Available on line at:
http://ijwem.ulm.ac.id/index.php/ijwem

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

The Study of Clean Water Demand in Palangka Raya City, Central Kalimantan

ULFA FITRIATI[1], AULIA ISRAMAULANA[2] AND ACHYAT YULIANTO ADI SAPUTRA[3]

Civil Engineering Department, Lambung Mangkurat University, Indonesia

ABSTRACT

Palangka Raya as the capital city of Central Kalimantan become the center lane economy leading to increase population growth and clean water demand. There are still areas experiencing water shortage problems because of the difficulty of distributing clean water. Objectives of this study were to determine the amount of water demand in 2016, 2020, 2025, 2030 and 2035 to fulfill the community requirements. Water quality and supply capacity at the intake system are also be the purposes of this study. In this study, the calculation of population projections using statistical methods in which to observe the rate of population growth of the past to estimate the number of people in the future. There are several methods that can be used to analyze the population growth in the future, specifically Arithmetic, Geometric, Linear Regression, Exponential, and Logarithmic. For water quality field survey was conducted to test parameters such as temperature, electrical conductivity, the amount of dissolved solids, pH, turbidity, salinity, and dissolved oxygen measurements. The method in this research was using Arithmetic method because the correlation can be said to be excellent compared to other methods. Results of this research were clean water demand discharge town of Palangka Raya with consecutive results as follows in 2016; 2020; 2025; 2030; 2035 amounted to 451.03 L/sec, 737.14 L/sec, 1,162.34 L/sec, 1,425.83 L/sec, 1,571.12 L/sec. In the aspect of water quality, source of raw water used PDAM Palangka Raya unqualified the standards in terms of pH value, so the use of water was not safe for the residents of Palangka Raya city.

Keywords: population projections, clean water demand, water quality

INTRODUCTION

Palangka Raya as the capital city of Central Kalimantan Province. Palangka Raya city has an area of 2678.51 km^2 that consists of 5 districts with a population of approximately 252,105 people. Geographically Palangka Raya city located at coordinates 2 ° 12'36 "N 113 ° 55'12" East.

Most area of Palangka Raya a marshy area, just to the north of Palangka Raya, whose land is hilly. Palangka Raya is a city growing quite rapidly as seen from the geographical location in Central Kalimantan, Palangka Raya is located right in the middle of Central Kalimantan province, it makes Palangka Raya city into lanes and the center of economic development in Central Kalimantan, which resulted in increased population growth and the needs of economy in particular the need for clean water in Palangka Raya city.

In Palangka Raya city there are still areas that experienced the problem of lack of clean water, especially during the dry season, such as in the District of Sebangau and Rakumpit because the area were still largely forested and distance from the city center, especially the District Rakumpit the area is still very far from downtown which made it

Correspondence: Ulfa Fitriati, Civil Engineering Department, Lambung Mangkurat University, Indonesia. E-mail: ufitriati@ulm.ac.id

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

difficult to distribute clean water.

Based on data from Drinking Water Company (PDAM) Palangka Raya, the customers of PDAM in 2010 as many as 16,347 customers, then increased in the next year (2011) as many as 17,075 customers. PDAM Palangka Raya were expected to know how to calculate the clean water demand to people in the city of Palangka Raya for the future. It is necessary to avoid excess supply resulting in wastage of water distribution and shortages of water supply for the people of Palangka Raya. The measurements in this study were calculated by a statistical method to predict the clean water demand for the future, where the results of this calculation is expected to guide Palangka Raya city taps in order to meet water demand in the city of Palangka Raya.

The purposes of this study are:

1. Projecting population growth for 5, 10, 15, and 20 years.
2. Calculating the need for clean water in Palangka Raya city up to 20 years into the future.
3. Comparing the intake capacity of PDAM Palangka Raya to total water demand of up to 20 years in the future.
4. Analyzing the quality of water in the intake PDAM Palangka Raya.

