# Design of Waste Water Treatment Plant for Hospital

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Abstract: Many methods have been done to treat hospital waste water before it's disposed into the environment because it's containing high organic matters and chemical compounds so it's harmful for environment. In this research, we designed Wastewater Treatment Plant (WWTP) so the output will fulfil environmental quality standard and can be disposed into the environment. The design of WWTP uses chemical and physical process to reduce high chemical compounds and organic matters in hospital waste water. The purpose of this research is to design WWTP in hospital, determine the output waste from WWTP and can be used as a basis in the calculation of WWTP. The research method is to design WWTP and calculation result output of design WWTP (Waste Water Treatment Plant). The WWTP design is consist of equalization bath, bath coagulation, chlorination and sump. Based on the result, one of waste water of hospital in Indonesia with discharge is 60 m3/day, the result BOD is 44.87 mg/L, COD is 19.24 mg/L, and TSS is 56.68 mg/L. Waste water of hospital processed from this WWTP can to be disposed into environment based on Minister of Health decree.

## 1 INTRODUCTION

Source of water pollution can be come from the hospital. Sources of hospital wastewater can be derived from bathrooms, kitchen rooms, the examination rooms, laboratories, operating rooms and other rooms containing hazardous materials and germs. Various kinds of toxicities such as pharmaceutical waste, radio-nuclides, solvents and disinfectants for medical purposes with a high concentration for laboratory activities. Hospital waste as well as other waste containing organic and inorganic materials, which the containing level can be determined by testing waste water such as BOD, COD, pH, microbiological, TSS and others. Water waste from hospitals is one source of water pollution potential because the hospital waste water is containing organic compounds, chemical compounds and pathogenic microorganisms that can cause disease to the surrounding community. Pursuant to Law No. 32 of 2009 in Indonesia about Protection and Management of the Environment, an activity is required to process and manage wastes produced by its activities, in order to conserve the environmental functions so the waste must be processed and managed with the applicable quality standards. Kep-MENLH/12/1995 concerning effluent quality standards for hospital activities that requires every hospital must treat wastewater to a permitted standard.

From the explanation above, those can be used as a guide for the hospital to process and manage the waste till get the environmental quality standards that applicable. Hospitals need to build Wastewater Treatment Plant to produce safe effluent which can be disposed to the environment that passed the quality standards. In this research, we make the WWTP so that the result processed can be disposed into environment. The main characteristics of the hospital's waste water is the content of coliform bacteria, because it has very high value. In addition to the high content of coliform bacteria, the characteristics that is high of the waste water are BOD, COD, and TSS. The objectives of this research are to are to design WWTP in hospital, determine the output waste from WWTP and can be used as a basis in the calculation of WWTP.

## 2 BASIC THEORY

Wastewater Treatment Plant (WWTP) is a structure that is designed to dispose of biological and chemical



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waste from the water thus allowing the water to be reused at other activities. The main purpose of wastewater treatment is to decompose the content of pollutants in the water, especially organic compounds, suspended solids, pathogens and organic compounds that cannot be decomposed by microorganisms found in nature. For treating wastewater parameters, processing units that will be applied consists of several treatment plant. Based on the selection it has been done, then in WWTP will be used unit - of processing unit as follows:

a. Equalisation

The use of equalization tank aims to generate a uniform flow so that the processing units in the installations be able to avoid shock loading. Form of equalization tank that will be used are rectangular. During the equalization stirring to prevent the precipitation of solid and odor. Biological oxidation due to the agitation in the tank, according to Metcalf & Eddy (2004), can reduce the concentration of 10-20% total COD, TDS and TSS by 15-20%.

b. Coagulation and Flocculation

In the process of coagulation and flocculation, the water will be very role, because the chemical must be mixed with water. Stirring / Agitation process will very quickly and uniform dispersion of compounds in water, the coagulation process occurs with rapid stirring. In this case the process of coagulation and flocculation chemical and physical reactions will occur precipitation: Poly Aluminium Chloride. After the formation of deposits caused by the large floc settles, and this process occurs with slow stirring. A fast stirrer is very important in the change of physical factors as well as the efficiency of coagulant addition, the flocculation is a method for taking particles and highly dependent on particle size.

c. Sedimentation

Particles that are in the water may be eliminated in the sedimentation vessel (Clarifier). In the sedimentation tank types horizontal removed particles is dependent upon over flow rate (Vo), in this type there are several assumptions:

