Peat water treatment using oxidation and physical filtration system and its performance in reducing iron (Fe), turbidity, and color

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Abstract. This research was conducted to treat peat water using oxidation and physical filtration system. Initially, the characterization of peat water was determined by three parameters, including iron (Fe), turbidity, and color. These three parameters exhibited values that exceeded the water standard limit. This study used two samples consisting of high and low iron content. Both samples were treated using NaClO for the oxidation-catalytic process and Manganese sand for the filter. The trial time is 67 minutes by calculating the value of each parameter every 10 minutes. The result shows different performance in the sample with low iron and high iron. In the sample with low iron (0.32 mg/l), the efficiency of reducing iron is 65.62%, the efficiency of reducing turbidity is 78.95% and the efficiency of reducing color is 78.77%. The results obtained showed differences in samples with high iron (6.75 mg / l). Iron reduction efficiency is 29.17%, turbidity reduction efficiency is 69.05% and color reduction efficiency is 61.32%.

1 Background

Water is essential and fundamental to all living forms and is spread over 70.9% of the earth's surface (Syafalni, Abustan, Brahmana, Zakaria, & Abdullah, 2013). Water is a basic need for human life (Rusdianasari, Bow, & Dewi, 2019). Freshwater is one of the basic human needs that is obtained from various sources, depending on local conditions (Zein, et al., 2016). By definition, clean water is water that is used for daily needs whose quality meets health requirements and can be drunk when cooked (Kemenkes, 1990).

Globally, there are lots of problem arising for the quality and quantity of water and in some cases it is getting more serious (Uddin, Alaama, & Nawi, 2018). It is essential to ensure the availability of local sources of water supply and even develops new potential sources of water such as from peat swamp forests to overcome future water shortages. (Syafalni, Abustan, Brahmana, Zakaria, & Abdullah, 2013). The scarcity of clean water sources caused peat water has been used as an alternative (Apriani, Masduqi, & Hadi, 2016), potential of water available in nature (Ardiansyah, Bahri,

Saryono, & Wawan, 2016) and an important natural resource comprising highly modified plant remains that accumulate in certain wet habitats. (McBrierty, Wardell, Keely, O'Neill, & Prasad, 1996). In terms of quantity, peat water has the potential to be a source of water for humans to use in their daily needs.(Daud, Asmura, & Sari, 2016).

Tropical peat swamp forests are most extensive in Southeast Asia where they are concentrated on the islands of Borneo and Sumatra, and on Peninsular Malaysia (Irvine, Vermette, & Mustafa, 2013). Peatlands are defined as land with water-saturated soil, formed from sediment originating from the accumulation of residues of weathered past plant tissue, with a thickness of more than 50 cm (Badan Sertifikasi Nasional, 2013). Peat can described as partially fossilized plant matter which occurs in wet areas where there is a lack of O₂. (Mathavan & Viraraghavan, 1989). As a wetland, peat water contains lots of Dissolved Organic Carbon (DOC). (Nuriman, Djajakirana, Darmawan, & Anshari, 2016). Peat water is a heterogeneous mixture of organic compounds that vary in terms of molecular weight (MW), chemical structure and functional groups. (Zulfikar, Setiyanto, Wahyuningrum, & Mukti, 2014).

Peat water has a high degree of acidity (pH between 3-5), low suspended particle content, and high brownish-red color intensity with high organic matter content. (Suherman & Sumawijaya, 2013), acidic (low pH), brown color and contains organic (Rusdianasari, Bow, & Dewi, 2019) (Eri & Hadi, Unknown) (Irvine, Vermette, & Mustafa, 2013). This is caused the water source in the area is peat water which based water quality parameter does not meet the requirements of the freshwater quality to WHO standard (Zein, et al., 2016) and peat water in general does not meet the clean water quality standards that are standardized by the Indonesian Ministry of Health through PERMENKES No.416/MENKES/PER/IX/1990. (Eri & Hadi, Unknown)