MATERIALS AND METHODS

The method used in this calculation is a statistical method because it requires consideration in the rate of population growth in the past in order to calculate the rate of progression residents in the future and the need for clean water. There are several methods that can be used to analyze the rate of population growth in the future, namely: arithmetic, geometric, linear regression, exponential and logarithmic.

In the method with the value of r the closest one to the value of the smallest standard deviation (STD), then this is the method used. Value % growth sought by the formula:

$$r^2 = \frac{n\sum(P.Pn) - (\sum P)(\sum Pn)}{\sqrt{(n\sum(P)^2 - (\sum P)^2)(n\sum(Pn)^2 - (\sum Pn)^2)}}$$

$$\text{STD} = \sqrt{\frac{\sum\left(P_n - \overline{P_n}\right)^2}{n-1}}$$

$$\%\text{growth} = \frac{\sum Pi - \sum Pi-1}{\sum Pi-1} * 100$$

Description:

r^2 = correlation value

STD = standard deviation

P = total population

P_n = total population in all n

$\overline{Pn}$ = average the total population (P_n)

n= time.

Factors affecting the projected need for clean water:

1. Population projections should be made for 5 year intervals during the planning time.
2. Water use (Liter person^{-1} day^{-1}). The rate of water consumption is projected every 5 years interval.
3. Service level and coverage.
4. Water requirements for installation and operational requirements.
5. Loss or leakage water factors.

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

In the analysis of water demand, water demand taken into account include the water demand of domestic and non-domestic water demand.

Standard domestic water demand according to the Directorate General of Cipta Karya, Ministry of Public Works, 2001 can be seen in Table 1.

Table 1. Domestic Water Demand

No.	The Categories of Cities	Water demand (L p^{-1} d^{-1})		Comparison HC – PH
		Home Connection (HC)	Public Hydrant (PH)	
1	Metropolitan City	190	30	90-10
2	Large City	170	30	80-20
3	City Average	150	30	80-20
4	Small Town	130	30	70-30
5	City District / Village	100	30	70-30

(Source: Ministry of Public Works. 2007)
Criterion service each HC = 3-6 people / house
Criterion service each PH = 100 people/ PH
Non-domestic : criteria of water demand based on the type of facility

To calculate water demand based facilities/domestic water demand, water demand standard table required by the facilities (non-domestic) which is presented in table 2.

Table 2. Water Demand Standard Based Facilities (non-domestic)

	Type of Facilities	Unit	Water Requirement
EDUCATIONAL FACILITIES			
1	Kindergarten	Liter $person^{-1}$ day^{-1}	15-30
2	Elemantary School	Liter $person^{-1}$ day^{-1}	15-30
3	Junior High School	Liter $person^{-1}$ day^{-1}	15-30
4	Senior High School	Liter $person^{-1}$ day^{-1}	15-30
5	College	Liter $person^{-1}$ day^{-1}	15-30
PLACES OF WORSHIP			
1	Mosque	Liter $unit^{-1}$ day^{-1}	800-2000
2	Little Mosque (*Musholla)*	Liter $unit^{-1}$ day^{-1}	300-1000
3	Churches	Liter $unit^{-1}$ day^{-1}	200-600
4	Temple / monastery (*Pura*)	Liter $unit^{-1}$ day^{-1}	100-500
HEALTH FACILITIES			
1	Public Hospital	Liter bed^{-1} day^{-1}	200-400
2	Maternity Hospital	Liter $unit^{-1}$ day^{-1}	600-1000
3	Community Health Center (*Puskesmas*)	Liter $unit^{-1}$ day^{-1}	1000 – 1200
4	Public Health Sub-centers / clinics	Liter $unit^{-1}$ day^{-1}	800-1200

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

Table 2 (Continued)