1. Particles and velocity vectors are distributed on a cross-section of the tank, as a function of the inlet zone.

2. Transfer the liquid will looking down on the length of the tank.

3. Particles below will be removed from the tank.

d. Chlorination Tank

Chlorine is commonly used for disinfecting; the term is usually used as a disinfectant is: $Cl_2$; NaOCl or $CaOCl_2$. When chlorine is added to water, the mixture Hipochlor (HOCl) and HCl will be formed by the reaction:

$$Cl_2\,(g) + H_2O \rightarrow HOCl + H^+ + Cl \quad (1)$$

The above reaction depends on pH, when the pH ≈ 1 reaction will occur right and very sidikit Cl2 in a solution. HOCl is a weak acid and dissociates at pH ≈ 6, at a pH between 6 to 8.5 dissociation occurs to HOCl.

$$HOCl \leftarrow\!=\!\rightarrow H^+ + Cl \rightarrow pK = 7.537 \text{ at } 25\,^\circ C \quad (2)$$

This chlorination with Cl2 generate HOCl at pH between 4 - 6. Below pH = 1 then it will be left to form Cl2 HOCl. While salt dissociates hypoklorida such as:

$$NaOCl \quad \leftarrow\!=\!=\!=\!\rightarrow \quad Na^+ + OCl^- \quad (3)$$

$$Ca(OCL)_2 \quad \leftarrow\!=\!=\!=\!\rightarrow \quad Ca^{2+} + 2.\,OCl^- \quad (4)$$

The presence of chlorine will tend to lower the pH, every mg / L of chlorine that is added will reduce hardness of 1.4 mg / L (equivalent to the concentration of CaCO3). Disinfectants will be well on the pH interval 6.5 - 7.5. Chlorine reacts with water to produce chlorine acts as an "oxidizing" very destructive of the organism.

# 3 RESEARCH METHOD

## 3.1 Study of Literature

Overview and Hospital Waste, Technique Wastewater Treatment and Design Options WWTP.

## 3.2 Data Collection

Wastewater discharge and the characteristics of the hospital.

## 3.3 Data Processing

The calculation of hospital waste, Determination of the quality standard as the basis of design, and Calculation of Dimension WWTP earned by each process.

## 3.4 Data Processing and Conclusion

Calculation of Dimension WWTP, The calculation of the final result output WWTP design results and Conclusion.

# 4 RESULT AND DISCUSSION

In this planning, hospital waste flow of water obtained as follows: 28 m3 / day. It refers of literature, including the text book Decentralised Wastewater Treatment in Developing Countries and Treatment and Reuse Fourth Edition by Metcalf and Eddy both in obtaining design criteria of planning and calculating the dimensions of the WWTP:

1. Equalization Tank.

The use of equalization tank aims to generate a uniform flow so that the processing units in the installations be able to avoid shock loading. Form of equalization tank that will be used are rectangular. During the equalization stirring to prevent the precipitation of solid and odor. Biological oxidation due to the agitation in the tank, according to Metcalf & Eddy (2004). After doing calculation, it will be shown at Table 1:

Table 1: Design Equalization from WWTP Hospital.

| Unit | Dimension | | | Over Flow Rate ($m^3/day.m^2$) | Residence time (h) |
|---|---|---|---|---|---|
| | Length (m) | Wide (m) | Head (m) | | |
| Equalisation | 2 | 1 | 3,3 | 30 | 2,5 |

2. Coagulation and Flocculation.

In the process of coagulation and flocculation, the water will be very role, because the chemical must be mixed with water so that the process will *very quickly and uniform dispersion of compounds* in water, the coagulation process occurs with rapid stirring. In this process of coagulation and flocculation, coagulant Poly Aluminium Chloride will be used.

Concentration of PAC : 80 ppm

Diameter Stirrer : 0,26 m

Flow rate PAC : 0,2 kg/d

Solution PAC : 5%

Flow rate water : 3,8 kg/d

Total volume : 1,76 $m^3$

After doing calculation, it will be shown at Table 2:

Table 2: Design Coagulation and Floculation from WWTP Hospital.

| Unit | Dimension | | | Residence time (h) | Power (watt) | Power of Stirrer Motor (rpm) | Height (m) |
|---|---|---|---|---|---|---|---|
| | Length (m) | Wide (m) | Head (m) | | | | |
| Coagulation I | 0,22 | 0,22 | 0,52 | 2,5 | 3,05 | 100 | 0,096 |
| Flocculation I | 0,22 | 0,22 | 0,52 | 2,5 | 3,05 | 20 | 0,096 |
| Coagulation II | 0,22 | 0,22 | 0,52 | 2,5 | 3,05 | 100 | 0,096 |
| Flocculation II | 0,22 | 0,22 | 0,52 | 2,5 | 3,05 | 20 | 0,096 |

