The Influence of Production Flow Rate and Raw Water Turbidity on Distributed Water Turbidity at Lambaro WTP

Fathul Mahdariza
Lecturer at Department of Environmental Engineering, UIN Ar-Raniry
Email: fathul.mahdariza@gmail.com

Abstract In order to fulfil the high water demand in Banda Aceh City, the Lambaro Water Treatment Plant (WTP) has been operating above its designed capacity. The produced and distributed water quality is decreasing in term of turbidity, as well. It is indicated by some events that the distributed water exceeds the allowed limit. The additional burden is that due to rainy season and human activities at river upstream, the raw water turbidity is higher than expectation in several occasions. This study is conducted to evaluate the influence of production flow rate and raw water turbidity on distributed water turbidity. The data used in this study is acquired from the SCADA system with time range from January to May 2014.

Keywords water treatment plant, turbidity, production flow rate, hydraulic capacity.

1. Introduction

Lambaro Water Treatment Plant (WTP) is operated by the Tirta Daroy Water Supply Company (Indonesian: PDAM Tirta Daroy). The raw water source is taken from Krueng Aceh River, which is situated in Aceh Besar Regency, approximately 8 km from the border of Banda Aceh City. After several capacity expansion and rehabilitation (PDAM Tirta Daroy, 2014), currently, the total designed hydraulic capacity for production of WTP Lambaro is 500 l/s and equipped with a controlling system so called SCADA (Murdani, et al., 2013). There is another WTP operated by Tirta Daroy namely Siron, with the capacity of 60 l/s (Murdani, et al., 2013).

The water process in Lambaro WTP in summary consists of 7 process stages: intake pumps, main distribution tower, 2 Clarifiers as first sedimentation ponds, 4 Pulsator tanks as secondary sedimentation ponds, 13 rapid sand filters, water reservoir and distribution pumps (Murdani, et al., 2013). Aluminum sulphate (alum) solution is injected at distribution tower which split flow to Pulsator 3 and 4 in order to enhance flocculation process at Pulsators, while caporite/chlorine solution dosing at the inlet of Reservoir is aimed to maintain the treated water quality during storage and distribution (SDC and PT NWC, 2007).

Due to high number of Non-Revenue Water (Abbreviation: NRW), Lambaro WTP is operating above its designed capacity (Murdani, et al., 2013). As the consequence of over capacity operation and aging, the installation condition is decreasing, as well. This study is conducted to evaluate the influence of production flow rate and raw water turbidity on distributed water quality. The data used in this study is acquired from the SCADA system with time range from January to May 2014.

2. High NRW Leads to Over Production and Low Quality

Based on Tirta Daroy annual report, the NRW in 2013 was 44.4% (PDAM Tirta Daroy, 2014) showing a significant gap in comparison to the suggested limit of 15% (Menteri Pekerjaan Umum RI, 2007). Consequently, the water demand in the city is increasing. The calculation of the water demand in the city of Banda Aceh based on the population 262,224 (BPS Kota Banda Aceh, 2014) and average consumption of 150 l/c.d for moderate city which population have private wells (Agustina, 2007; Ratnayaka, et al., 2009) contributes to 1,180,008 m^3 per month. If the NRW had been 15%, the amount of theoretical supplied water would have been only 1,388,245 m^3 per month from both Lambaro and Siron WTPs. As the comparison, the following Table 1 shows the actual distributed water from Lambaro WTP, which is calculated based on average number from SCADA data. The Figure 1 shows the graph of distributed water amount during April 2014 as an example.

Table 1: Distributed Water from Lambaro WTP

Period	Distributed Water (m3/month)
Jan 2014	1,872,023.04
Feb 2014	1,669,456.32
Mar 2014	1,831,065.84
Apr 2014	1,703,508.91
May 2014	1,652,417.08

Figure 1: SCADA Distributed Water Graphs during April 2014

As shown in Table 1, the monthly distributed water varies between 1,652,417 m^3 to 1,872,023 m^3. The number will increase even more after we add the number of distributed water from Siron WTP, which is averagely 207,360 m^3 per month (PDAM Tirta Daroy, 2014). Hence, the distributed water is approximately twice the theoretical amount when the NRW is only 15%.

Designed for 500 l/s hydraulic capacity and in order to maintain below overload limit of 125% (Foellmi, 2005), the Lambaro WTP is basically limited to production flow rate of 625 l/s. To get the production flow rate, the number of distributed water from SCADA is converted to the production flow rate in l/s. The obtained result is then paired with the quality of distributed water and the number of accident that turbidity is above 5 NTU, as shown in the Table 2.