COMMERCE & SERVICES FACILITIES			
1	point / store	Liter unit^{-1} day^{-1}	6-12
2	Market	Liter unit^{-1} day^{-1}	2500-5000
3	Supermarket	Liter unit^{-1} day^{-1}	1500 – 2500
4	Restaurant	Liter seat^{-1} day^{-1}	40-140
5	Cooperative	Liter unit^{-1} day^{-1}	500-1000
6	Bank	Liter unit^{-1} day^{-1}	1100-1500
8	Terminal station	Liter unit^{-1} day^{-1}	2000-45000
UTILITIES, RECREATION and SPORTS			
1	Government Offices		
	a. Village office	Liter person^{-1} day^{-1}	10-50
	b. Sub District office	Liter person^{-1} day^{-1}	10-50
	c. District office	Liter person^{-1} day^{-1}	10-50
	d. Autonomous agencies	Liter person^{-1} day^{-1}	10-50
	e. Government enterprise	Liter person^{-1} day^{-1}	10-50
2	Cinema	Liter unit^{-1} day^{-1}	1000-3000
3	multipurpose building	Liter unit^{-1} day^{-1}	1000-3000
4	Hall meetings	Liter unit^{-1} day^{-1}	1500-2000
5	hotels / inns	Liter bed^{-1} day^{-1}	75-150
6	Arena sports	Liter unit^{-1} day^{-1}	1200-1600
7	Swimming pool	Liter unit^{-1} day^{-1}	1000-1300
INDUSTRIAL ACTIVITY			
1	large industry	Liter person^{-1} day^{-1}	25
2	Industrial	Liter person^{-1} day^{-1}	25
3	small industry	Liter person^{-1} day^{-1}	25

(Source: Ministry of Public Works. 2007)

In this study, first the literature study is done to obtain the necessary community supply water sources. Then the formulation of the issues to be raised is determined to calculate clean water demand required by Palangka Raya city. Data collection is the next step in this research, the data obtained in the form of primary data and secondary data. Primary data are data that is obtained directly from the source. The primary data in the form of interviews, water quality at the intake system collect by using a U-50 HORIBA *(multi water quality* checker), and water quality data of (pH, TDS, EC, and temperature) PDAM Palangka Raya city. Secondary data are data that were collected by researchers indirectly or using other sources. These data are PDAM's data, images and data locations for 5 years of the total population of Palangka Raya city derived from Central Agency on Statistics (BPS). Followed by analyzing primary and secondary data to obtain population projections over the next 20 years and the need for clean water for domestic and non-domestic in Palangka Raya city that use Ministry of Publick Works standards, as well as comparing the intake capacity and clean water demand in Palangka Raya city.

RESULTS AND DISCUSSION

The population of Palangka Raya city in 2015 was as much as 259,865 people. The numbers of residents of Palangka Raya city in the last 5 years are in table 3, PDAM data

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

are shown in Table 4 until Table 7.

Table 3. The total population of Palangka Raya city for 5 years

No.	Year	Population
1	2011	229,355
2	2012	236,831
3	2013	244,454
4	2014	252,105
5	2015	259,865

(Source: BPS Palangka Raya city 2016)

Table 4. PDAM data of Palangka Raya city

No.	Year	Total HC Customers	Water Producted (M^3)	Water Distributed (M^3)	Water Sold (M^3)
1	2010	15,156	5,107,595	4,906,463	3,773,274
2	2011	15,235	5,231,713	5,046,829	3,872,950
3	2012	15,026	5,294,958	5,017,711	3,827,079
4	2013	15,226	5,129,362	4,821,239	3,616,329
5	2014	16,081	5,314,600	5,018,029	3,764,505
6	2015	16,474	5,109,648	4,911,816	3,731,815

(Source: PDAM Palangka Raya 2016)

Table 5. PDAM data of Palangka Raya intake capacity in 2016

No.	Location	Total Water Treatmant Plan (unit)	Capacity (L s^{-1})
1.	Palangka Raya	2	220
2.	Tangkiling	1	30
	Total	3	250