3. Sedimentation.

Over Flow Rate : 30 $m^3$/hari.$m^2$

Number of Weir Loading : 1

Weir Loading : 150 $m^3$/day.m

Scour Velocity :12,53cm/s

Horizontal Velocity : 0,83 cm/s

The slope of the Wall Channels : 0,00097

After doing calculation, it will b shown at Table 3:

Table 3: Design Sedimentation from WWTP Hospital.

| Unit | Dimension | | | Residence time (h) |
|---|---|---|---|---|
| | Length (m) | Wide (m) | Head (m) | |
| Sedimentation I | 5 | 0,4 | 3,425 | 2,5 |
| Sedimentation II | 5 | 0,4 | 3,425 | 2,5 |

4. Chlorination.

Debit (Q) = 0.138 L / dt

*The planned concentration = 4%

Chlorine that is used contains (Solution) = 60% Chlorine

Chlorine density = 1.2 kg/L

Capacity affixing maximum = 600 cc / min

Chlorine binding force = 1.18 mg/L→ DPC

Residual chlorine planned = 0.4 mg / L

*Efficiency = 65%

Dose Chlorine = DPC + Time chlorine = 1.18 mg / L + 0.4 mg / L = 1.58 mg / L

Requirement for 2.5 hours = 0.00327 kg

*Chlorination basin capacity = 1,242 m3

After the chlorination process, the treated water supplied to the sump. As for the design of a tank shown in Table 5. The calculation can be shown at Table 4:

Table 4: Design Chlorination from WWTP Hospital.

| Unit | Dimension | | | Power (watt) | Residence time (h) |
|---|---|---|---|---|---|
| | Length (m) | Wide (m) | Head (m) | | |
| Sump | 3,91 | 3,91 | 4,21 | - | 24 |

Table 5: Design Sump from WWTP Hospital.

| Unit | Dimension | | | Residence time (h) |
|---|---|---|---|---|
| | Length (m) | Wide (m) | Head (m) | |
| Chlorination | 1,07 | 1,07 | 1,07 | 2,5 |

Generally, calculation of dimensions in the planning of these is shown in Table 6:

Table 6: Design WWTP Hospital.

| Unit | Dimension | | | Residence time (h) | Power (watt) |
|---|---|---|---|---|---|
| | Length (m) | Wide (m) | Head (m) | | |
| Equalisation | 2 | 1 | 3,3 | 2,5 | - |
| Coagulation | 0,22 | 0,22 | 0,52 | 2,5 | 3,05 |
| Floculation | 0,22 | 0,22 | 0,52 | 2,5 | 3,05 |
| Coagulation | 0,22 | 0,22 | 0,52 | 2,5 | 3,05 |
| Floculation | 0,22 | 0,22 | 0,52 | 2,5 | 3,05 |
| Sedimentation | 5 | 0,2 | 3,425 | 2,5 | - |
| Chlorination | 1,07 | 1,07 | 1,07 | 2,5 | 25 |
| Sump | 3,03 | 3,03 | 3,33 | 24 | - |

5. Calculation Result WWTP.

In this planning, hospital waste flow of water obtained as follows: 60 $m^3$ / day so that calculation Result WWTP refers to parameters of efficiency reduction of some of the literature includes text book Decentralised Wastewater Treatment in Developing Countries and Treatment and Reuse Fourth Edition by Metcalf and Eddy. After calculation can be shown at Picture 3 dan Table 7:

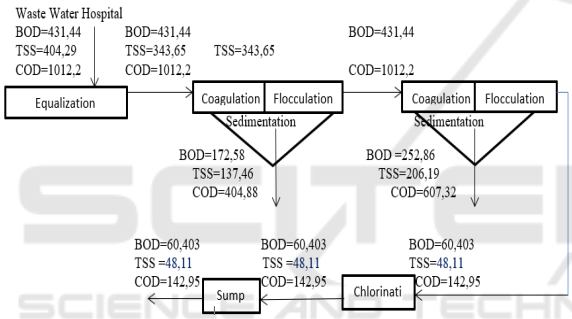


Figure 3: Mass Balance Desain IPAL.

