Waste Water Treatment of Hospital for Drinking Water Scale with Ozonation Method

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Abstract: Waste water from the hospital is containing organic compounds, chemical compounds and pathogenic microorganisms. Various studies have been done to process the hospital waste to fit quality standards so it can be disposal into the environment, but in this research, we conducted waste water treatment of hospital for drinking water using ozonation so the output not only fulfills as environmental quality standards, but it's expected output of hospital can be used as drinking water. Ozone is used as a disinfectant for killing microorganisms and water. The purpose of this research is to know the characteristics of wastewater in the hospital, know the results processed use the design of the hospital with ozonation if it is appropriate with drinking water standards. The research method is to study treatment of hospital waste water so that we can obtain WWTP and calculation result output of design WWTP (Waste Water Treatment Plant). The WWTP design made consisting of equalization bath, bath coagulation, ozonation bath and sump. Based on result, one of waste water of hospital in Indonesia with discharge is 28 m^3/day, the result BOD is 0.75 mg/L, COD is 2.4 mg/L, TSS is 18.94 mg/L, TDS is 1.81 mg/L and Total Coliform is zero. Waste water of hospital processed from this WWTP can be used as drinking water based on Minister of Health decree.

1 INTRODUCTION

Lately requirement of clean water, especially for drinking water is difficult to get cause of many water pollution factors. 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. Hospital wastewater may contain assorted microorganisms depending on the source. Various kinds of toxicities such as pharmaceutical waste, radio-nuclides, solvents and disinfectants for medical purposes with a high concentration for laboratory activities (Verlicchi, 2010). Of course, from the types of microorganisms, there are pathogenic microorganisms. 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 hospitalsls 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. However, much researches have been done only till the hospital waste disposal into the environment that passed quality standards, so if it wants to be drinking water, the water must get into the next process.

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In this research, we use the ozonation method for waste water treatment so we wish the output of the process in the hospital can be used as drinking water, because of ozonizer fit to kill bacteria - in the waste. Beside having a high efficiency, this type of Wastewater Treatment also can solve the limited land in the hospital. Ozone is a molecule made of three oxygen atoms that occurs naturally in the earth and that can also be manmade. Ozone is used as a disinfectant for killing microorganisms in the air and water. Many spas and hot tubs use ozone to keep the water free of algae and harmful bacteria. Ozone is also used for industrial and manufacturing purposes, as well as a bleaching and deodorizing agent. Ozone was chosen because it is a proven cost-effective disinfectant that improves the taste of the treated water and decreases unwanted disinfection by-products. However, ozone is more effective than chlorine in disinfecting the water. Ozone disinfection produces less disinfection by products which will enable these facilities to meet more stringent drinking water standards and regulations. Ozone also removes more trace organic compounds than chlorine which will result in better tasting and smelling water.

In this research, the data is obtained from one of the hospitals in Indonesia. there are many contaminants in wastewater. Contaminants in wastewater may include physical, chemical, and biological. 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, TDS and TSS. They should be able to done the processing of the water, but it also can be used as drinking water for the future. The objectives of this research are:

1. Knowing the characteristics of wastewater in the hospital.
2. Knowing the results of Wastewater treatment design of the hospital using ozonation method if it is appropriate with drinking water standards.

2 BASIC THEORY

Wastewater Treatment Plant (WWTP) is a structure that is designed to dispose of biological and chemical 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: Aluminium Hydroxide, or ferry hydroxide. 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. Ozonation Process:

Ozone is produced when oxygen (O2) molecules are dissociated by an energy source into oxygen atoms and subsequently collide with an oxygen molecule to form an unstable gas, ozone (O3), which is used to disinfect wastewater. Most wastewater treatment plants generate ozone by imposing a high voltage alternating current (6 to 20 kilovolts) across a dielectric discharge gap that contains an oxygen-bearing gas. Ozone is generated onsite because it is unstable and decomposes to elemental oxygen in a short amount of time after generation. Ozone is a very

strong oxidant and virucide only next to OH radicals. How effective ozone is, will depend entirely on the nature of the contaminant and is directly dependant in the chemistry involved in the process. Many other oxidation agents are often used in combination with ozone to provide increased efficacy. Agents such as peroxides, UV, and conditions of high pH assist ozone in the oxidation process. Ozone Chemistry is composed of a single bond and one double bond. The single bonds are weak and this leads to easy formation of free radicals. The double bond is as strong as the double bond of oxygen and so un reactive. Two resonance structure of ozone exists and they are interring convertible. The inter-convertabilty is so fast that at point of time ozone as seen as a blend of the two-resonance structure.