(Source: PDAM Palangka Raya 2016)

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

Table 6. Water loss calculation

No.	Year	Distributed (M^3)	Water sold (M^3)	Loss of water (M^3)	Percentage Loss of Water (%)
1	2010	4,906,463	3,773,274	1,133,189	23.10
2	2011	5,046,829	3,872,950	1,173,879	23.26
3	2012	5,017,711	3,827,079	1,190,632	23.73
4	2013	4,821,239	3,616,329	1,204,910	24.99
5	2014	5,018,029	3,764,505	1,253,524	24.98
6	2015	4,911,816	3,731,815	1,180,001	24.02
Average					24.01

Table 7. Coverage calculation service

No.	Year	Total Home Connection Customer (unit)	Number of Households (unit)	Service Coverage (%)
1	2012	15,026	63,764	23.57
2	2013	15,226	65,438	23.27
3	2014	16,081	66,241	24.28
4	2015	16,474	68,469	24.06

The selected projection method is a method with the lowest standard deviation and the most correlation coefficients. The development patterns of the city in accordance with the function of the city in the future also be used as a reference in determining the method of projection. In general, the functions of a city may show a tendency of population growth in the future. A comparison chart of the existing population growth and population growth according to the projections of all methods are shown Figure 1 and Table 8. Further calculations of non domestic water demand of Palangka Raya city can be seen in table 10.

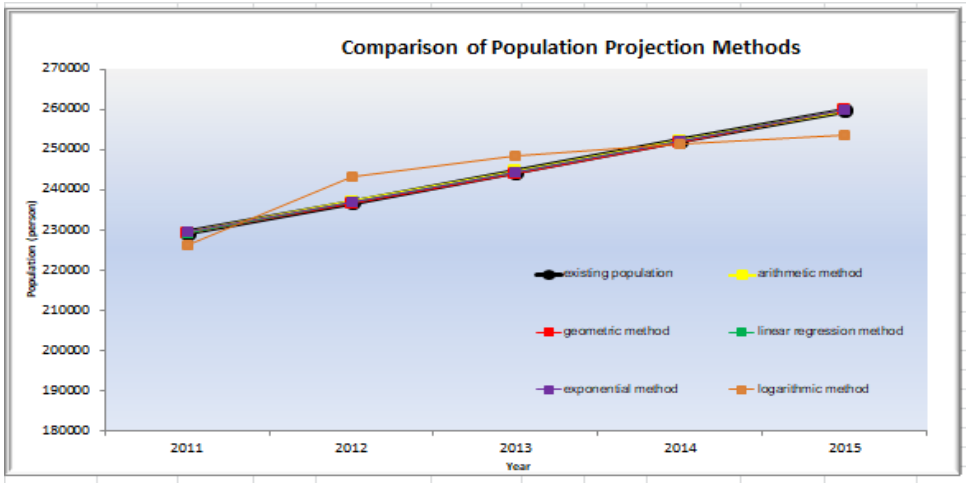

Figure 1. Recapitulation graph of population projections

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

Table 8. Summary of Value correlation (R^2) and standard deviation (STD)

	Arithmetic	Geometric	Linear Regression	Exponential	Logarithmic
R^2	1.0000	0.9999	1.0000	0.9999	0.9030
STD	12,060.14	12,061.12	12,063.14	12,070.49	10,893.71

Standard deviation and correlation coefficients each method. Method that meets the requirements of the criteria is the *Arithmetic method*. This method was taken because it had a correlation coefficient (R^2) equal to 1, which meant perfect, though seen from the smallest STD is the Logarithmic method, but also be seen from the recapitulation graph of Arithmetic method which is perpendicular to the growth of population. This method is used to calculate the population growth in the 20 years planning period ahead. Projected total population, population density, percentage of population growth until 2035 are presented in Table 9 and Figure 2.

