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PROCEEDING

International Conference on Green Technology and Design

"A Dissemination platform for supporting green energy, green building, green automation, green transportation and environmental sustainability"

BANDUNG 4 – 5, DECEMBER 2019

BALE DAYANG SUMBI
INSTITUT TEKNOLOGI NASIONAL BANDUNG
WEST JAVA - INDONESIA

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BOOK OF PROCEEDING

INTERNATIONAL CONFERENCE ON GREEN TECHNOLOGY AND DESIGN

Bandung, 4 – 5 December 2019

Bale Dayang Sumbi
Institut Teknologi Nasional Bandung
West Java - Indonesia

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RUNDOWN ICGTD

Day	***Time***	***Description***
Wednesday, December 4th 2019	*08.00 – 08.30*	*Registration*
	08.30 – 09.00	*Welcome speech:* ***ICGTD Chair, Rector of Itenas*** *and Opening*
	09.00 – 09.45	*Plenary Session: "Assessment of Solar PV Power Potential over Asia Pacific Region with Remote Sensing and GIS"* ***Jeark A. Principe, Ph.D (Philipine)***
	09.45 – 10.30	*Plenary Session: "Emissions and Mitigation Scenarios for Residential Combustion of Solid Fuels in Developing Countries"* ***Dr. Ekbordin Winijkul (Thailand)***
	10.30 – 10.45	*Coffee Break*
	10.45 – 11.30	*Plenary Session: "Water Resource Management Framework For West Java Province, Indonesia"* ***Iwan Juwana Ph.D (Indonesia)***
	11.30 – 12.30	*Ishoma Break*
	12.30 – 16.45	*Parallel Sessions – as attached*
	16.45 – 19.00	*Closing*

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1	Niken Syafitri	Institut Teknologi Nasional Bandung	Green Automation	13.00	GSG Bale Dayang Sumbi Lt 1 (A)
2	Febrian Hadiatna	Institut Teknologi Nasional Bandung	Green Automation	13.15	
3	Florentinus budi setiawan	Soegijapranata catholic university	Green Automation	13.30	
4	Waluyo	Institut Teknologi Nasional Bandung	Green Automation	13.45	
5	Priyo Agus Setiawan	Politeknik Perkapalan Negeri Surabaya	Green Energy	14.00	
6	Lita Lidyawati	Institut Teknologi Nasional Bandung	Green Energy	14.15	
7	Bagus Rizky Pratama Budiajih	Institute Technologi Sepuluh Nopember	Green Energy	14.30	
8	Vibianti Dwi Pratiwi	Institut Teknologi Nasional Bandung	Green Energy	14.45	
9	Rachmad Ramadhan Yogaswara	Universitas Pembangunan Nasional (UPN) "Veteran"	Green Energy	15.00	
10	Lisa Kristiana	Institut Teknologi Nasional Bandung	Green IT	15.15	
11	Achmad Hizazi	Universitas Jambi	Green IT	15.30	
12	Dewi Rosmala	Institut Teknologi Nasional Bandung	Green IT	15.45	
13	Diki Ismail Permana	Institut Teknologi Nasional Bandung	Green Energy	16.00	
14	Yusup Miftahuddin	Institut Teknologi Nasional Bandung	Green IT	16.15	
15	Yudi Widiawan	Institut Teknologi Nasional Bandung	Green IT	16.30	
16	Rifqi Finaldy	Institut Teknologi Nasional Bandung	Green IT	16.45	
17	Hafidz Dayu Aditya	Institut Teknologi Nasional Bandung	Green IT	17.15	
18	Agus Hermanto	Institut Teknologi Nasional Bandung	Green Energy	17.30	
19	Meilinda Nurbanasari	Institut Teknologi Nasional Bandung	Green Energy	17.45	
20	Alfan Ekajati Latief	Institut Teknologi Nasional Bandung	Green Energy	18.00	
21	Lakshmanan Gurusamy	Universiti Malaysia Sarawak (UNIMAS)	Green IT	18.15	