The mechanisms of disinfection using ozone include:

a. Direct oxidation/destruction of the cell wall with leakage of cellular constituents outside of the cell.
b. Reactions with radical by-products of ozone decomposition.
c. Damage to the constituents of the nucleic acids (purines and pyrimidines).
d. Breakage of carbon-nitrogen bonds leading to depolymerization.

When ozone decomposes in water, the free radicals hydrogen peroxy (HO2) and hydroxyl (OH) that are formed have great oxidizing capacity and play an active role in the disinfection process. It is generally believed that the bacteria are destroyed because of protoplasmic oxidation resulting in cell wall disintegration (cell lysis).

1. A healthy bacillus bacterial cell (waiting to ruin your day).
2. Zooming in closer, Ozone (light green) comes into contact with the cell wall. The cell wall is vital to the bacteria because it ensures the organism can maintain its shape.
3. As ozone molecules make contact with the cell wall, a reaction called an oxidative burst occurs which literally creates a tiny hole in the cell wall.
4. A newly created hole in the cell wall has injured the bacterium.
5. The bacterium begins to lose its shape while ozone molecules continue creating holes in the cell wall.
6. After thousands of ozone collisions over only a few seconds, the bacterial wall can no longer maintain its shape and the cell dies.

3 RESEARCH METHOD

3.1 Study of Literature

Overview and Hospital Waste, Technique Wastewater Treatment Hospital, Design Options WWTP and Research and Planning with different methods.

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 Result and Conclusion

Calculation of Dimension WWTP, The calculation of the final result output WWTP design results and Comparison of the results of the design output with

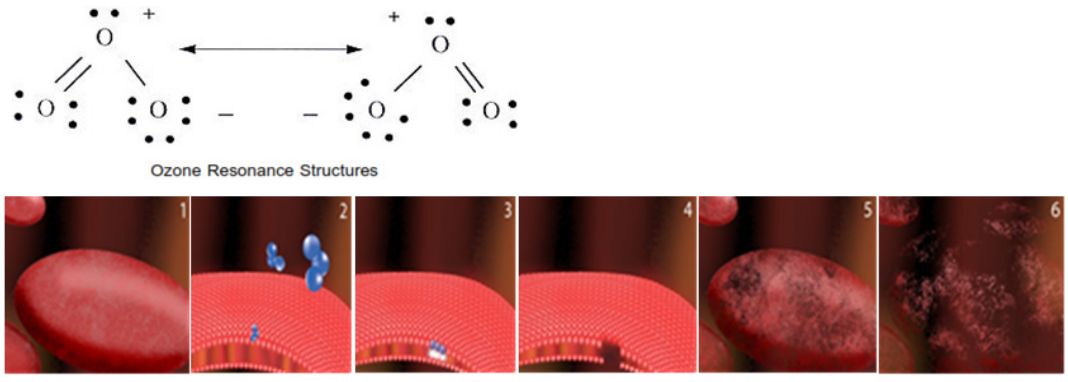

Figure 1: How ozone kills healthy bacteria.

the output results WWTP's in hospital.

4 RESULT AND DISCUSSION

4.1 Design Wastewater Hospital

To treat wastewater hospital, it is necessary to design that fits inside the hospital waste water treatment, the processing units used is composed of pre-treatment unit such as equalization bath, flocculation and coagulation treatment unit ozonation unit. In the treatment of coagulation and flocculation done a physical operation which aims to eliminate floating and dissolved solids in wastewater and wastewater preparing to enter the further treatment stages, namely treatment ozonation bath. In this ozonation bath will acts in killing bacteria present in the water and to eliminate most of the organic content in wastewater.

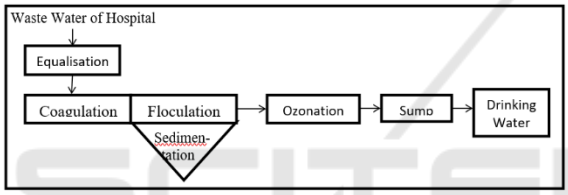

Figure 2: Diagram Block WWTP Hospital.

4.2 Calculation of Dimension WWTP

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 calculation, it can be show that in 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	1	0,5	3,3	28	1,54

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. 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: Aluminium Hydroxide (Alum).

*Concentration Of Alum : 75,5 ppm
*Power of stirrer motor : 3,05 Watt
*Flow rate Alum : 0,088 kg/h
*Solution Alum : 5%
*Flow rate air : 1,672 kg/h
*Total volume : 1,76 m^3
*Diameter Stirrer : 0,26 m

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

Table 2: Design Coagulation and Flocculation from WWTP Hospital.