Table 9. Arithmetic Population Projection Method

No.	Year	Population Projection (Pn)	Population Density (person KM^{-2})	Population Growth (%)
1	2016	267,493	99.87	
2	2017	275,120	102.71	2.85
3	2018	282,748	105.56	2.77
4	2019	290,375	108.41	2.70
5	2020	298,003	111.26	2.63
6	2021	305,630	114.10	2.56
7	2022	313,258	116.95	2.50
8	2023	320,885	119.80	2.43
9	2024	328,513	122.65	2.38
10	2025	336,140	125.50	2.32
11	2026	343,768	128.34	2.27
12	2027	351,395	131.19	2.22
13	2028	359,023	134.04	2.17
14	2029	366,650	136.89	2.12
15	2030	374,278	139.73	2.08
16	2031	381,905	142.58	2.04
17	2032	389,533	145.43	2.00
18	2033	397,160	148.28	1.96
19	2034	404,788	151.12	1.92
20	2035	412,415	153.97	1.88

-----Accredited by Directorate General of Higher Education Indonesia, No. 21/E/KPT/2018, Valid until 9 July 2023-----

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

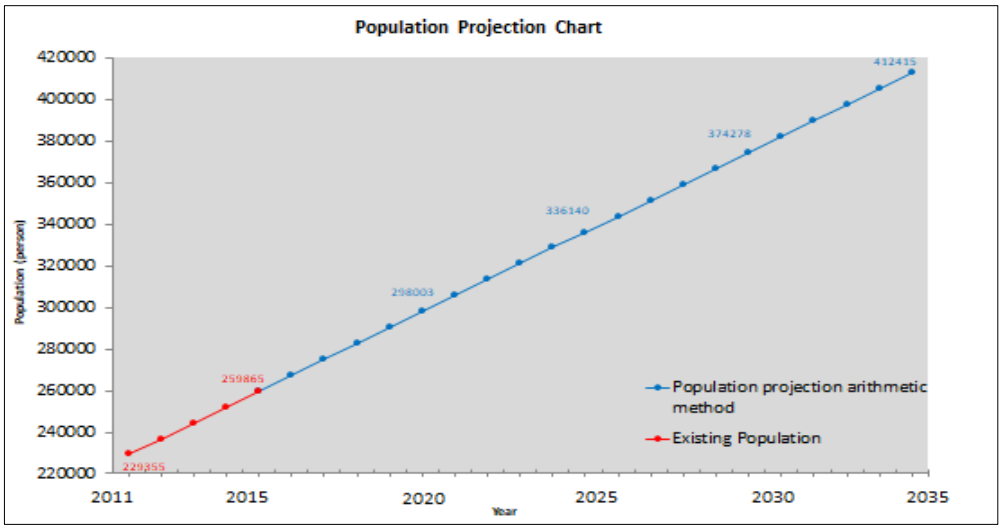

Figure 2. Population Projection Arithmetic Method

Table 10. Calculation Result of Non Domestic Water Demand

No	Data	Amount	Unit	Standard	Unit	Total Consumption (L day^{-1})
(A)	(B)	(C)	(D)	(E)	(F)	G = (C x E)
1	School	81,288	people	20	L students^{-1} day^{-1}	1,625,760
2	Mosque	151	units	1,500	L day^{-1}	226,500
3	Little mosque	241	Unit	750	L day^{-1}	180,750
4	Church	138	Unit	400	L day^{-1}	55,200
5	Temple / monastery	19	Unit	400	L day^{-1}	7,600
6	Hospitals	630	Bed	400	L bed^{-1} day^{-1}	252,000
7	Health Center	10	Unit	1,000	L day^{-1}	10,000
8	Auxiliary health center (Puskemas pembantu)	45	Unit	800	L day^{-1}	36,000
9	Integrated Healthcare Center (Posyandu)	137	Unit	800	L day^{-1}	109,600
10	Market	22	Unit	3,000	L day^{-1}	66,000
11	Cooperative	273	unit	800	L day^{-1}	218,400
12	Restaurant	2,100 *	Sit	40	L sit^{-1} day^{-1}	84,000
13	Bank	19	units of	1,200	L day^{-1}	22,800
14	Terminal/station/airport	4	units of	3,000	L day^{-1}	12,000
15	Village Office	900	people	10	L person^{-1} day^{-1}	9,000
16	District Office	250	people	10	L person^{-1} day^{-1}	2,500
17	Government office	140	people	10	L person^{-1} day^{-1}	1,400
18	Hotel / Inn	2,483	Unit	100	L day^{-1}	248,300
19	Sports venues	5	Unit	1,400	L day^{-1}	7,000
20	Swimming pool	1	Unit	1,200	L day^{-1}	1,200
21	Small Industry	4,076	Unit	25	L day^{-1}	101,900
				TOTAL	**L day^{-1}**	**3,277,910**
					L sec^{-1}	**37.94**

