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WATER QUALITY AND QUANTITY ISSUES OF URBAN LAKES IN MEGACITY JAKARTA

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ABSTRACT

The lakes in urban megacity Jakarta, called as "setu or situ" by the local people, play a central role in integrated water resources management. Despite its pivotal role in maintaining the balance of urban water system, they have not received sufficient attention. Rapid urban development in a very distinct urban watershed type of lake's surroundings has impacted on the water quantity and quality of urban lakes in megacity Jakarta. Chronic problems faced by downstream area in megacity Jakarta such as flash floods in the rainy season and water scarcity in the dry season have indicated that the lakes have not been managed and functioned well. Human and nature disturbances such as shoreline encroachment, shoreline erosion, garbage dump and inflow from untreated sewage and urban runoff have polluted the lake water and reduced its volume capacity. Nearly half of the existing lakes have reduced from 10 to > 50% of its water volume capacity due to lake area shrinkage, siltation and even excessive growth of invasive macrophytes. The lakes are mostly in disturbed to damaged environmental conditions. Lakes in urban and rural villages have less in water quantity and higher solids, organic matter, nutrients and even fecal bacteria concentrations than the lakes in planned residential, high-rise residential and industrial areas types of urban surroundings. As the lakes in the urban village and industrial area, elevated toxic metal concentrations have become public concern due to lake hygiene problems. Elevated nutrient concentrations have caused the lake eutrophication, where some lakes have suffered from excessive macrophyte coverage, algal bloom even toxic cyanobacterial bloom. The urban lakes in megacity Jakarta constantly have been degrading physically and ecologically affecting its water quantity and quality which is increasing the threat to human's health and impact future human's resilience in urban megacity Jakarta.

Keyword: urban lakes, water quality, water quantity, urbanization impacts, megacity

ABSTRAK

MASALAH KUALITAS DAN KUANTITAS AIR DANAU URBAN DI JAKARTA MEGAPOLITAN. *Danau urban di Jakarta megapolitan yang dikenal dengan "setu atau situ" sangat mempunyai peranan penting dalam pengelolan sumber daya air yang terintergrasi. Walau peranannya sangat utama dalam menjaga keseimbangan sistem air di area urban, danau urban kurang mendapat perhatian. Pesatnya perkembangan di area urban pada daerah tangkapan berdampak terhadap kuantitas dan kualitas air danau urban di Jakarta megapolitan. Masalah kronis di daerah hilir Jakarta seperti banjir kiriman pada musim hujan dan kekurangan air pada musim kering mengindikasikan danau tidak dikelola dan difungsikan dengan baik. Gangguan oleh aktivitas manusia ataupun oleh ala, antara lainnya seperti alih fungsi lahan di area tangkapan danau, erosi, pembuangan sampah, air limbah dan aliran permukaan telah menurunkan kapasitas/volume air dan kualitas air danau berupa pencemaran. Diperkirakan 10 sampai > 50% dari jumlah total danau yang ada mengalami penurunan kapasitas volume yang disebabkan oleh alih fungsi lahan di area tangkapan danau, menyusutnya area danau, pendangkalan dan penutupan area danau oleh gulma tanaman air. Sebagian besar danau dalam kondisi lingkungan yang terganggu dan rusak. Danau-danau di area kampong urban dan rural mempunyai kapasitas volume air yang menyusut, kandungan padatan, bahan organik, nutrien bahkan kandungan bakteri koli yang tinggi dibandingkan danau-danau di area pemukiman yang tertata dan terkelola baik, di pemukiman gedung-gedung tinggi dan di lingkungan area industry. Namun demikian danau di area lingkungan industri, kandungan logam toksik di air yang lebih tinggi menjadi perhatian publik dikarenakan dapat berdampak pada kesehatan manusia. Tingginya kandungan nutrien dapat menyebabkan eutrofikasi danau dimana terjadinya peledakan populasi alga hijau biru yang beracun dan penutupan area danau oleh gulma tanaman air. Danau urban terus menglami kerusakan baik secara fisik dan ekologis yang berpengaruh terhadap kuantitas dan kualitas air danau yang dapat membahayakan kesehatan manusia dan berdanpak kepada ketahanan air dan manusia di masa depan di area Jakarta megapolitan.*

Kata kunci: danau urban, kualitas air, kuantitas air, dampak urbanisasi, megapolitan

INTRODUCTION

Urban lakes are distinct than common natural lakes. They tend to be small and shallow with a large watershed area that contains more impervious cover such as pavement, roads and buildings and often lack of substantial vegetation cover. The large watersheds exert strong influence to the lakes meaning that everything such as urban runoff, sewage inflow ends in the lakes (Schueler and Simpson, 2001). Urban lakes play an important role not only in maintaining the balance of hydrology (groundwater and surface water) but ecology as well in urban ecosystem. The lakes must be managed for flood control, water supply, recreation, fishing or some other direct human use.

