile, the sludge from Secondary Settling Tank is counted as organic sludge. Each of produced sludge could be processed in different dewatering systems, which are sludge drying bed and belt filter press. The unit determination is based on the characteristics produced by the different processing unit also different and high level of rain fall makes it impossible to use sludge drying bed and the alternative is to use belt filter press. Dewatered sludge from belt filter press (sludge cake) is approved for direct disposal to landfill category 1 which is vacuum-packed site with clay double layer bottom soil.

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