

Study on Rivers Pollution and Water Quality in DKI Jakarta

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ABSTRACT

As many other cities in the world, DKI Jakarta faces serious problems in the flood. In rainy season, common flooding is caused by several factors as follows: lowland areas in the northern part of Jakarta below sea level, urbanization rate, irregular population density, river pollution, slum neighborhood where scattered rubbish where quickly provoke the flood to stagnate and increase rather than receding. This paper studied on rivers pollution in DKI Jakarta. It was founded that water quality from 13 rivers in DKI Jakarta was at a critical level. The lack of sanitation systems in residential areas around rivers has highly contributed to pollute the rivers. It was 96 percent of the water is badly polluted. Therefore river water in DKI Jakarta can be harmful to health if consumed by the community.

KEY WORDS: *Pollution; River Water, DKI Jakarta.*

NOMENCLATURE

<i>WFC</i>	West Flood Canal
<i>EFC</i>	East Flood Canal
<i>DKI</i>	Daerah Khusus Ibukota
<i>RTH</i>	Ruang Terbuka Hijau
<i>KK</i>	Kepala Keluarga
<i>BMKG</i>	Badan- Meteorologi-Klimatologi-Geofisika
<i>JABODETABEK</i>	Jakarta-Bogor-Depok-Tangerang-Bekasi
<i>BPBD</i>	Badan Penanggulangan Bencana Daerah
<i>BAPPENAS</i>	Badan Perencanaan Pembangunan Nasional

IPLS Instalasi Pengolahan Limbah Septik tank

1.0 INTRODUCTION

The high level of urbanization in DKI Jakarta has caused complex problems such as unemployment, crime, economic equality, housing, floods, traffic congestion, poverty, slums, water supply and urban planning. In addition, DKI Jakarta also faces some infrastructure challenges for water regulation caused by 13 rivers like Ciliwung, Kalibaru, Pesanggrahan, and other rivers caused by its unique topography. DKI Jakarta has topography that most of the city over the sea, with some sinks 25 cm per year with an average of 5-10 cm as shown in Figure 1.

Coupled with heavy rain during the rainy season, floods become a perennial problem that occurs every year in the rainy season. The floods in DKI Jakarta are commonly caused by several factors as follows: lowland areas in the northern part of DKI Jakarta below sea level, high urbanization level, irregular urban planning and slum environments coupled with scattered waste where, thus rapidly triggering flooding stagnation and rising rather than receding. Flooding occurred on the northwest coast of Java, at the mouth of the Ciliwung River in Jakarta Bay. Floods have occurred recently in 1996, 2002, 2007 and 2013, 2014, 2017. During the rainy season, floods occur in DKI Jakarta due to the above factors causing rivers full of garbage, clogged waterways, river sedimentation the high, and the overflowing seawater. Mixing flood water with a pile of waste in a narrow residential area can spur disease, including skin infections and diarrhea, especially in children under 5 years of age.

In order to overcome the complex problems as mentioned above, since 2015, the government of DKI Jakarta has made a program for resettling the population, especially the area adjacent to the river. This government program provides pros and cons at the general public level. This paper reviews the population evictions program and proposes a solution that may provide satisfaction to the government and the community.

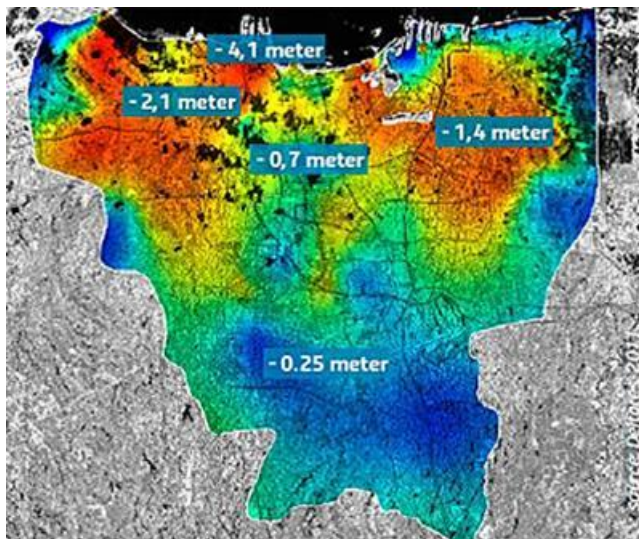


Figure 1: Land subsidence in Jakarta in period 1974-2010 [Indonesian & Dutch].