Urban lakes in megacity Jakarta called as "situ or setu" have been functioned for flood control, water supply, water retention as ground water recharge, irrigation, recreation, fishing and fishery as well. Downstream area of megacity Jakarta has been facing chronic problems of severe flash floods annually from the upstream region during the wet season. In addition, the exploitation of groundwater usage and polluted surface water has caused shortage of clean water during the dry season. The lakes in urban megacity Jakarta have lost their capacity to support their function as flood control, water supply, and for other direct human use. It is quite unfortunate that despite its pivotal role in maintaining urban water and urban ecosystem, lakes in the urban areas have received little attention.

The urban lakes in megacity Jakarta share the common types of urban lakes which impervious cover and lack of vegetation, however many lakes have quite distinct types of watershed. Previous study discovers that urban lakes in megacity Jakarta have several distinct types of watershed including urban village, planned residential area, high-rise residential area, rural, industrial and even agricultural areas, even some lakes can have mixed types of watershed. The impacts of urbanization in these distinct watersheds on the lakes in megacity Jakarta have aggravated the environmental conditions of the lakes and make the problems in lakes so very complex. Previous studies indicate that urban lakes in megacity Jakarta were at high risk of disappear due to land use change, area shrinkage, siltation/sedimentation, eutrophication and water pollution due to the lakes as the end point collecting garbage, untreated storm water runoff and sewage inflow (Henny and Meutia, 2014).

Shoreline development and encroachment as impacts of urbanization have sacrificed urban lakes for residential/industrial development area. Several previous studies from other urban cities have indicated the lakes have been disappeared and many lakes area have shrunkn (Henny and Meutia, 2014; Wu and Xie, 2011; Pradhan and Latkar, 2008; Roemantyo et al, 2003). Among water pollution problems, the most common water pollution problem faced by urban lakes is the eutrophication due to nutrient overloading where not only the growth of nuisance algae is excessive known as cyanobacteria or blue green algae blooming but the invasive aquatic weeds covers all the lake's surface as well. The nuisance algae are toxic to fish and can cause the fish kill in the lake (Schueler and Simpson, 2001; Islam et al, 2012; Naselli-Flores, 2008; Birch and McCaskie, 1999; Snehal and Unnati, 2012; Priadie, 2011, Wetzel, 2001). Most pollution problems to the urban lakes in megacity Jakarta include cyanobacteria blooms, faecal contamination and toxic metals (Prihantini et al 2008; Hendrawan, 2005, Satya et al, 2011, 2012; Sulawesty et al, 2011, Satya and Larasati, 2012). Faecal and metals contamination and cyanobacteria blooms may deteriorate the ecological value of the urban lake's environment and can have potential risk to human health. Lack of concern by the public and lack of management by the government have been causing more damage on the environmental conditions of urban lakes in megacity Jakarta.

This paper is aimed to examine the water quantity and quality of urban lakes in megacity Jakarta according to the inhabited types of lake surroundings (buffer zone

types) and addresses the impacts of distinct urban development to the lake water quantity and quality.

METHODOLOGY

Water Quantity of Urban Lakes

Determination of water quantity of urban lakes in megacity Jakarta was conducted by using the urban lakes database from Ministry of Public Work Agency for Region of Ciliwung-Cisadane Rivers (BBWS-CC (2007, 2011)). Out of 203 lakes data only168 lakes has the complete area and volume data. The map of JABODETABEK (megacity Jakarta) area which covers for area of Jakarta, Bogor, Depok, Tangerang and Bekasi including city and regency and distribution of urban lakes which is basically spread out in the watershed of two main rivers i.e. Ciliwung and Cisadane Rivers is presented in Figure 1. Beside the BBWS database, the environmental condition of urban lakes also were identified by using the data collection of this study (2012, 2013) (11 lakes); and by using the database of PSDA(Center for Water Resources in Bogor-Bodebek area) (2011) (137 lakes); BPLH the capital city of Jakarta (Environmental Management Agency) (2008-2012) (15 lakes); BLH Depok (Environmental Management Agency) (2006, 2009, 2011) (11 lakes); and Public Work Agency – Tangerang city (2010) (6 data). The lakes determined for their water quantity were also categorised according to their watershed types so the results can show that what types or urban development impact on the water quantity. The environmental conditions of lakes were classified based on morphohydrological conditions, and water pollution.