No.	Name	Institution	Paper Topic	Presentation Time	Place
22	Abu Arif Jalaluddin	Universiti Malaysia Sarawak (UNIMAS)	Green IT	18.30	
23	Yanuar Z. Arief	Universiti Malaysia Sarawak (UNIMAS)	Green IT	18.45	
24	Nur Laela Latifah	Institut Teknologi Nasional Bandung	Green Building	13.00	GSG Bale Dayang Sumbi Lt 2 B
25	Riny Yolandha Parapat	Technische Universität Berlin (TU-Berlin), Berlin, Germany	Green Transportation	13.15	
26	Erwin Yuniar Rahadian	Institut Teknologi Nasional Bandung	Green Building	13.30	
27	Ardhiana Muhsin Machdi	Institut Teknologi Nasional Bandung	Green Building	13.45	
28	Tiara Anantika	Institut Teknologi Nasional Bandung	Green Building	14.00	
29	Wahyudi	Institut Teknologi Nasional Bandung	Green Building	14.15	
30	Dwi Prasetyanto	Institut Teknologi Nasional Bandung	Green Transportation	14.30	
31	Fred Soritua Rudiyanto Manurung	Institut Teknologi Bandung	Green Transportation	14.45	
32	Tarsisius Kristyadi	Institut Teknologi Nasional Bandung	Green Transportation	15.00	
33	Tarsisius Kristyadi	Institut Teknologi Nasional Bandung	Green Transportation	15.15	
34	Reza Phalevi	Institut Teknologi Nasional Bandung	Green Building	15.30	
35	Hendro Prasetiyo	Institut Teknologi Nasional Bandung	Green Building	15.45	
36	Ratna Agustina	Institut Teknologi Nasional Bandung	Green Transportation	16.00	
37	Jatmiko Wahyudi	Regional Development Planning Agency	Suistanability Environment	13.00	GSG Bale Dayang Sumbi Lt 1 (B)
38	Desti Santi Pratiwi	Institut Teknologi Nasional Bandung	Suistanability Environment	13.15	
39	Nguyen Thi Kim Oanh	Asian Institute of Technology (AIT)	Suistanability Environment	13.30	
40	Agung Pramudya Wijaya	Institut Teknologi Nasional Bandung	Suistanability Environment	13.45	
41	Edi Wahyu Wibowo	Politeknik LP3I Jakarta	Suistanability Environment	14.00	

No.	Name	Institution	Paper Topic	Presentation Time	Place
42	Taufan Hidjaz	Institut Teknologi Nasional Bandung	Suistanability Environment	14.15	
43	Elvira Rizqita Utami	Institut Teknologi Nasional Bandung	Suistanability Environment	14.30	
44	Farah Fauzia Raihana	Institut Teknologi Nasional Bandung	Suistanability Environment	14.45	
45	Byna Kameswara	Institut Teknologi Nasional Bandung	Suistanability Environment	15.00	
46	Ajeng Alya Hidrijanti	Institut Teknologi Nasional Bandung	Suistanability Environment	15.15	
47	Fenty Wastika Sari	Institut Teknologi Nasional Bandung	Suistanability Environment	15.30	
48	Yudi Adi Pratama	Institut Teknologi Nasional Bandung	Suistanability Environment	15.45	
49	Jono Suhartono	Institut Teknologi Nasional Bandung	Suistanability Environment	16.00	
50	Iredo Bettie Puspita	Institut Teknologi Nasional Bandung	Suistanability Environment	16.15	
51	Ronny Kurniawan	Institut Teknologi Nasional Bandung	Suistanability Environment	16.30	
52	Yulianti Pratama	Institut Teknologi Nasional Bandung	Suistanability Environment	16.45	
53	Maya Ramadianti Musadi	Institut Teknologi Nasional Bandung	Suistanability Environment	17.00	
54	Maya Ramadianti Musadi	Institut Teknologi Nasional Bandung	Suistanability Environment	17.00	
55	Soni Darmawan	Institut Teknologi Nasional Bandung	Suistanability Environment	17.15	
56	Soni Darmawan	Institut Teknologi Nasional Bandung	Suistanability Environment	17.30	
57	Rika Hernawati	Institut Teknologi Nasional Bandung	Suistanability Environment	17.45	
58	Ida Wati	Institut Teknologi Nasional Bandung	Suistanability Environment	18.00	
59	Caecilia Sri Wahyuning	Institut Teknologi Nasional Bandung	Suistanability Environment	18.15	
60	Fifi Herni Mustofa	Institut Teknologi Nasional Bandung	Suistanability Environment	18.30	
61	Enni Lindia Mayona	Institut Teknologi Nasional Bandung	Suistanability Environment	18.45	
62	Maharani Dian Permanasari, M. Ds., PhD.	Institut Teknologi Nasional Bandung	Green Design	13.00	GSG Bale Dayang