2.0 DKI JAKARTA

2.1 History of DKI Jakarta

Jakarta is the capital city of Indonesia as well as the largest city which is located on an estuary of the Ciliwung River. Short story, Jakarta was called Sunda Kelapa in the Kingdom of Sunda period then it was changed to be Jayakarta in 22 June 1527 during period of the Sultan Banten. In 4 March 1621 during Dutch colonial period (1619–1949), it was called as Batavia as shown in Figure 2, and then it was changed to be Jakarta Tokubetsu Shi in 8 August 1942 during the Japanese occupation. As Japan's defeat in World War II, Indonesia declared its independence on August 17, 1945 at Jalan Pegangsaan Timur No. 56 (Jalan Proklamasi), Jakarta Pusat and the position was immediately changed to the National Government of Jakarta or Provincial Government of DKI Jakarta.



Figure 2: Batavia under the Dutch colonial period, 1780 [Wikipedia].

2.2 Geography of DKI Jakarta

Jakarta lies in a low and flat alluvial plain, ranging from -2 to 50

metres with an average elevation of 8 metres above sea level with historically extensive swampy areas. 40% of Jakarta is below sea level particularly the northern areas, while the southern parts are comparatively hilly.

There is thirteen rivers flow through Jakarta. Firstly, river of Ciliwung divides the city into the western and eastern districts. The river of Ciliwung is across the city northwards towards the Java Sea which flows from the Puncak highlands to the south of the city. Other rivers include as follows: Kalibaru, Pesanggrahan, Cipinang, Angke River, Maja, Mookervart, Krukut, West Tarum, Cakung, Petukangan, Sunter River and Grogol River. These rivers flow from the Puncak highlands to the south of the city, then across the city northwards towards the Jakarta Bay as shown in Figure 3.

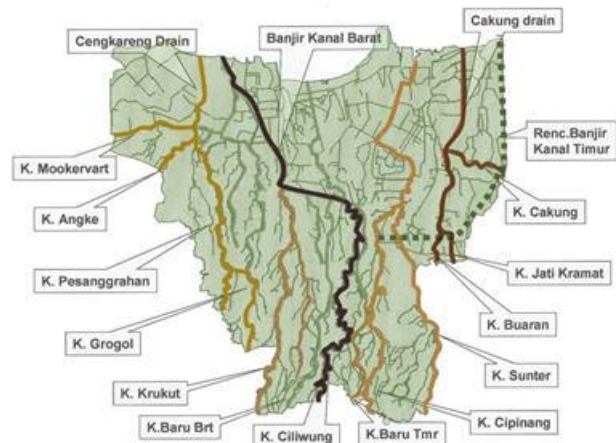


Figure.1.3: List of rivers in Jakarta [Pemprov DKI].

2.3 Population of DKI Jakarta

Since 1950, Jakarta has attracted the attention of many people from all over Indonesia. The large number of migrants came to Jakarta for economic reasons and job vacancies. Based on the 1961 census shows only 51% of the city's population is born in Jakarta. Megacity Jakarta increased from 11.91 million people in 1980, 17.14 million in 1990, and 20.63 million in 2000 to 28.01 million in 2010. In 2010, broader Jakarta accounted for 11.79 percent of the total population of Indonesia, but with this population is below 0.3 percent of the total area of the country. Jakarta has an estimated population of over 10 million people in 2016 as shown in Figure 4.

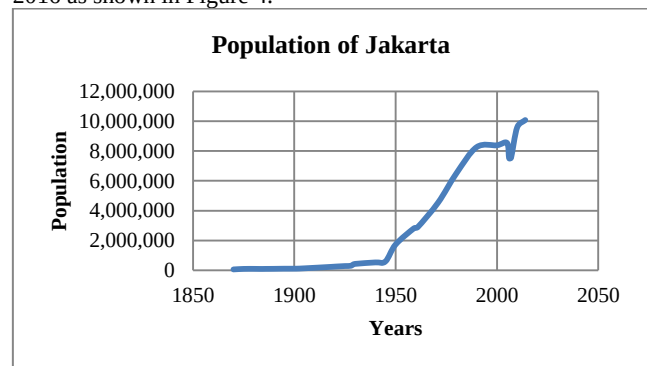


Figure 4: Statistic population of Jakarta in 1860 – 2014.