Table 2: The Comparison of Production Flow Rate to Turbidity

Period	Production rate (l/s)	Average turbidity of distributed water (NTU)	Number of accident that turbidity is above 5 NTU
Jan 2014	699	0.28	1
Feb 2014	690	0.25	0
Mar 2014	684	0.28	1
Apr 2014	657	0.43	2
May 2014	617	0.12	0

As shown in the Table 2, the lowest production flow rate gives best quality supplied water in term of monthly average turbidity. Although all numbers of monthly average supplied water within the sampling period are still below the Indonesian standard limit of 5 NTU (Menteri Kesehatan RI, 2010), but 3 of 5 observed months have accident that the turbidity of distributed water is above 5 NTU. The obtained data also shows that if the production flow rate is below 625 l/s, the distributed water will be achieved in the best quality.

Furthermore, the high NRW contributes to the low rate of service coverage, as well. The service coverage of PDAM is calculated based on the following Eq. 1 (BPPSPAM, 2014):

$$Coverage = \frac{Connections \ x \ Average \ person \ per \ household}{Total \ population \ in \ served \ area} x \ 100\% \ ...(Eq.1)$$

The calculation of Tirta Daroy service coverage in 2013 with total connections of 40,639 and total population of 262,224 results that the number is still 77%. Should the NRW decrease, the water loss will be able to reduce the production flow rate or supply the new connection, and hence, increase the service coverage, as well.

3. The Influences of Raw Water Turbidity and Filters Condition

During the sampling period, Lambaro WTP faces several events that the raw water turbidity exceeds the designed turbidity of 500 NTU. Some causes of this high raw water turbidity are rainy season and declining condition of river due to human activities at the mainstream of the river. The following Figure 1 shows the example rough data from April 2014.

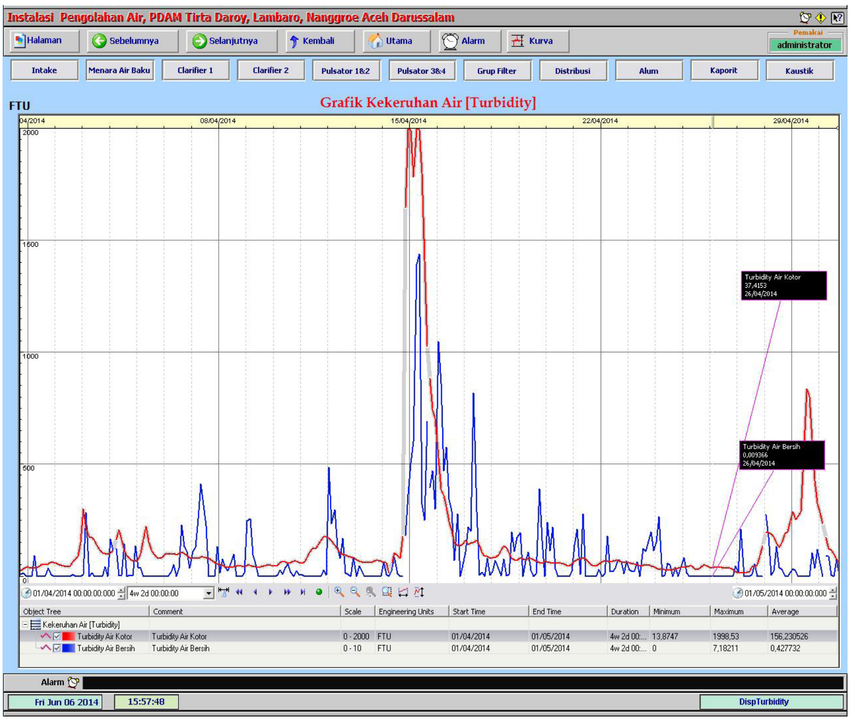

Figure 1: SCADA Turbidity Graphs for April 2014

The following Table 3 shows the translated turbidity data based on obtained SCADA data for the period January to April 2014.