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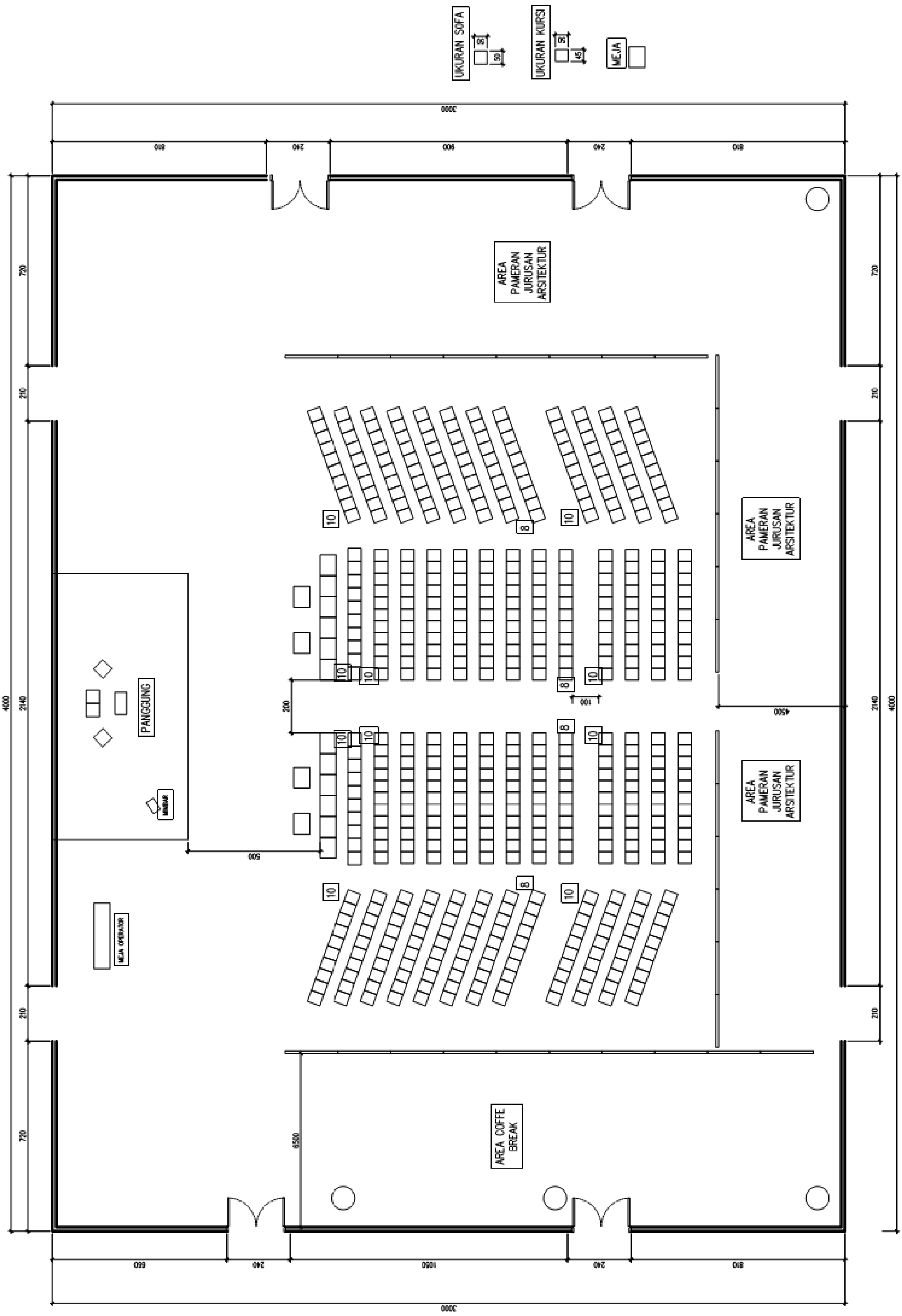
64	Maugina Rizki Havier	Institut Teknologi Nasional Bandung	Green Design	13.30	
65	Dwi Novirani	Institut Teknologi Nasional Bandung	Green Design	13.45	
66	Mohamad Arif Waskito	Institut Teknologi Nasional Bandung	Green Design	14.00	
67	Edi Setiadi Putra	Institut Teknologi Nasional Bandung	Green Design	14.15	
68	Sulistyo Setiawan	Institut Teknologi Nasional Bandung	Green Design	14.30	
69	Edwin Widia	Institut Teknologi Nasional Bandung	Green Design	14.45	
70	Agung Pramudya Wijaya	Institut Teknologi Nasional Bandung	Green Design	15.00	
71	Gita Permata Liansari	Institut Teknologi Nasional Bandung	Green Design	15.15	
72	M. Djalu Djatmiko	Institut Teknologi Nasional Bandung	Green Design	15.30	
73	Detty Fitriany	Institut Teknologi Nasional Bandung	Green Design	15.45	
74	Andri Masri	Institut Teknologi Nasional Bandung	Green Design	16.00	
75	Aditya Januarsa	Institut Teknologi Nasional Bandung	Green Design	16.15	
76	Bambang Arief Ruby,	Institut Teknologi Nasional Bandung	Green Design	16.30	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PANGGUNG
MIMBAR
MEJA OPERATOR
AREA COFFE BREAK

FOREWARD

Welcome to the 1st International Conference on Green Technology and Design. This conference takes place in Bandung, 4th December 2019 and become our first international conference in green technology and design.

It is our responsibility to contribute in the national development and sustainability, the Institut Teknologi Nasional (Itenas) Bandung through its Lembaga Penelitian dan Pengabdian kepada Masyarakat (LP2M) conducts this conference and draws upon the expertise of wide range of knowledge.

The ICGTD 2019 conference aims to promote research in the field of Green Energy, Green Building Green Automation, Green Transportation, Sustainability Environment, Green IT and Green Design, and to facilitate the exchange of new ideas in these fields among academicians, engineers, junior and senior researchers, scientists and practitioners. It also includes the plenary, keynote and invited speakers.

On behalf of Organizing Committee, it is a great pleasure to welcome you in Itenas Bandung and look forward to meeting you at ICGTD2019.

Warm regards,

Chair
Dr. Ir. Nurtati Soewarno M.T.