DKI Jakarta covers an area of 662.3 km² of land area and 6,977 km² of sea area. The Greater Jakarta metropolitan area has an area of 6,392 km² as shown in Table 1. DKI Jakarta consists of five Administrative Cities as follows: Jakarta Pusat, Jakarta

Barat, Jakarta Selatan, Jakarta Timur, Jakarta Utara as shown in Figure 5 and an Administrative Regency: Kepulauan Seribu.

Table 1: Jakarta's Municipalities

City/Regency	Area (km ²)	Total population (2014)	Population Density (per km ²) in 2014	HDI 2014 Estimated	HDI level
Jakarta Barat	129.54	2,430,410	18,762	0.797	High
Jakarta Selatan	141.27	2,164,070	15,319	0.833	Very High
Jakarta Utara	146.66	1,729,444	11,792	0.796	High
Jakarta Timur	188.03	2,817,994	14,987	0.807	Very High
Jakarta Pusat	48.13	910,381	18,915	0.796	High
Kepulauan Seribu	8.7	23,011	2,645	0.688	Medium

Note: Human Development Index (HDI)

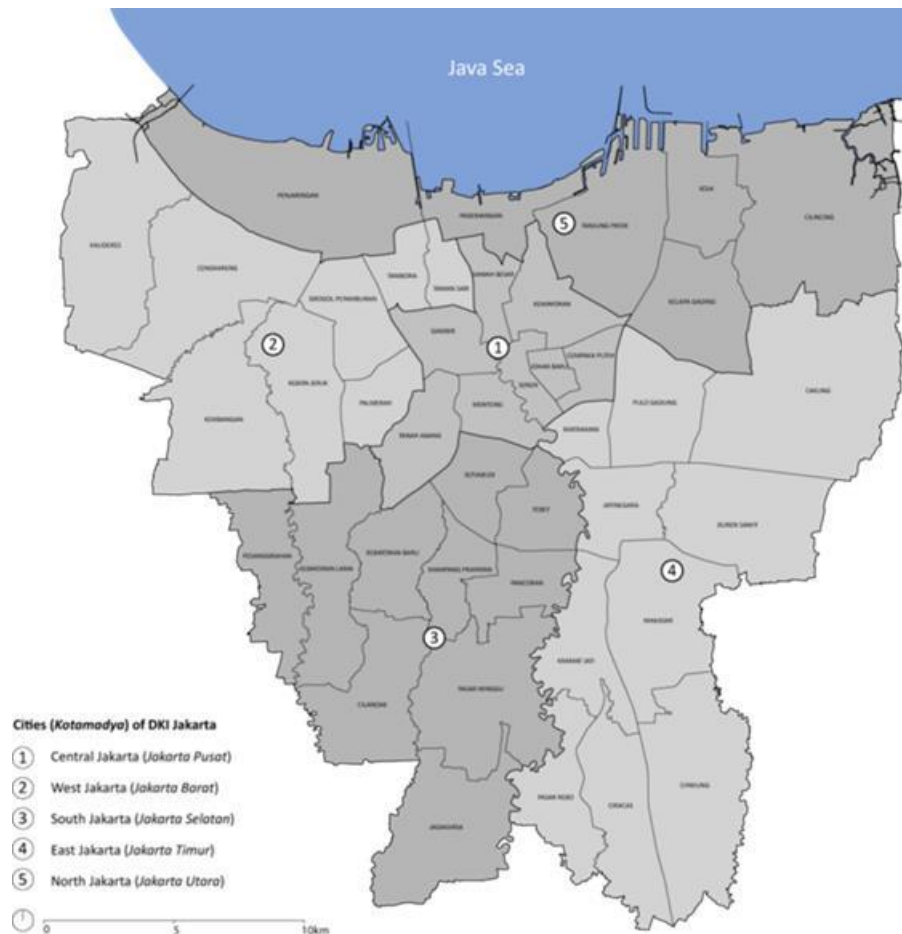


Figure 5: Map of the municipalities in Jakarta [DKI Jakarta].