*) the number of seats the restaurant assumed to be 20 Seats

Journal of Wetlands Environmental Management
Vol 9, No 2 (2021) 33-44
http://dx.doi.org/ 10.20527/jwem.v9.v2.254

-----Accredited by Directorate General of Higher Education Indonesia, No. 21/E/KPT/2018, Valid until 9 July 2023-----

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

Table 11. Calculation Result of Domestic Water Demand

No	Description	Category	2016	2020	2025	2030	2035
1	Projections Population	Population	267,492.50	298,002.50	336,140.00	374,277.50	412,415.00
2	Service Target	% Of Population	31	56	89	100	100
3	Population Served (person)	a. Home Connection (HC)	81,706	168,327	298,862	375,756	414,044
		b. Public Hydrant (PH)	185,787	129,676	37,278	0	0
4	Σ domestic Connection Projected	a. Home Connection (HC) = 6 org/HC	13,618	28,054	49,810	62,626	69,007
		Added Σ connection	-	3,857	4,681	1,276	1,276
		b. Public Hydrant (PH) = 100 org/PH	1,858	1,297	373	0	0
		Added Σ connection	-	-561	-924	-373	0
5	Water Demand	HC (L person^{-1} day^{-1})	150	150	150	150	150
		a. Home Connection	12,255,837.62	25,249,006.82	44,829,311.10	56,363,384.42	62,106,605.89
		b. Public Hydrant (PH) = 30 L person^{-1} day^{-1}	5,573,607.48	3,890,273.64	1,118,337.78	0.00	0.00
6	Total domestic water demand	Total (L day^{-1})	17,829,445.10	29,139,280.46	45,947,648.88	56,363,384.42	62,106,605.89
		Total L sec^{-1}	206.36	337.26	531.80	652.35	718.83

Further recapitulation of domestic water requirement calculations Palangka Raya city can be seen in table 11.

Further recapitulation of non-domestic water demand calculations Palangka Raya city can be seen in table 12.

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

Table 12 Clean Water Demand Calculation Results Total of Palangka Raya city

No	Description	Unit	Year 2016	2020	2025	2030	2035
1	Population Projection	Person	267,493	298,003	336,140	374,278	412,415
2	Total domestic demand	L day^{-1}	17,829,445	29,139,280	45,947,649	56,363,384	62,106,606
3	the percentage of non-domestic demand	%	21.43%	21.43%	21.43%	21.43%	21.43%
4	Total non-domestic demand	L day^{-1}	3,820,131.14	6,243,372.80	9,844,728.39	12,076,400.51	13,306,941.29
5	Total water demand	L day^{-1}	21,649,576.23	35,382,653.26	55,792,377.27	68,439,784.93	75,413,547.18
6	Loss of Air (leakage rate of 20%)	L day^{-1} L sec^{-1}	4,329,915.25 50.11	7,076,530.65 81.90	11,158,475.45 129.15	13,687,956.99 158.43	15,082,709.44 174.57
7	Water Production	L day^{-1} L sec^{-1}	25,979,491.48 300.69	42,459,183.91 491.43	66,950,852.72 774.89	82,127,741.92 950.55	90,496,256.61 1,047.41
8	factor Maximum day (110%)	L day^{-1} L sec^{-1}	28,577,440.63 330.76	46,705,102.30 540.57	73,645,937.99 852.38	90,340,516.11 1,045.61	99,545,882.27 1,152.15
9	Total needs Water (peak hours 150%)	L day^{-1} L sec^{-1}	38,969,237.22 451.03	63,688,775.87 737.14	100,426,279.08 1,162.34	123,191,612.88 1,425.83	135,744,384.92 1,571.12