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A Study of Using Membranes Carbon Nanotubes Integrating with Ozone for Reducing Natural Organic Matter (NOM) Jatiluhur Dam

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***Abstract*— this paper investigates the implementation of carbon nanotubes membrane integrating with ozone technology in reducing Natural Organic Matter (NOM) where in this case used approach humic acid as representative of NOM. NOM is the one indication of impurities in water thus it needs to be remove the NOM contained in water especially for consumption demand. In this study, water sample was taken Jatiluhur dam. Membrane is capable to filter some of molecule which cannot be pass through the flow because of it have selective semipermeable properties. On the other hands Ozone is one of the strongest oxidizer that may well reduce impurities in water. This study was conducted by integrating Ozone and membrane process expected to improve membrane performance because of this oxidizer may also reduce fouling in membrane surface. There are three types of membranes being used that is pure PVDF, CNTs-P/PVDF, and CNTs-O/PVDF. The experiment was also conducted in different range of pH where the NOM content in permeate resulting from the process is analyzed.**

Keywords— Carbon Nanotubes, Membrane, NOM, Ozone, Water

I. INTRODUCTION

Jatiluhur dam is one of the water sources in Indonesia which has many functions. Its main functions are to meet the irrigation needs of paddy fields around 242,000 ha, the supply of raw water for DKI Jakarta and surrounding areas, power plants with an installed capacity of 187.5 MW, flood control in Karawang regency, Bekasi and Jakarta, water supply for industry and for fishery cultivation an area of 20,000 ha, for tourism and water sports[3]. Due to a lot of activities are conducted by residents in the river region flow can affect the quality of water and could be soiling the water. Polluter in water can be microorganism, organic, and inorganic compounds. This pollutants can cause change properties of water such as discoloration, odor, and taste[1].

Natural Organic Matter is a part of organic pollutant in water and its existence must be removed especially for the needs of water consumption. After living and growing matter throughout the ecosystem, such as humans, animals, plants, and microorganisms contain organic components are dying, the organic matter decomposes into NOM, and also the excretions of living matter are broken down through a reactive process into NOM[2]. NOM also indirectly influences which can cause problems, such as the formation of disinfection by products (DBPs), for example tri-halomethanes (THMs) due to chlorination. A study of drinking water quality in Rotterdam by J. Rook around 1972 stated that THMs were formed due to the reaction between chlorine and natural compounds such as "humic substance" in raw water [4]. In 1976, the National Cancer Institute stated that with a fairly high dose of chloroform compound which is the most common THMs compound, it can cause cancer in mice[5].

When the source water contains high NOM concentrations, this should be removed to a high extent during drinking water treatment[1]. Therefore, it needs a specific method to remove NOM content in water efficient and economically. There are several ways to remove NOM, one of them is with coagulation-flocculation process. This process is done by adding coagulant to water, this coagulant can be aluminum sulfate. But this process has a weakness in the clarification process because the separation process based on gravity takes a long time until the flocculants and clean water are separated[6].

A study by Fitria and Handayani 2010[7] given result removal with two staged coagulation process have higher efficiency at between 70 – 99%. Two stage coagulation works by double coagulation process with addition of alum twice in rapid stirring it was followed by flocculation. This is happen because addition of alum doses conducted in twice will improve the efficiency for organic content removal with alum hydroxide. At neutral pH (6,5-7,5) $Al_2(SO_4)_3$ will be hydrolyzed become $Al(OH)_3$, but amount of organic substance which is hydrophobic tend to react and adsorbed quickly with the newly formed hydroxide alum (precipitation), so that if the addition of coagulant twice then the removal not only happened to hydrophobic organic substance but also happened to hydrophilic organic substance because of organic content that have hydrophilic properties can be adsorb to the alum precipitant newly formed in the second addition of alum. The process carried out in this study is batches and sample of raw water were given alum as a coagulant. In its practice, the addition of alum is done twice with a variation that performed on the addition of alum as much as 1 / 3: 2 / 3, 1 / 2: 1 / 2, 2 / 3: 1 / 3 doses of the total of alum. As a result, in the given of alum dose at 1/3:2/3 ratio give the highest efficiency which is 98,98% on the sample of artificial water, while on the sample of raw water the highest removal efficiency given by alum dose at the ratio 2/3:1/3 which is 97,34%.

Another method for NOM removal is with Ozonation. Because of it is a strong oxidizer and acts as disinfection in water treatment against bacteria and viruses. In addition, oxidizing properties can also reduce the concentration of iron, manganese, sulfur and reduce or eliminate taste and odor[1].

Furthermore, NOM removal can also use membrane filtration. Membrane separation is commonly used and has become a modern separation technology. There are various type of membrane materials one of them are polymers. Membranes work by dividing the flow, one of flow can pass through the membrane layer and the other cannot. During the membrane filtration process, fouling will be possible occur due to a buildup of molecules that cannot pass through the membrane. Therefore, by combining the polymer material on the membrane with nanomaterial can increase the permeability of the membrane itself[9].