3.0 RIVERS POLLUTION IN DKI JAKARTA

Since ancient times until now, the river has become an important part in human life. Around the world, rivers are used in addition to transportation, many people use the river for various purposes such as washing, bathing, sanitation, even cooking. There are also a variety of fish in the river that can be caught and consumed to meet the nutrients that humans need. It can happen if the river is clean and free of pollutants

DKI Jakarta with all its prowess and beauty is very interesting to attract people to come. It has become the most popular urbanization destination. The city is crowded with high intensity of population. This caused many residents to have difficulty in the settlement. Those who do not get home end up making semi-permanent homes in various places, one of which is the riverside land as shown in Figure 6. The land along the river in DKI Jakarta has turned into a slum. People inhabiting slum dwellings usually have a low level of awareness of the cleanliness and beauty of rivers where throwing useless things into the river. Because their house is right on the banks of the river so that any waste they produce will soon be thrown into the river as shown in Figure 7. Because of the bad habits of the community, this causes waste to accumulate in the river so that the river polluted, foul smell, dredge the river, blockage of water flow, the cause of malaria disease dengue fever, the quality of river water is not healthy for consumption..

Moreover, many other people also just pass the garbage carelessly. They do not realize that the waste will flow into the river. In turn, the river becomes filled with garbage and then undergoes siltation. The shallowness of the river causes not able to accommodate the flow of water. When the rainy season arrives, the polluted shallow river will cause flooding. River water floods carry harmful bacteria that eventually cause many other diseases.

Water quality from 13 rivers in DKI Jakarta shows at a critical level. The lack of sanitation systems in residential areas has contributed to the condition. Thus, river water in Jakarta can be harmful to health if consumed by the community, because 96 percent of the water is badly polluted reported by National Development Planning Agency (BAPPENAS).



Figure 6: Heavily polluted river in Muara Baru, Jakarta Utara [The Jakarta Post]

Among the rivers in Jakarta, the most contaminated is the Ciliwung River. The river is accused of being responsible for

annual flooding in several places in Jakarta. The quality of Ciliwung river water is highly polluted in all segments, from upstream (Puncak, Bogor) to downstream (DKI Jakarta). Fluctuations in river water discharges between dry and rainy seasons are high enough to cause regular flooding in Jakarta.

In May 2011, the Jakarta Environmental Management Board categorized all rivers in Jakarta as polluted; 71% were heavily polluted, 20% partially polluted and 9% tainted lightly.

Responding to the disaster, Jakarta City Government has made various efforts to reduce the risk and eliminate the impact. Among other efforts, the most intense activity was the revitalization of house pumping and river normalization in addition to the massive campaigns in order not to pollute the river.



Figure 7: River pollution in Jakarta.

Compared to rivers in other major cities of the world such as Tokyo, for example the Meguro River in Tokyo is cleaner, more beautiful, more orderly, more attractive and greener than in Jakarta as seen from Figure 8. The river is a popular venue for cherry blossom viewing in the spring. This is more due by level community awareness is high not to throw garbage, keep clean and green of river. In addition, the government built public facilities such as sidewalks for pedestrians in order to enjoy the beauty and cleanliness of the river.



Figure 8: Cherry blossom along Meguro River near Naka Meguro, Tokyo, Japan.

Besides, the river can also provide economic income for the surrounding community by opening river tourism as shown in

Figure 9. This is the main attraction for big cities.



Figure 9: Inland waterway tourism at the river of Meguro in Tokyo, Japan.

4.0 RIVER WATER QUALITY IN DKI JAKARTA

Human and industrial waste water is another water management issue that needs to be considered more thoroughly in DKI Jakarta. With higher population density as shown in Table 1 and activities of Jakarta residents not only affect the supply and demand of clean water, but also the production of waste water from residents and industries dumped into rivers or open ducts through sewers.