Table 3: The Raw Water and Distributed Water Turbidity

Period	Average turbidity of raw water (NTU)	Number of days when raw water turbidity exceeds 500 NTU	Average turbidity of distributed water (NTU)	Number of accidents that distributed water turbidity is above 5 NTU
Jan 2014	80.80	3	0.28	1
Feb 2014	40.24	0	0.25	0
Mar 2014	36.54	0	0.28	1
Apr 2014	156.23	5	0.43	2
May 2014	160.81	6	0.12	0

Table 3 shows that during January, April and May 2014, there were several events that the raw water turbidity exceeded 500 NTU. When it is combined with the high average turbidity in April and May 2014, the average turbidity of distributed water gives contrast results, where April and May 2014 are the worst and the best results among the sampling period, respectively. The pattern is also applied for number of accidents when distributed water turbidity is above 5 NTU. The different condition between April and May 2014 is that during April 2014, the production flow rate was above the Lambaro WTP design, whilst during May 2014, the production flow rate was below the Lambaro WTP design (see Table 2).

As an alternative to solve high raw water turbidity problem, a pre-treatment in form of pre-sedimentation basin can be applied (Ray, et al., 2011). However, several factors i.e.: cost benefit analysis and land availability must be taken into account prior to the design, because pre-sedimentation basin typically needs a large area. Some other alternative measures such as modifying chemical dosage, improving flocculation, improving sedimentation process and modifying filtration process (Smith Jr, et al., 1991) are worth to discuss, especially by the technical division of Tirta Daroy in order to upgrade Lambaro WTP.

4. Conclusion

Based on the given result, both production flow rate and raw water turbidity play an important role on distributed water turbidity. When compared, production flow rate gives more effect than raw water turbidity. If the production flow rate is set below the design, the distributed water turbidity will be maintained below the allowed limit. A further study regarding the cause of high raw water turbidity and the feasibility study for plant modification are suggested to be conducted.

References

[1.] Agustina, Dian Vitta. *Analisa Kinerja Sistem Distribusi Air Bersih PDAM Kecamatan Banyumanik di Perumnas Banyumanik* (Eng: Performance Analysis of PDAM Water Distribution at Banyumanik Settlement). Semarang: Universitas Diponegoro. Thesis. 2007.

[2.] BPPSPAM. *Petunjuk Teknis Penilaian Kinerja PDAM* (Eng: Technical Guideline to Evaluate PDAM Performance). Jakarta: Kementerian Pekerjaan Umum. 2014.

[3.] BPS Kota Banda Aceh. Banda Aceh in Figures. Banda Aceh: BPS Kota Banda Aceh. 2014.

[4.] Foellmi, Steven N. Intake Facilities (In: Water Treatment Plant Design. Editor: Edward Baruth. New York: McGraw-Hill. 2005).

[5.] Menteri Kesehatan RI. *Peraturan Menteri Kesehatan Republik Indonesia Nomor Nomor 492/MENKES/PER/IV/2010 tentang Persyaratan Kualitas Air Minum* (Eng: Indonesian Public Health Minister Decree Number 492/MENKES/PER/IV/2010 about the Conditions of Drinking Water). Jakarta: Kementerian Kesehatan. 2010.

[6.] Menteri Pekerjaan Umum. *Peraturan Menteri Pekerjaan Umum Republik Indonesia Nomor 18/PRT/M/2007 tentang Penyelenggaraan Pengembangan Sistem Penyediaan Air Minum* (Eng: Indonesian Public Work Minister Decree Number 18/PRT/M/2007 about the Development Act on Drinking Water Providing System). Jakarta: Kementerian Pekerjaan Umum. 2007.

[7.] Murdani; Rohadi, Irwan; Efendi, Salman and Irwandi. *Instalasi Pengolahan Air PDAM Tirta Daroy Kota Banda Aceh* (Eng: Water Treatment Plant PDAM Tirta Daroy Banda Aceh). 2013. Presentation.

[8.] PDAM Tirta Daroy. *Laporan Keuangan Tahun 2013* (Eng: 2013 Annual Report). Banda Aceh: PDAM Tirta Daroy. 2014.

[9.] Ratnayaka, Don D.; Brandt, Malcom J.;Johnson, Michael. Twort's Water Supply – 6th Edition. Oxford: Elsevier. 2009.

[10.] Ray, Chittaranjan; Jasperse, Jay and Grischek, Thomas. Bank Filtration as Natural Filtration (In:Drinking Water Treatment. Editor: Ray, Chittaranjan and Jain, Ravi. Berlin: Springer. 2011).

[11.] SDC and PT NWC. Lambaro WTP Operation Manual. 2007.

[12.] Smith Jr, James E; Renner, Robert C; Hegg, Bob A and Bender, Jon H. Upgrading Existing or Designing New Drinking Water Facilities. New Jersey: Noyes Data Corp. 1991.