Several experiments of peat water treatments had been carried out (Apriani, Masduqi, & Hadi, 2016). Some of them are Multi-Soil-Layering (MSL) method with organic materials mixture is bagasse. (Zein, et al., 2016), electrocoagulation (Rusdianasari, Bow, & Dewi, 2019), membrane technology (Daud, Asmura, & Sari, 2016), coagulation, flocculation, sedimentation and filtration (Daud, Asmura, & Sari, 2016) and (Suherman & Sumawijaya, 2013), Upflow Anaerobic Filter (UAF) and Slow Sand Filter (SSF) (Eri & Hadi, Unknown), chitosan-silica composite (CSC) using (Zulfikar, Setiyanto, Wahyuningrum, & Mukti, 2014), Advanced Oxidation Process (AOP) and Reverse Osmosis (RO) method using a programmable logic-controller (PLC) unit. (Turnip, Hutagalung, Muchlis, & Amri, 2017), natural clays (Muhdarina, et al., 2018), adsorbents. (Syafalni, Abustan, Brahmana, Zakaria, & Abdullah, 2013). Various efforts and techniques need to be continued to find the most effective and efficient ways to manage clean water.

2 Materials and Methods

2.1 Materials

All materials used in this experiment namely NaClO 20 ppm, FerroVer Iron Reagent Powder Pillows 10 ml pk/100, aquadest, the equipment to measure iron, turbidity and color is HACH DR900, main tank, NaClO tank, main pump, injection pump, filter, and flow meter. Filter contains activated carbon (24 ml) and Mn sand (48 ml) with ϕ 0.020 m. The capacity filter is 0.093 l/min. The peat water was collected from region Kampung Baru and Rumbai Pesisir, Pekanbaru City, Riau Province, Indonesia. The characteristics of peat water are summarized in Table 1.

Table 1. The characteristics of peat water in Kampung Baru and Rumbai Pesisir, Pekanbaru-Riau Province

Parameter	Unit	Kampung Baru	Rumbai Pesisir
pH		5.5	6.1
Conductivity	us/cm	90	75
Temperature	°C	29.1	27.8
COD (Permanganate)	mg/L	20	20
Color	Pt/Co	212.00	605.00
Turbidity	NTU	19	42
Iron	mg/L	0.32	7.2
Manganese	mg/L	0.01	0.01
Hardness	mg/L	50.00	25.00
Free Chlorine	mg/L	0.02	0.01
Source		PDAM (Water company)	well

2.2 Methods

Ten liters of water is put into the main tank. The main pump is turned on and the flow rate is set according to the number specified by turning the dial pump, usually a flow rate of 0.093 liters/minute. Valve is set to backwash mode for 5 minutes. To assist with washing, column shaking can also be performed. The valve is turned in the direction of purification mode and is waited for 3 minutes to separate the clean media from the water from the backwash. 1000 ppm NaClO was added to the NaClO tank. The injection pump is turned on to drain the chlorine. If enough, the injection pump is turned off. The flow rate on the injection pump is set according to the specified flow rate then the injection pump and main pump are turned on. The experiments were carried out for 67 minutes and samples were taken every 10 minutes. After it's done, backwashing is done. Prototype parts that have been disassembled and exposed to chlorine are cleaned with clean water.

Fig. 1. Prototype oxidation and filtration system.

Fig. 2. Scheme of purification and backwash mode

3 Results and Discussion

This experiment is to study the removal efficiency of peat water treatment in terms of iron, color and turbidity parameters.

3.1 Parameter 1: Fe (mg/l)

Fig. 3. The concentration of Fe (mg/l) in Kampung Baru and Rumbai Pesisir processed by oxidation and filtration system

Based on Fig 3 it can be seen that the oxidation and filtration system can reduce Fe concentrations in Kampung Baru to below the standard quality standard since the 10th minute. The quality standard of Fe according to Permenkes No. 492 Tahun 2010. The concentration of Fe in the 0th minute was 0.32 mg / l and at the 67th minute, the concentration of Fe had reached

0.11 mg / l. This means that there is a decrease in Fe concentration of 65.62%. Meanwhile, the oxidation and filtration system cannot reduce Fe in the Rumbai Pesisir to below the quality standard that is 0.3 mg / l. At the 67th minute, Fe concentrations only reached 5 mg / l. Iron reduction efficiency in Rumbai Pesisir is 29.17%.