Palupi.et.al 1995 studied on River water quality study in the vicinity of Jakarta based on a field on the Ciliwung, SunSet and Krukut Rivers. The quality of the rivers' water was determined using a Water Quality Index (WQI) which is scaled from zero to a hundred. It was founded that in the dry season the WQIs of Ciliwung, Sunter and Krukut Rivers ranged between 21–42, 20–29 and 21–38, respectively. In the rainy season the WQIs of Ciliwung, Sunter and Krukut Rivers ranged between 34–47, 32–50, and 34–47, respectively. The level of heavy metals did not exceed current Indonesian Standards. It was concluded that the overall water quality of the Ciliwung, Sunter, and Krukut Rivers was between very poor and poor, and the rivers were polluted by Cu, Pb, Cd, Zn and Hg.

Amira et.al 2017 identified the incoming pollutants and assessed the water quality in Grogol River, DKI Jakarta, Indonesia. Based on the analyses of 10 key parameters and the calculation of pollution index value, it can be concluded that Grogol River is low polluted in rainy season and moderate polluted in dry season.

Based on statistical data from PD PAL Jaya, there is still 75% of waste water left to be treated in DKI Jakarta. However, the amount of waste water is still released directly to the river. More than 50% of shallow wells have been contaminated by E. coli originating from domestic waste water, and more than 10% of shallow wells are also contaminated by iron and manganese. Based on BPLHD Pollutants Index from 2004-2009, most of the river water quality in Jakarta is highly polluted. Although in 2007 to 2008 there was a decrease in the percentage of polluted river water, but in general river water in Jakarta is still highly polluted

as shown in Table 2.

Additionally, all the rivers in Jakarta are heavily polluted. Rivers in Jakarta have been monitored on a regular basis for the past ten years, and these findings consistently show high Biochemical Oxygen Demand (BOD) readings. The sources of BOD in Jakarta's River system originate from industrial and other waste water, solid waste, and domestic sewage. High pollution levels causing treatment costs to increase. In 2010, all surface waters crossing Jakarta are heavily polluted by gray water from households, commercial buildings, together with discharges from industries, pesticide and fertilizer run-off from agricultural land, solid waste, and fecal matter from overflowing or leaking septic tanks as shown Figure 9.

Table 2: River Water Quality Index in DKI Jakarta

Quality Status	POLLUTANT INDEX					
	2004	2005	2006	2007	2008	2009
Good	0%	0%	3 %	0%	0%	0%
Low Polluted	3%	5%	9%	0%	0%	9%
Moderate Polluted	16%	16%	10%	6%	12%	9%
High Polluted	81%	79%	78%	94%	88%	82%

5.0 GROUND WATER QUALITY IN DKI JAKARTA

Different from ground water case in Jakarta, pollutant index shows that from 2004 - 2009, most of the ground water quality was low polluted. Unfortunately, even though ground water has better quality water comparing to river water, ground water volume was limited to meet the needs of water use in Jakarta.

In Jakarta, there are 11,800,000 populations for waste water treatment (including floating population) and 9,900,000 if only the actual population. Waste water treatment divided into off-site (sewerage) and on-site sanitation (PD PAL JAYA, 2012). On-site sanitation was mainly used in residential and slum area. About 8,4 million populations in Jakarta (71%) treat their waste water using individual septic tank before release the waste water to the sewerage.

About 1,300,000 populations (11%) in slum area will directly deliver their waste water into the river. Off-site sanitation was used by mainly apartment, office buildings, and industry in Jakarta. There are 1,900,000 of population (16%) using Individual Treatment Plant (ITP) and some using individual treatment plant with Advanced Treatment Process (ATP) before the waste water was delivered into the river. There are also 200,000 of population who use off-site sanitation by delivered their waste water through sewerage into Pumping Station and Setiabudi Waste Water Treatment Plant (WWTP) as shown in Figures with specification as follows: treatment technology using Aerated Lagoon, total capacity is 450 L/sec ~ 38.880 m³/day, the utilize capacity is 19.029 m³/day and the average BOD effluent is 45-55 mg/l.