In this study, PVDF polymers is the material used on membranes. This membrane has been given the addition of nanomaterial in the form of Carbon Nanotubes (CNTs), the addition of CNTs to the PVDF membrane as a form of way to improve permeability of the membrane. An ozonation process is also carried out in this study which the PVDF polymer has a high compatibility with ozone[13]. So that the integration of these two processes is expected to be able to improve the performance of membrane in NOM removal.

II. METHOD

A. Materials

For sampling water on this study was carried out in the rainy season on the surface of Jatiluhur dam. Sodium hydroxide was bought in PT. Seger Chemical whilst Nitric acid, potassium iodide, and demineralized water were purchased from PT. Brataco Chemika, Indonesia. Humic acid to represent natural organic matter (NOM) for standardization were purchased from Sigma Aldrich. Membrane fabrication was described on previous studies from Aztari & Fauzia, 2017[6]. Briefly, the method involved: nanomaterial dispersion, homogenization of matrix membrane and fabrication of membrane by the immersion precipitation method. Ozone generator equipment used has the ability to produce ozone with a concentration of 3 mg / hour. According to Mulder, 1996 [12] there are two main parameters that determine membrane performance that is flux and selectivity. The membrane performances were evaluated by calculating membrane flux using the following equations:

$$J = \frac{V}{A.t} \qquad (1)$$

Where J is the water flux of membrane (L/m^2.h). V is volume of permeate (L) A is membrane area (m^2) and t is the operating time (h). While selectivity is expressed by a parameter, namely the coefficient of rejection were calculated using:

$$R = 1 - \frac{Cp}{Cf} \qquad (2)$$

Where R is rejection factor, Cp is the concentration of solute in feed (mg/L) and Cf is the concentration of solute in permeate (mg/L).

B. Procedure Preparation of Humic Acid Mother Liquor

To make a Humic Acid mother solution first, prepared NaOH solution at pH ≥ 9 by dissolving 0.1 gram of NaOH into 200 mL demineralized water then poured the NaOH solution into a 500 mL volumetric flask. After that, prepare 0.025 g of humic acid and put in a 500 mL volumetric flask containing NaOH solution. Then add the demineralized water to the measuring flask limit line. Stir the humic acid solution that has been added to NaOH for 3 hours until it is homogeneous and filtered the solution using 0.45μm Buchner filter.

C. Preparing NOM Standard Solution

In making standard Natural Organic Matter (NOM) solutions with a concentration of 5 mg/L, 10 mg/L, 15 mg/L, 20 mg/L and 25 mg/L. Take 50 mL of the mother liquor then dilute to 100 mL in a 100 mL volumetric flask to obtain a HA concentration of 25 mg / L. Then, do the same procedure to make another standard solution with a concentration of 5 mg/L, 10 mg/L, 15 mg/L, and 20 mg/L through dilution from the mother liquor

D. Integration of Ozone and Membrane in Jatiluhur Dam

In is about to prepare 500 mL of demineralized water in a beaker. Turn on the button of compressor in ozone generator while opening the valve so that air can flow. Contact the demineralized water with ozone for 5 minutes. Prepare sample water then as much as 500 mL while arranged the pH set. Water samples that have been ready will be put into the tank Prepare membrane which will be used on membrane filtration device. Contact ozone with the prepared sample for 1 hour while pumping the resulting ozonation solution to the flat membrane by adjusting the operating pressure at 4 bars and set the flow rate. Accommodate permeate output and take samples every 1, 2, 5, 10, 15, 30, and 60 minutes. Do the same procedures for other variations of pH.

E. Analysis of UV-Vis Spectrofotometers

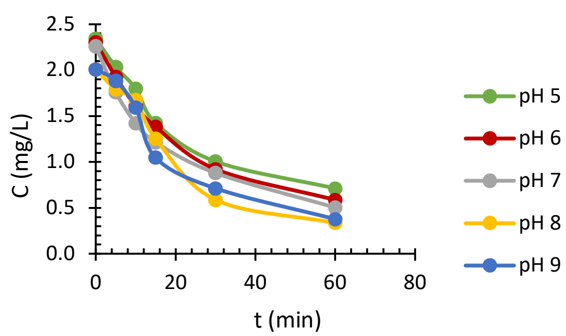
This analysis aimed to observe the components that exist before and after the NOM removal process. Observations were made to ensure reduced levels of NOM after the removal process. Observations were made by making a calibration curve at the maximum wavelength, after which checking the NOM concentration were measured by a UV-Vis spectrophotometer (Model Genesys 10 UV, Thermo Electron Corporation, USA) using a pre-determined calibration curve at a wavelength of 254 nm.

III. RESULT AND DISCUSSION

A. Process NOM Removal with Integration of Ozone and Membrane Technology

In this study, sample water which has been contacted with ozone would be forwarded to flat membrane filtration. This process conducted for 60 minutes. From the test results concentration of the sample was obtained at 2.3 mg/L which would be filtered by pure PVDF membrane, CNTs-P/PVDF membrane, and CNTs-O/PVDF membrane under conditions of pH 5, 6, 7, 8 and 9. The use of ozone in water treatment systems is as disinfection. Ozone is a strong oxidizer (E = 2.07 V) which is able to reduce NOM levels from water samples to a certain extent[11]. The ozone contact in this study aims to reduce the content of NOM in the sample used by oxidizing the NOM in the sample so that the aromatic structure of the NOM will change to a simpler structure, resulting in decreased NOM levels from sample water. Ozone is able to make aromatic ring division and depolymerization, the decomposition of organic compounds into two or more molecules will cause a decrease in molecular weight [10].