3.2 Parameter 2: Turbidity (NTU)

Fig.4. The concentration of turbidity (NTU) in Kampung Baru and Rumbai Pesisir processed by oxidation and filtration system

Based on Fig 4 it can be seen that the oxidation and filtration system can reduce the concentration of turbidity in Kampung Baru to below the standard quality standard since the 10th minute. Turbidity quality standard according to Permenkes No. 492 of 2010 was 5 NTU. In the 40th minute, Turbidity concentration reached 1 NTU but in the 50th minute, until the 67th minute it increased to 4 NTU. Turbidity concentration decreased by 78.95%. Meanwhile, the oxidation and filtration system is not able to reduce turbidity concentrations in Rumbai Pesisir to below the quality standard. In the 67th minute, the turbidity concentration reached 12 NTU. Turbidity reduction efficiency in Rumbai Pesisir is 69.05%.

3.3 Parameter 3: Color (Pt/Co)

Fig. 5. Concentration of Color (Pt/Co) in Kampung Baru and Rumbai Pesisir processed by oxidation and filtration system

Based on Fig 5 it can be seen that oxidation and filtration system cannot reduce color concentration in the Kampung Baru to below the quality standard 15 Pt / Co based on Permenkes No. 492 of 2010. At the 0th minute, the color concentration in the sample is 212 Pt / Co and at 67th minute color concentration becomes 45 Pt / Co. Although it has a 78.77% allowance, the color concentration is still above the standard. Oxidation and filtration system also cannot reduce color concentration in the Rumbai Pesisir to below the quality standard. At the 0th minute, the color concentration in the sample was 605 Pt / Co and at the 67th minute the color concentration was 234 Pt/Co. Color reduction efficiency in Rumbai Pesisir is 61.32%.

The concept of the oxidation and filtration system is divided into three parts. First is the pre-treatment section. At the pre-treatment section added an oxidizer in the form of chlorine. Second is the filter section which is the core of this oxidation and filtration system. In the filter, accelerated aggregation and Manganese (Mn) sand filtration processes occur. In principle, Fe^{2+} ions will be oxidized to Fe^{3+} to form a precipitate which will then increase in particle size so that it can be filtered by Mn sand.

The amount of organic content can reduce the oxidation efficiency of Fe^{2+} to Fe^{3+} . Because NaClO which functions as an oxidizer will oxidize many organic contents before oxidizing Fe^{2+} . This also affects the color removal.

Peat water containing lots of Fe^{2+} ions should use oxidation with H_2O_2 and Fenton systems. Because Fe^{2+} reacts with H_2O_2 will produce OH radical ions which can be used to oxidize organic compounds (Huling, Arnold, Sierka, & Miller, 2001)

4 Conclusion

Oxidation and filtration system can reduce Fe content, turbidity, and color in peat water. In the sample with low iron (0.32 mg/l), the efficiency of reducing iron is 65.62%, the efficiency of reducing turbidity is 78.95% and the efficiency of reducing color is 78.77%. The results obtained showed differences in samples with high iron (6.75 mg / l). Iron reduction efficiency is 29.17%, turbidity reduction efficiency is 69.05% and color reduction efficiency is 61.32%.