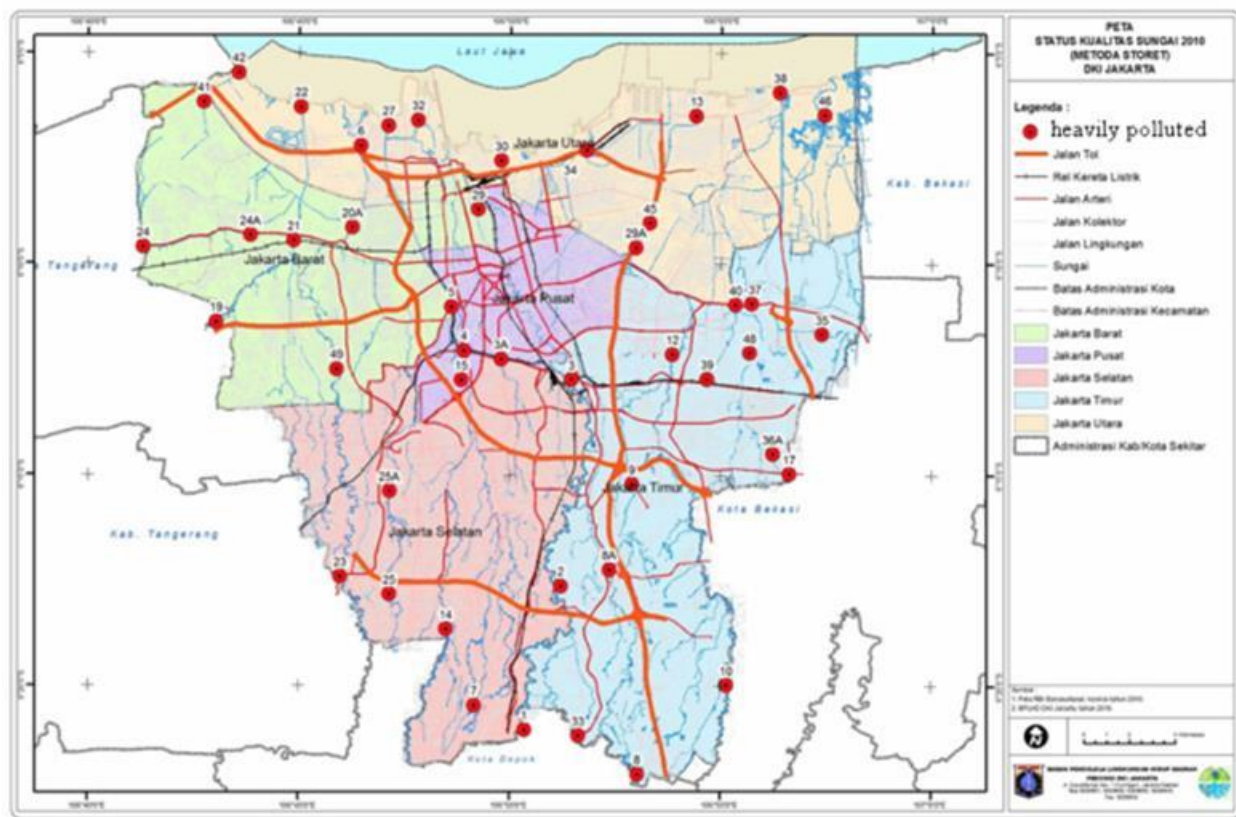


Figure 10: Map of river water quality in DKI Jakarta.

Physical		West Pond	East Pond	Total
Surface Area		26.100 m ²	17.400 m ²	43.500 m ²
Water Level	High level condition	4.5 m	4.7 m	-
	Low level condition	1.5 m	1.5 m	-
Elevation depth (effective)		3.00 m	3.20 m	-
Elevation at the bottom of pond		-0.5 m	-0.5 m	-
Pond capacity (effective volume)		78.300 m ³	55.680 m ³	122.980 m ³
Treatment process		Aerated Lagoon	Aerated Lagoon	-
Inlet	Waste water	3	2	5
	Drainage	6	2	8
Screen (Manual & Mechanical screen)		2 (Manual)	2 (Mechanical)	4
Aerator Unit		4	3	7

Sources: PD PAL Jaya & JICA, 2010

Figure 11: Description of Setiabudi WWTP



Figure 12: Setiabudi Waste Water Treatment Plant (WWTP)

Table 3: Ground Water Quality in DKI Jakarta

Quality Status	POLLUTANT INDEX					
	2004	2005	2006	2007	2008	2009
Good	18%	16%	7 %	25%	23%	23%
Low	33%	33%	55%	43%	48%	41%
Polluted	28%	35%	13%	20%	16%	19%
High Polluted	21%	16%	25%	12%	13%	17%

Waste Water Treatment

There is a sewerage system in the cities, but they are inadequate and not well maintained. Sewerage system is usually directly connected to the rivers accrossed the city. Though there are some waste water treatment systems, most of them are not functioning well. The rising demand for water and in the Jakarta Province has put pressure on the quality of water. The quality of both surface and ground water has deteriorated and scientific study for the urban water environment of Jakarta Capital City has become essential.