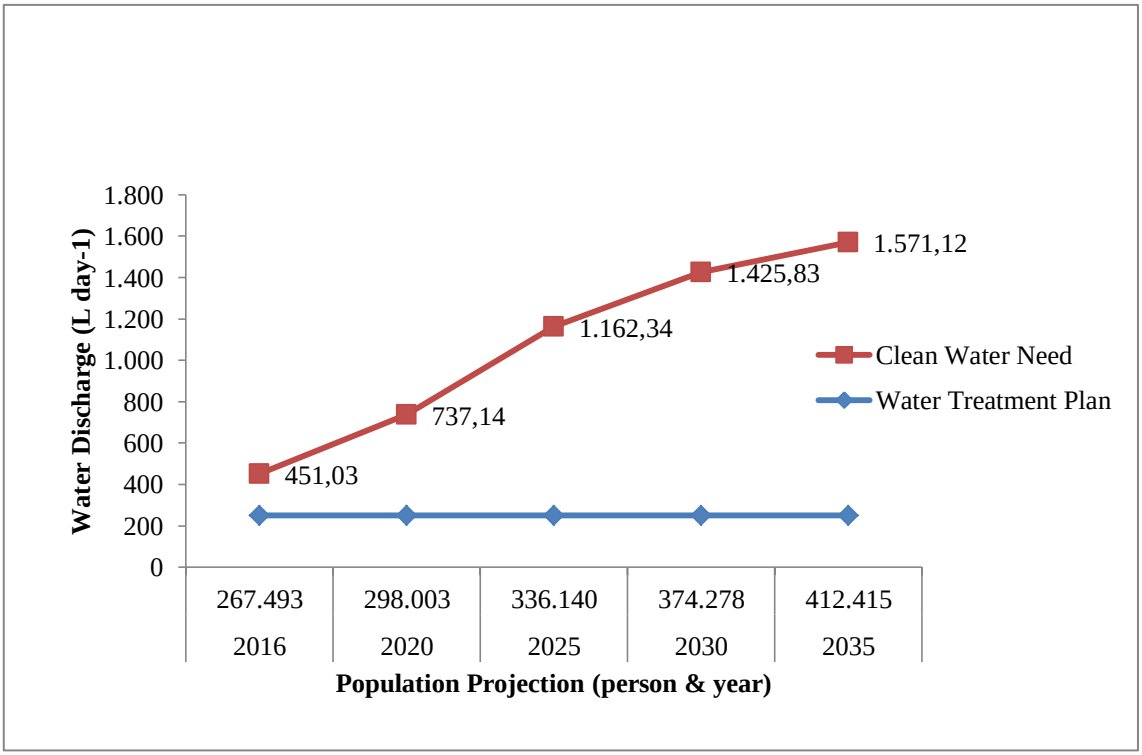

Figure 3. Graph of Clean Water Demand & Population Projection

-----Accredited by Directorate General of Higher Education Indonesia, No. 21/E/KPT/2018, Valid until 9 July 2023-----

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

PDAM Water Treatment Plant (WTP) of Palangka Raya have a capacity of 250 L/s, According to the Figure 3, obtained clean water demand for Palangka Raya city in 2016 was on the top line or the WTP capacity of 451,03 L/sec, can be said for the year 2016 unqualified for clean water demand, Therefore, PDAM Palangka Raya needs immediate plan to increase the capacity of the WTP / intake as soon as possible so that water demand are always met. The test results of water parameters in the field compared to the Indonesian Health Ministry regulation No, 492 / Menkes / PER / IV / 2010 on quality requirement of drinking water. The parameters tested are shown in Table 13.