References

- [1] Apriani, M., Masduqi, A., & Hadi, W. DEGRADATION OF ORGANIC, IRON, COLOR AND TURBIDITY FROM PEAT WATER. *ARPJ Journal of Engineering and Applied Sciences*, 8132-8138 (2016)
- [2] Ardiansyah, Bahri, S., Saryono, & Wawan. Peat Water Treatment with Natural Inorganic Coagulant. *International Journal of Science and Research*, 389-394 (2016).
- [3] Daud, S., Asmura, J., & Sari, M. E. PENGOLAHAN AIR GAMBUT DENGAN MEMBRAN ULTRAFILTRASI SISTEM ALIRAN CROSS FLOW UNTUK MENYISIHKAN ZAT WARNA DENGAN PENGOLAHAN PENDAHULUAN MENGGUNAKAN KOAGULAN CAIR DARI TANAH LEMPUNG LAHAN GAMBUT. *Seminar Nasional Sains dan Teknologi Lingkungan II*, 110-114 (2016).
- [4] Eri, I. R., & Hadi, W. Kajian Pengolahan Air Gambut Menjadi Air Bersih dengan Kombinasi Proses UpFlow Anaerobik Filter dan Slow Sand Filter. *Teknik Lingkungan. Tesis FTSP-ITS Surabaya*, 1-8 (2008)
- [5] Huling, S. G., Arnold, R. G., Sierka, R. A., & Miller, M. R. Influence of peat on Fenton oxidation. *Water research*, **35**(7), 1687-1694 (2001).
- [6] Irvine, K., Vermette, S., & Mustafa, F. B. The 'Black Waters' of Malaysia: Tracking Water Quality from the Peat Swamp Forest to the Sea. *Sains Malaysiana*, 1539-1548. (2013).
- [7] Kemenkes. PERATURAN MENTERI KESEHATAN Nomor : 416/MEN.KES/PER/IX/1990 tentang Syarat-syarat Dan Pengawasan Kualitas Air. *Kementerian Kesehatan Republik Indonesia*. (1990)
- [8] Mathavan, G. N., & Viraraghavan, T. Use of peat in the treatment of oily waters. *Water, Air, and Soil Pollution*, **45**(1-2), 17-26. (1989).
- [9] McBrierty, V. J., Wardell, G. E., Keely, C. M., O'Neill, E. P., & Prasad, M. The characterization of water in peat. *Soil Science Society of America Journal*, **60**(4), 991-1000 (1996).
- [10] Muhdarina, M., Lingawati, A., Putri, K. A., Muharani, D., Awaluddin, A., & Bahri, S. Peat Water Treatment by Two Stages Coagulation

- Processes Using Natural Clay Based Liquid Coagulant. *International Journal of Science and Research*, 1058-1061. (2018).
- [11] Nuriman, M., Djajakirana, G., Darmawan, & Anshari, G. Z. Dissolved Organic Carbon (DOC) in Peat Water Suggest Limit to Decomposition. *International Peat Congress*, 54-57. (2016).
- [12] Bow, Y., & Dewi, T. Peat Water Treatment by Electrocoagulation using Aluminium Electrodes. In *IOP Conference Series: Earth and Environmental Science* (Vol. **258**, No. **1**, p. 012013). IOP Publishing. (2019, April).
- [13] Suherman, D., & Sumawijaya, N. Menghilangkan warna dan zat organik air gambut dengan metode koagulasi-flokulasi suasana basa. *Riset Geologi dan Pertambangan*, **23**(2), 125-137 (2013).
- [14] Syafalni, S., Abustan, I., Brahmana, A., Zakaria, S. N. F., & Abdullah, R. Peat Water Treatment Using Combination of Cationic Surfactant Modified Zeolite, Granular Activated Carbon, and Limestone. *Modern Applied Science*, **7**(2), 39. (2013).
- [15] Turnip, A., Hutagalung, S. S., Muchlis, I., & Amri, M. F. Peat Water Treatment based Wireless Data Acquisition System for Flexible Remote Monitoring. *INTERNETWORKING INDONESIA*, **9**(1), 27-32 (2017).
- [16] Uddin, A. B., Alaama, M., & Nawi, M. A. COMPARATIVE WATER QUALITY STUDY BETWEEN PEAT COAGULANT TREATED AND UNTREATED MODEL WATER BODIES. *ARPJ Journal of Engineering and Applied Sciences*, 1503-1511. (2018).
- [17] Zein, R., Mukhlis, Swesti, N., Novita, L., Novrian, E., Ningsih, S., et al. Peat Water Treatment by Using Multi Soil Layering (MSL) Method . *Der Pharma Chemica*, 254-261. (2016).
- [18] Zulfikar, M. A., Setiyanto, H., Wahyuningrum, D., & Mukti, R. R. (2014). Peat water treatment using chitosan-silica composite as an adsorbent. *International Journal of Environmental Research*, **8**(3), 687-710.