Jakarta Province Government currently manages two Septic tank Waste Treatment Installation (IPLS) that hold 300 m³ of their capacities, which are IPLS Pulo Gebang and IPLS Duri Kosambi. The monitoring report shows that both of IPLS currently have ineffective and inefficient operation due to the advance of technology nowadays, there is no further septic tank waste

process so the waste can be used as energy resources for example, IPLS capacity cannot meet the needs of the population, and current IPLS technology spends a lot of cost and time (DKI Jakarta Province Government, 2013). Wastewater management issue deals with a comprehensive team work between government, professional companies, and community is needed.

5.0 CONCLUSION

In conclusion, this paper discusses on pollution and water quality of river water in DKI Jakarta. It was founded that water quality from 13 rivers in DKI Jakarta was at a critical level. The lack of sanitation systems in residential areas around rivers has highly contributed to pollute the rivers. It was 96 percent of the water is badly polluted. Therefore river water in DKI Jakarta can be harmful to health if consumed by the community.

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REFERENCE

1. 80 Persen Sungai di Jakarta Tercemar Limbah Rumah Tangga, <http://www.portalhijau.com/2016/05/80-persen-sungai-di-jakarta-tercemar.html>.
2. Alamy, Waterfront Buildings in Pontocho along the Kamogawa or Kamo River During Cherry Blossom Season, Kyoto, Japan
3. Apip, Saut AH Sagala, Luo Pingping, 2015, Overview of Jakarta Water Related Environmental Challenges, *Water and Urban Initiative Working Paper Series Number 04, April 2015*,
4. Asia, Jakarta hit by floods due to heavy overnight rain, <http://www.straitstimes.com/asia/se-asia/jakarta-hit-by-floods-due-to-heavy-overnight-rain>.
5. Badan Nasional Penanggulangan Bencana (BNPB), <https://www.merdeka.com/peristiwa/bnpb-banjir-jakarta-saat-ini-tak-separah-2007.html>
6. BBC Indonesia, Banjir melanda, separuh ibu kota Jakarta sempat lumpuh, 11 Desember 2017, <http://www.bbc.com/indonesia/indonesia-42305789>.
7. BBC, Jakarta flood toll rises, 31 January, 2002, <http://news.bbc.co.uk/2/hi/asia-pacific/1791623.stm>
8. Civil Engineering Solution (CES), 2013, The Hydrological Cycle, <https://civilsolution.wordpress.com/2013/02/06/the-hydrological-cycle/>
9. Detikfinance, 17 Pulau Buatan di Teluk Jakarta akan Selesai Pada 2030, Senin 14 Jul 2014, 15:24 WIB, <https://finance.detik.com/berita-ekonomi-bisnis/2636528/17-pulau-buatan-di-teluk-jakarta-akan-selesai-pada-2030>.
10. DREF Final Report, Indonesia: Floods, 28 June 2013, The International Federation of Red Cross and Red Crescent (IFRC)
11. Dutch and Indonesian institutes intensify collaboration on water, weather and climate forecasts, <https://www.dutchwatersector.com/news-events/news/8615-dutch-and-indonesian-institutes-intensify-collaboration-on-water-weather-and-climate-forecasts.html>
12. Fish market residents celebrate end of Ramadan in tents, <https://www.rappler.com/world/regions/asia-pacific/indonesia/bahasa/englishedition/138866-pasar-ikan-residents-celebrate-lebaran-tents>
13. Floods in Jakarta, Indonesia 06 Feb 2002,
14. History of Jakarta, https://en.wikipedia.org/wiki/History_of_Jakarta
15. Human Cities Coalition, 2017, Jakarta Urban Challenges Overview, <https://www.humancities.co/2017/01/jakarta-urban-challenges-overview/>
16. Ida Ayu Mas Amelia Kusumaningtyas, Water Pollution in Jakarta, Indonesia, <https://tunza.eco-generation.org/ambassadorReportView.jsp?viewID=42840>
17. Ini Wilayah yang Digusur Ahok Selama Jadi Gubernur, <https://metro.sindonews.com/read/1202531/170/ini-wilayah-yang-digusur-ahok-selama-jadi-gubernur-1493901138>
18. J.Koto, Ridho Bela Negara, 2017, *Japanese's River Culture as an Alternative Flood Prevention Remedy in DKI Jakarta during Rainy Season*, Journal of Aeronautical -science and engineering-, Vol.11, pp.1-12.
19. J.Koto, Ridho Bela Negara, 2017, *Review Study on Rainfall Characteristics in DKI Jakarta*, Journal of Aeronautical -science and engineering-, Vol.9, pp.1-6.
20. J.Koto, Ridho Bela Negara, 2017, *Review Study on the Pros and Cons of Flood Prevention Plan during Rainy Season in DKI Jakarta*, Journal of Aeronautical -science and engineering-, Vol.10, pp.1-11.
21. Jakartans lament the sorry state of the capital's rivers. The Jakarta Post, Jakarta. May 20, 2011
22. K.Palupi, S.Sumengen, S.Inswiasri, L.Agustina, S.A.Nunik, W.Sunarya, A.Quraishyn, 1995, *River water quality study in the vicinity of Jakarta*, Water Science and Technology Vol.31, Issue 9, 1995, Pages 17-25.
23. Merdeka, 2015, Ditolak pihak rusun, warga Pinangisia bertahan di lokasi gusuran, <https://www.merdeka.com/foto/peristiwa/546862/20150528133747-ditolak-pihak-rusun-warga-pinangisia-bertahan-di-lokasi-gusuran-002-isn.html>
24. Michael Case, Fitriani Ardiansyah, Emily Spector, Climate Change in Indonesia -Implications for Humans and Nature-,
25. Normalisasi Sungai Ciliwung, <https://www.antarafoto.com/peristiwa/v1516271708/normalisasi-sungai-ciliwung>
26. Okezone News, 2017, Pemprov DKI Tertibkan 60 Bangunan Liar di Rusun Bidara Cina, <https://news.okezone.com/view/2017/09/14/1/42388/pempro-v-dki-tertibkan-60-bangunan-liar-di-rusun-bidara-cina>
27. Pemda DKI Jakarta, http://www.serverjakarta.com/peta_13sungai.aspx
28. Pemerintah DKI Dinilai Gagal Pahami Tipe Banjir di Jakarta, <https://wahanahajumrah.com/artikel/140/pemerintah-dki-dinilai-gagal-pahami-tipe-banjir-di-jakarta.html>
29. Rappler, Angka penggusuran di Jakarta meningkat pada