When viewed from the sieving mechanism, membranes have small pores that can only be passed by molecules that are smaller than the membrane pores. In this case, humic acid will be stuck on the surface of the membrane because it has a molecular size that exceeds the size of the membrane pores, while water that has a smaller molecular size can pass through the membrane as a permeate.



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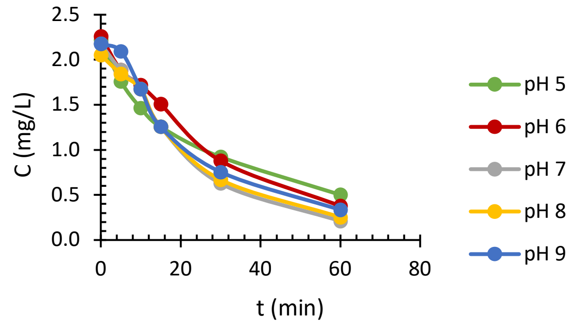


(b)

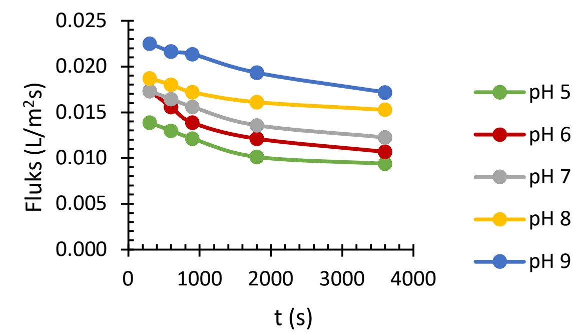
Fig. 2. NOM Profile Concentration to Time (a) CNTs-P/PVDF Membrane and (b) CNTs-O/PVDF Membrane

As NOM removal results are shown in Figure 2, integration of the two processes can be used as a NOM removal process as evidenced by a decrease in permeate concentration when compared with the concentration of feed. This process can occur because ozone can react quickly by breaking off unsaturated bonds and the aromatic ring that the NOM has so that the molecular weight decreases. Decreasing the molecular weight of NOM will produce more carbonyl, carboxyl, hydroxyl, alkoxy, and amino groups which have more hydrophilic properties compared to their parent molecules[11].

On the other hand, the process in this study used membrane technology which is a selective semipermeable resistance that can prevent the movement of certain molecules in a specific way. Poly(vinylidene) fluoride (PVDF) was chosen as a membrane material used because of its high compatibility with ozone[13]. The membrane has a smaller pore than the molecular size of the NOM so that many NOMs are retained on the surface of the membrane. This is proven by two types of membrane giving result concentration of NOM has decreased every time. From the Figure 2, it can also be seen start from 30^{th} minute that the decreasing of NOM concentration is not that significant and relatively small this is due to the occurrence of fouling on the surface of membrane so that water cannot enter through the pores of membrane. Fouling occurs due to blockage of the membrane pores due to being covered by retained particles or called foulant, if the process continues to do then the foulant will accumulate and cause the membrane flux to decrease so that the concentration of permeate obtained reduced but not that significant. NOM molecules that restrained in the membrane pore due to this fouling process cause an increase in resistance, this resistance can help the membrane in the elimination process so that the concentration of permeate becomes smaller. As a result integrating process, it is proven that this can remove NOM content in Jatiluhur dam water due to a decrease in concentration of NOM on feed solution.

B. Effect of Flux on Time at Various pH in the NOM Removal

Sampling in this study was carried out during the rainy season. Based on the characterization of Jatiluhur dam water that has been carried out by [14] stated that NOM in Jatiluhur dam water tends to be more dominant hydrophobic both in the rainy and dry season. There are three types of membranes with nanomaterial are used in this study and one pure membrane polymer as a comparison there is pure PVDF membrane, CNTs-P/PVDF membrane, and CNTs-O/PVDF membrane.



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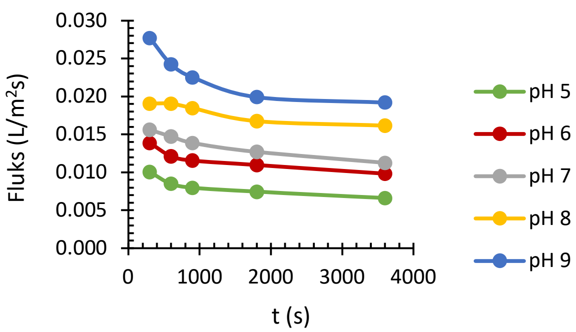
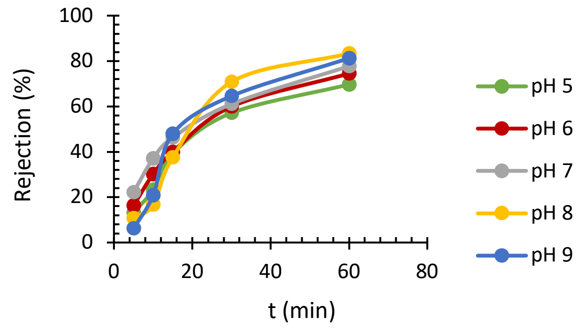