Table 7: Mass Balance and Efficiency Design WWTP.

| Section | Parameter | | |
|---|---|---|---|
| | BOD (mg/L) | COD (mg/L) | TSS (mg/L) |
| Influent | 431,44 | 404,29 | 1012,2 |
| Equalization | 0%<br>431,44 | 0%<br>343,65 | 15%<br>1012,2 |
| Coagulation and Floculation I | 60%<br>172,58 | 60%<br>137,46 | 60%<br>404,88 |
| Coagulation and Floculation II | 60%<br>69,032 | 60%<br>54,98 | 60%<br>161,95 |
| Chlorination | 65%<br>44,87 | 65%<br>19,24 | 65%<br>56,68 |
| Sump | 44,87 | 19,24 | 56,68 |
| Effluent by design | 44,87 | 19,24 | 56,68 |
| *Standard Dispose Water | 75* | 100* | 100 |

*based on KEPUTUSAN MENTERI NEGARA LINGKUNGAN HIDUP NO. 58 TAHUN 1995 TANGGAL 21 DESEMBER 1995

# 4 CONCLUSIONS

Hospital Waste water treatment at one of the hospitals in Indonesia. debits 60 $m^3$ / day. WWTP hospital building consists of equalization bath, flocculation coagulation bath, chlorination bath and sump. Wastewater treatment plant at the hospital are planned can be disposed into environment because has fit to the standards.

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# REFERENCES

Ayu Taurini, Putri. 2014. *Perencanaan Pengolahan Air Limbah Sistem Setempat (On Site) dengan Sistem Tangki Septik Bersusun dengan Filter pada Perumahan PT Pertamina UP III Plaju Palembang)*. Fakultas Teknik Jurusan Teknik Sipil, Universitas Sriwijaya.

Basak, NN. 2003. *Environmental Engineering*. Tata Mc Graw Hill: New Delhi.

Batterman S. (2004). Findings on an Assessment of Small-scale Incinerators for Health-care Waste. WHO, Geneva, Switzerland.

Batterman S, (Website Updated April 9, 2008), Mozambique Program for Healthcare facility waste treatment, The Regents of the University of Michigan School of Public Health (MSPH).

Crites, Tchobanoglous. 2003. *Small and Decentralized Wastewater Management System.* McGraw-Hill. Singapore.

Depkes RI, 2004. *Keputuan Menteri Kesehatan No.1204/MENKES/SK/2004 tentang Persyaratan Kesehatan Lingkungan Rumah Sakit*, Jakarta: DepkesRI.

Eckenfelder, W Wesley Jr. 2000. *Industrial Water Pollution Control*. The McGraw Hill Companies. Singapore.

Ginting Perdana, 2007. *Sistem Pengelolaan Lingkungan dan Limbah Industri*,Bandung : CV. Yrama Widya.

Hermana, Joni. 2010. *Dasar - dasar Teknik Pengelolaan Air Limbah*. Jurusan Teknik Lingkungan. Institut Teknologi Sepuluh November, Surabaya.

Kementerian Pekerjaan Umum. 2012. *Pedoman Pengelolaan Program Hibah Air Limbah,* Direktorat Jenderal Cipta Karya, Jakarta.

Kementrian Kesehatan RI. 2011. *Seri Sanitasi Lingkungan: Pedoman Teknis Instalasi Pengolahan Air Limbah Dengan Sistem Biofilter Anaerob Aerob Pada Fasilitas Pelayanan Kesehatan.* Kementrian Kesehatan RI, Direktorat Jenderal Bina Upaya Kesehatan.

Metcalf & Eddy, Inc. 2004. *Wastewater Engineering: Treatment, Disposal and Reuse 4th Edition*. Mc Graw Hill. New York.

Siregar A., 2005. *Instalasi Pengolahan Air Limbah*, Yogyakarta: Kanisius.

Said, Nusa Idaman, 2006. *Instalasi Pengolahan Air Limbah Rumah Sakit*. Kelompok Tehnologi Pengolahan Air Bersih dan Air Limbah, Pusat Pengkajian dan Penerapan Lingkungan, BPPT, Jakarta.

Zaenal, A.Z, 2005. *Analisis Bangunan: Menghitung Anggaran Biaya Bangunan*. Gramedia PustakaUtama, Jakarta.

Wulanarum, Rina. 2008. *Laporan Tugas Akhir: Perancangan Sistem Penyaluran dan Bangunan Pengolahan Air Buangan Domestik Kelurahan Rejowinangun Selatan Kecamatan Magelang Selatan.* Teknik Lingkungan UNDIP. Semarang.

Verlicchi, P et al., "Hospital effluents as a source of emerging pollutants: An overview of micropollutants and sustainable treatment options." Journal of Hydrology: Elsevier, (2010).