Unit	Dimension			Residence time (h)	Power (watt)	Power of Stirrer Motor (rpm)	Height (m)
	Length (m)	Wide (m)	Head (m)				
Coagulation	1,21	1,21	1,51	4	3,05	100	0,096
Flocculation	1,21	1,21	1,51	4	3,05	20	0,096

3 Sedimentation

*Number of Weir Loading : 1
*Weir Loading : 140 $m^3/day.m$
*Over Flow Rate : 28 $m^3/day.m^2$
*Scour Velocity : 12,53 cm/s
*Horizontal Velocity : 0,78 cm/s
*The slope of the Wall Channels : 0,00097

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

Table 3: Design Sedimentation from WWTP Hospital.

Unit	Dimension			Residence time (h)
	Length (m)	Wide (m)	Head (m)	
Sedimentation	5	0,2	3,5	3

3. Ozonation

*Type Ozonizer: Plasma ozonizer PSTA BATAN
*Power: 48,61 Watt
*Voltage: 25 kV/1,5 kHz
*Flow rate ozon: 1,94 mg/det
*Ozon Concentration: 0,12 ppm
*Cost Ozone Requirements once: Rp 131,47

When ozone decomposes in water, the free radicals hydrogen peroxy (HO_2) and hydroxyl (OH) that are formed have great oxidizing capacity and play an active role in the disinfection process. It is generally believed that the bacteria are destroyed because of protoplasmic oxidation resulting in cell wall

disintegration (cell lysis). After the ozonation 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 Ozonation from WWTP Hospital.

Unit	Dimension			Power (watt)	Residence time (h)	Flow rate Ozone (mg/s)
	Length (m)	Wide (m)	Head (m)			
Ozonation	0,92	0,92	1,22	25	0,67	0,04

Table 5: Design Sump from WWTP Hospital.

Unit	Dimension			Daya (watt)	Residence time (h)
	Length (m)	Wide (m)	Head (m)		
Sump	3,03	3,03	3,33	-	24

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

Table 6: Design WWTP Hospital.

Unit	Dimension			Residence time (h)	Daya (watt)
	Length (m)	Wide (m)	Head (m)		
Equalisation	1	0,5	3,3	1,54	-
Coagulation	1,21	1,21	1,51	4	3,05
Floculation	1,21	1,21	1,51	4	3,05
Sedimentation	5	0,2	3,5	3	-
Ozonation	0,92	0,92	1,22	0,67	25
Sump	3,03	3,03	3,33	24	-

4.3 Calculation of Dimension WWTP

In this planning, hospital waste flow of water obtained as follows: 28 m3 / 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, we can obtain mass balance from design WWTP at Table 7 and Figure 3 (the units in mg/L):

Table 7: Mass Balance and Effisiency Design WWTP.

Section	Parameter				
	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	TSS (mg/L)	Bacteria (mg/L)
Influent	64,9	228,4	458	45	6300
Equalization	0% 64,9	0% 228,4	15% 389,3	15% 38,25	0% 6300
Coagulation and Floculation	60% 22,72	60% 79,94	60% 136,26	60% 13,3	60% 2205
Ozonation	96,7% 0,75	97% 2,4	86,1% 18,94	86,4% 1,81	100% 0
Sump	0,75	2,4	18,94	1,81	0
Effluent by design	0,75	2,4	18,94	1,81	0
Outlet of Hospital	7,1	21,67	116	2	620
*Quality of Drinking Water Standard	30**	12**	500*	500**	0*

*based on PERMENKES RI No.492/MENKES/PER/IV/2010

**based on PP RI No.82 on 2010

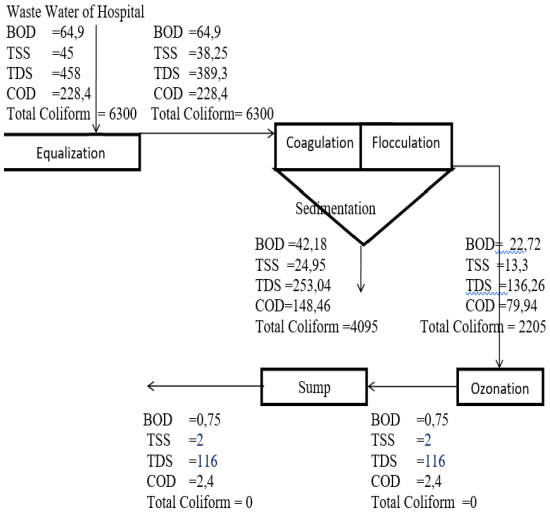

Figure 3: Mass Balance Desain IPAL.

5 CONCLUSION

Hospital Waste water treatment into drinking water at one of the hospitals in Indonesia. debits 28 m^3 / day using ozonation. WWTP hospital building consists of equalization bath, flocculation coagulation bath, bath and sump ozonation. Wastewater treatment plant at the hospital are planned to be produce effluents conforming to the standards drinking water quality standard health department.

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