Water Quality of Urban Lakes

There are eight inhabited types of lakes surrounding (buffer zone types) in megacity Jakarta determined in the previous study i.e. urban village, planned residential area, high rise residential area, rural village, ruban (rural-urban) village, industrial area, urban village-industrial area and agricultural area (Henny and Meutia, 2014). There were eleven lakes which represents distinct types of surroundings observed in this study for water quality measurements. Water quality examined was from several physical and chemical parameters related to the urban lake water quality issues including temperature, pH, turbidity, conductivity, Dissolved Oxygen (DO), Oxidation reduction potential (ORP)' and total

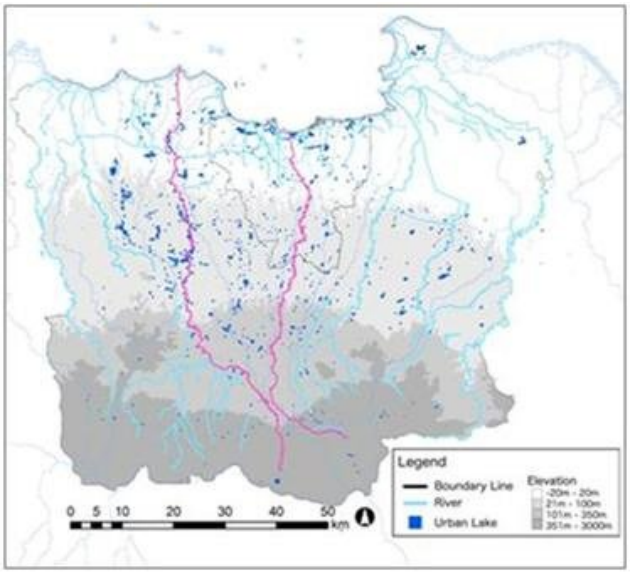


Figure 1. Urban lakes distribution in megacity Jakarta. (The map was digitized by Mimura and Uchiyama (RIHN project researchers, 2013) based on the SRTM and BAKOSURTANAL map of 2006).

dissolved solids (TDS) which were measured by using the Water Quality Checker (WQC, Horiba U). Lake water was sampled at the inlet and the middle of lakes for lab measurements such as Chemical Oxygen Demand (COD) as organic material parameter and nutrient (inorganic nitrogen and phosphate) concentrations. The measurements and the water sampling were done in September 2012 and March 2013. The analyses of COD, inorganic N and P were done by using HACH method procedure (HACH, 2005). Each lake water quality was compared with water standard status issued by the Environmental Ministry of Indonesia (PP no. 82, 2001).

Location and description of eleven lakes selected in this study can be seen in Table 1.

Table 1. Location and description of eleven lakes selected in this study (The image by Google Earth, 2014)

No.	Lakes	Location	Buffer Zone type (lake surroundings) - Description
1.	Kelapa Dua Wetan 	DKI Jakarta S 6°21'18.13" E 106°53'10.51" Elevation 52.67 m	Urban village Garbage spreads in the water, water color is green to black. There is no riparian vegetation or aquatic vegetation. Lake receives domestic waste water and inflow from canal which also receives domestic waste water and urban runoff.
2.	Teluk Gong 	DKI Jakarta S 6°08'01.84" E 106°46'42.12" Elevation 3.33 m	Urban village Surrounding area is dense residential area. Lake receives garbage and domestic waste water. Water color is blackish and with nuisance odor. No riparian vegetation. All round bank site and riparian is cemented.
3.	Rawa Dongkal 	DKI Jakarta S 6°21'26.97" E 106°53'15.91" Elevation 73 m	Planned residential area The surrounding area is planned residential area. The green open space such as city forest managed very well. The riparian vegetation is present. The water color is light green. The lake is in good condition.
4.	Situ Lembang 	DKI Jakarta S 6°11'52.29" E 106°50'05.29" Elevation 11 m	Planned residential area Morphohydrologically, the lake is in good condition. The lake is surrounded with the green open space and shoreline is managed well. The riparian vegetation and aquatic plant are present. There is no sewage inflow from domestic waste water but the lake is still receiving the storm water runoff.
5.	Situ Babakan 	DKI Jakarta S 6°20'31.14" E 106°49'23.76" Elevation 62.33 m	Rural-Urban village Lake's bank is cemented with concrete wall. There is almost no riparian vegetation and green open space area. The lake does not collect domestic waste water from surrounding inhabitants but still receives the storm water runoff and the channel inflow which receives sewage effluent.
6.	Hutan Taman Kota 	DKI Jakarta S 6°12'39.92" E 106°45'55.80" Elevation 10.33 m	Rural-Urban village Lake is surrounded by green open space which is managed as a city forest, however lake receive inflow from channel polluted by sewage effluent from the residential area. All-around lake's bank is cemented with concrete wall.
7.	Rawa Kepa 	DKI Jakarta S 6°11'18.30" E 106°48'08.61" Elevation 5.33 m	Urban village-Industrial area There is industrial area on the surrounding area of lake. There is green open space and riparian vegetation. Lakes receive urban runoff. The water is turbid.