(b)

Fig. 3. Membrane Flux Trends of NOM Feed Solutions Filtered (a) CNTs-P/PVDF Membrane and (b) CNTs-O/PVDF Membrane

Figure 3 has shown effect of difference pH on membrane flux. The permeate flux obtained decreased in time as a result of fouling occur during process. Fouling would be blockage in pores of membrane and resulted amount of permeate become less. The best flux is obtained at pH 9 this occurs because at high pH NOM deprotonation will be happened so that resulting in an increase in the amount of negative charge. This could be increase the electrostatic repulsion between the charge on the membrane and the NOM molecule. Whereas in pH 5 conditions produce the lowest flux because of protonation will be happen in NOM substance and tend to aggregate to form a solid macromolecule through hydrogen bonds. At pH 5 the electronegativity is low so that more NOM molecules are held in the membrane because there is a pulling process between the molecule of NOM and membrane and decreases the value of flux obtained because fouling occurs faster.

C. Membrane Rejection Performance as Function of Time at Various pH in the NOM Removal Process



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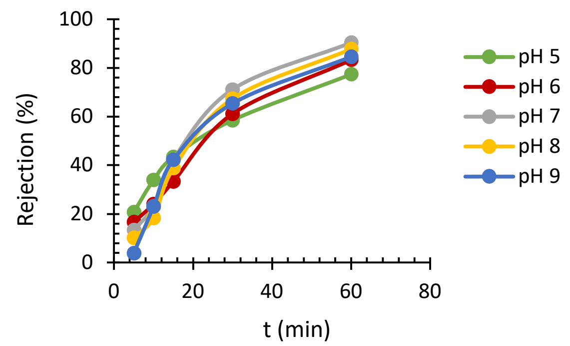

(b)

Fig. 4. Membrane Solute Rejection Performance (a) CNTs-P/PVDF Membrane and (b) CNTs-O/PVDF Membrane

The value of pH affects membrane rejection performance as it shown in Figure 4. The higher value of pH will deprotonate and increase the amount of negative charge. It would be electrostatic resistance between the membrane charge and the NOM charge so that the chance of NOM molecules which can pass through membrane layer would be decrease. At the lower pH NOM molecules would be restrained on to the membrane itself due to the attraction each charge and the shape of the NOM molecules which tend to form more agglomerates. However, at low pH conditions NOM molecules might be staying at the membrane surface, but Figure 4 shows at pH 5 given the lowest result of membrane rejection. This happened because the ability of ozone in oxidation can cause the changing size of NOMs in so that the particles that are held up in the membrane might pass through the permeate flow.

For CNTs-P/PVDF membrane, at pH 9 membranes having a rejection that is lower than pH 8. This happened because at the conditions of pH 9 would cause more elements of hydroxide ions in water. The hydroxide ion in ozone decomposition, acts as an initiator that can accelerate the formation of non-selective radical OH which will help in the oxidation process. Hydroxyl radicals are also strong oxidation because they have a high value of standard potential (E = 2.8 V) [8] so that besides oxidized by ozone, NOM is also oxidized by the hydroxyl radicals formed. This causes more NOM to be formed which is smaller than the membrane pore so that it can pass through out to the permeate flow.

Whereas for CNTs-O/PVDF membrane given results at pH 8 and 9 have a rejection value lower than pH 7, this happened because, at higher pH conditions would cause more content of hydroxide ions in water. This hydroxide ion in ozone decomposition acts as an initiator that can accelerate the formation of non-selective radical OH which will help in the oxidation process. As a result, besides oxidized by ozone, NOM is also oxidized by hydroxyl radicals. It causes more NOM formed to become smaller than membrane pore so that NOM could go out to the permeate flow. On the other hand, highest rejection value was obtained at pH 7 due to the presence of an oxide group in the CNTs-O/PVDF membrane as a result of addition carbon nanotube on the polymer which had been functionalized with other elements (in this case oxygen). This causes the formation of radical OH much faster than which not functionalized with oxygen. Therefore at pH 8 and 9 for CNTs-O/PVDF membrane more NOM molecules are oxidized to a smaller size than the membrane pore and pass to the permeate flow.