Table 13. Water quality

No	Parameter	Unit	Testing Results		Terms	Info.
			Before Processing	After Processing		
1	Temperature	^{o}C	27.77	28.55	25 $^{\circ}C$ (± 3)	Qualify
2	pH	pH	4.46	3.87	6.5 to 8.5	Unqualify
3	Electricity Conductvity	mS cm^{-1}	0.011	0.081	-	
4	Turbidity	NTU	39.0	3.0	≤ 5	Qualify
5	Dissolved Oxygen	mg L^{-1}	5.27	5.21	-	
6	Total Dissolved Solids	g L^{-1}	0.007	0.053	≤ 0.5	Qualify
7	Salinity	Ppt	0.0	0.0	-	

In the aspect of water quality, the source of raw water used in PDAM Palangka Raya were not meet the standards, because the pH value below the minimum standard, it may also be caused by factors which resulted in reducing the water quality of distribution system.

CONCLUSION

According to the analysis in this study area, growth rate is increased 2.85%. It means the clean water requirement is increase from 451.03 L sec^{-1} in 2016 to 1,571.12 L sec^{-1} in 2035. As predicted the water supply will not sufficient in 2016 because of the raw water amount calculation about 451.03 L sec^{-1} compare to PDAM of Palangka Raya in 2015 have intake about 250 L sec^{-1}. The water quality results show that the raw water in the intake system does not meet the requirements as a source of raw water based on regulations in Indonesia because the degree of acidity is less than 6.5 so it requires an advanced treatment system.

REFERENCES

Badan Pusat Statistik Kota Palangka Raya. 2016. Kota Palangka Raya dalam Tahun 2015. Badan Perencana Pembangunan Daerah Kota Palangka Raya, Kalimantan Tengah.

Cipta Karya. 2007. Buku Panduan Pengembangan Air Minum, Rencana Program Investasi Jangka Menengah (RPIJM) Bidang PU/Cipta Karya.

ISSN: 2354-5844 (Print)
ISSN: 2477-5223 (Online)

Effendi, H. 2003. Telaah Kualitas Air – Bagi Pengelolaan Sumber Daya dan Lingkungan Perairan. Kanisius

Fitriati, U., Novitasari dan Eriyanie, E. 2015. A Study on Water Quality of Raw Water Sources of PDAM (Munipical Water Company) *Bandarmasih*. Tropical Wetland Journal, Vol. 1 No.1 2015 p. 39-45 ISSN : 2338-7653.

Fitriati, U., Novitasari dan Ma'ruf, M. A. 2017. A Study of Urban Water Demand in South Kalimantan Province. Tropical Wetland Journal, Vol. 3 No.1 2017 p. 23-30, ISSN : 2338-7653.

Fitriati U., Fathurrachman, S. A., dan Rusdiansyah, A. 2018, Studi Kebutuhan Air Bersih Di Kabupaten Pulang Pisau. Jukung Jurnal Teknik Lingkungan, Vol. 4 No. 2 p. 34-41.

Menteri Kesehatan Republik Indonesia. 2010. Peraturan Menteri Kesehatan Republik Indonesia No. 492/MENKES/PER/IV/2010.

Menteri Kesehatan Republik Indonesia. 2015. Keputusan Menteri Kesehatan Nomor 97: Kesehatan Dalam Rangka Sustainable Development Goals. Jakarta.

Wadsworth, Jr. and Harrison, M. 1998. Handbook of Statistical Methods for Engineers and Scientists. McGraw-Hill. New York