- 2016, <https://www.rappler.com/indonesia/berita/166890-data-lbh-pengggusuran-paksa-jakarta>.
30. Rappler, Yang tertinggal di Kalijodo, <https://www.rappler.com/indonesia/125813-yang-tertinggal-di-kalijodo>
31. riverculture, Nature & Society at Sophia University, <https://riverculture.wordpress.com/tag/yokohama/>
32. S Amira, W Astono, D Hendrawan, 2017, Study of pollution effect on water quality of Grogol River, DKI Jakarta, The 4th International Seminar on Sustainable Urban Development, pp.1-6.
33. The Jakarta Post, Jakarta's river water severely polluted: Bappenas, February 2, 2018, <http://www.thejakartapost.com/news/2018/02/02/jakartas-river-water-severely-polluted-bappenas.html>.
34. Warta Koto, 2015, Janji Bangun Kampung Deret Dipertanyakan, <http://wartakota.tribunnews.com/2015/08/22/janji-bangun-kampung-deret-dipertanyakan>.
35. Water basics: the hydrologic cycle, Government of Canada, <https://www.canada.ca/en/environment-climate-change/services/water-overview/basics/hydrologic-cycle.html>
36. Wikipedia, 2007, 2013 Jakarta flood, <https://en.wikipedia.org>
37. WSWS, At least 50 dead as floods inundate much of Jakarta, 13 February 2002, <https://www.wsws.org/en/articles/2002/02/indo-f13.html>