D. Determination of Optimal Membranes in the NOM Removal Process

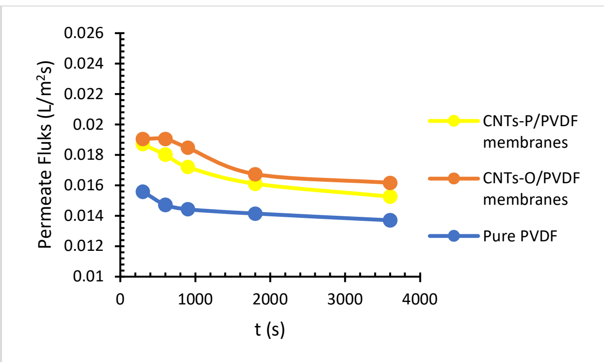

Fig. 5. Comparison of Time-Flux Curve of Various Types of Membranes

Figure 5 shown that CNTs-O/PVDF flux is higher than CNTs-P/PVDF this can be due to nature on CNTs-O/PVDF membrane is more hydrophilic so it would be easier for water to pass. This nature proven by value of contact angle for CNTs-O/PVDF membrane is 54° while CNTs-P/PVDF membrane is 65°[9]. The smaller the value of contact angle, membrane more become hydrophilic. As the result shown pure PVDF gave the lowest flux membrane. This might be happen because PVDF membranes without the addition of nanomaterials have more hydrophobic nature than membranes with addition of nanomaterials. This hydrophobic nature also increases the interaction between the surface of the membrane with NOM which have same hydrophobic nature thereby a lot of NOM will hold in the membrane pore and fouling would become faster.

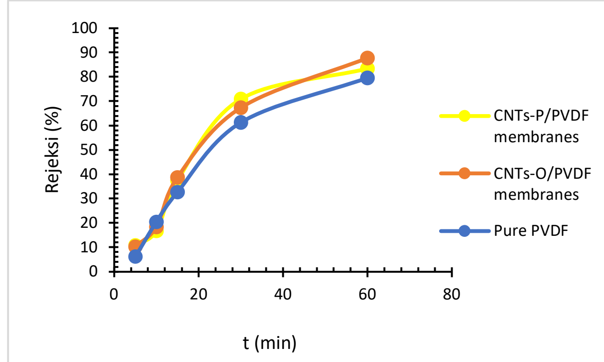

Fig. 6. The Time-Rejection Profile of Various Types of Membranes

From Figure 6 it can be seen that the highest membrane rejection is obtained in the CNTs-O/PVDF membrane compared to the CNTs-P/PVDF membrane. This happened because functional group in CNTs-O/PVDF membrane decreased contact angel value and increase electronegativity on potential zeta. Potential zeta (also known as electro kinetics potential) is formed on the surface of any material when coming into contact with liquid media. With the lower the potential zeta value, would be more electronegative. A more electronegative membrane will increase the electrostatic repulsion between the charge on the membrane and the NOM molecule thereby reducing fouling and increasing rejection.

For pure PVDF membrane gave result the lowest membrane rejection because it has hydrophobic nature compared than other membranes. Could also be shown from the contact angle value that is 84° for pure PVDF. Besides that, pure PVDF membrane has lower electronegativity value than others so that would make more fouling happen. This is caused by of NOM and pure PVDF membrane both have hydrophobic nature thus pure PVDF membrane tend to be fouled more than other membranes. However foulants on the membrane surface will be in contact with ozone so that the surface of the PVDF membrane oxidizes and helps clear the fouling where this is in accordance to research studied by Suhartono and Tizaoui, 2018 [13]. So that NOM that was initially held on membrane surface would be released and escape into permeate flow. Thus gave membrane rejection value of pure PVDF membranes became the lowest.

IV. CONCLUSION

This paper shows a result of integrating ozonization and membranes (bare PVDF, CNTs-P/PVDF and CNTs-O/PVDF membranes) which process were given various of pH. NOM removal process by using this method were able to eliminate the NOM content and gave membrane rejections up to 96 %. On the other hand, the best pH conditions was obtained at pH 8 by giving membrane rejection value 96.29% and flux of 0.0187 L / m^2 s. Among the three membranes used, Functionalized membrane types have a highest flux that is 0,0137 L / m^2 s, 0,0153 L / m^2 s, and 0,0162 L / m^2 s also membrane rejection that is 79,59 %, 83.33%, and 87.75% for pure PVDF, CNTs-P/PVDF and CNTs-O/PVDF membranes, respectively. Among the three membrane used, flux obtained by CNTs-O/PVDF membranes was the highest, while the lowest flux was obtained for the pure PVDF. This was due to addition of carbon nanotubes into membrane polymer which functionalized with oxygen would boost membrane performance, thus make CNTs-O/PVDF membranes more hydrophilic. The same thing with membrane rejection giving result that CNTs-O/PVDF membranes was the highest while the lowest flux was obtained for the pure PVDF. The same thing with membrane rejection giving result that CNTs-O/PVDF membranes was the highest while the lowest flux was obtained for the pure PVDF. This might be caused by CNTs-O/PVDF membrane decreased contact angel value and increase electronegativity on potential zeta. So it makes increase the electrostatic repulsion between the charge on the membrane and the NOM molecule thereby reducing fouling and increasing rejection. Pure PVDF membrane given result the lowest flux and membrane rejection. Because of stronger hydrophobic attraction between NOM and Pure PVDF membrane and influence of ozone injection is believed to be the main cause. For the high fouling in this type of membrane cause when given ozone injection, at first NOM attached in the surface of the membrane would be released and escape into permeate flow.

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