Table 1. continued

No.	Lakes	Location	Buffer Zone Type (lake surroundings) - Description
8.	Situ Gintung 	South Tangerang S 6°18'23.41" E 106°45'52.31" Elevation 45.67 m	Suburb-Planned residential area The surrounding area is filled with planned residential area and semi rural area. The riparian is kept natural with vegetation but no green open space. The inlet filled with garbage and the lake receives sewage effluent. The water color is greenish and floating aquatic plants such as *Eichornia sp*. and water spinach are observed at the littoral zone.
9.	Situ Gede 	Tangerang S 6°212'11.07" E 106°38'38.02" Elevation 15.33 m	High rise residential area. Riparian is kept natural, however lack of riparian vegetation. The lake is managed well and in good condition. Lake receives waste inflow from the small vendors around the lakes.
10.	Rawa Cipondoh 	Tangerang S 6°11'57.08" E 106°40'22.02" Elevation 15 m	Rural-urban village One of the largest urban lakes in Megacity Jakarta with the complex surrounding area. Buffer zone area comprises mixed types land use such as urban village, planned residential area, rural village and agricultural area. Big percentage of lake's surface has been covered by invasive macrophyte. Lakes receive sewage effluent, and storm water runoff. Lack of riparian vegetation and green open space on the surrounding lake.
11.	Juanda 	Depok-West Java S 6°22'57.81" E 106°51'30.66" Elevation 81 m	Rural-Urban village The watershed types are semi rural and urban village mixed residential and agricultural areas. Lake receives sewage effluent and storm water runoff. Near the agricultural area and village water color is greenish black, but other part of the water appears in good condition.

RESULT AND DISCUSSION

Water Quantity of Urban Lakes

Most of existing lakes have the area < 200,000 m^3, however the lakes with the highest reduced volume recorded were the lakes with area > 500,000 m^3 (Figure 2). Lake loss also recorded with high lake loss quantity from the lakes with the volume<200,000 m^3. Close to half of existing lakes have reduced their water volume (Figure 3). The lakes determined for their water quantity were also categorised according to their buffer zone types so the results can show that what types or urban development impact on the water quantity. Most lakes with reduced water volume identified were in rural-urban village and rural areas with approximately 36% and 25% of volume reduction respectively (Figure 3). The most lake with reduced water volume case occurred mainly because the lake's area shrink and lakes become shallow due to sedimentation. Shoreline development and encroachment for residential area development, expanding the agricultural area to the lake's littoral zone, garbage dump and invasive macrophyte coverage by aquatic plant of *Eichornia sp.* are the main causes of the lake's water volume reduction. The lakes with significant change of water volume also suffered from siltation/sedimentation. Previous studies indicate the lakes loss and area reduced examined from the Dutch colonial maps to the recent year maps (Roemantyo et al, 2003, Henny and Meutia, 2014). Land use changes due to lake surrounding area development and massive macrophyte coverage on lake have reduced the lake's area and unquestionably the lake's water volume (Rosnilla, 2004; Priadie, 2005). Based on the morphology of lakes data such as lakefront landscape destruction, the existence of green buffer zone, shoreline encroachment, siltation, percentage of macrophyte coverage and water pollution, almost all lakes in megacity Jakarta are in disturbed condition and close to half of existing lakes were damaged (Figure 4). The lakes that were in damaged conditions were more in the BODEBEK area (Bogor-Depok-Bekasi, West Java) and Tangerang areas. The lakes in these areas are mostly in the rural and agricultural area types of watersheds. Previous study indicated that most of lake loss and lakes with area reduced and degraded conditions were in the urban village, rural village, rural-urban

village, urban village-industrial and agricultural areas (Henny and Meutia, 2014). The results indicate that many lakes in these types of watersheds receive lack of attention and management. Ongoing urban development for residential areas will likely to cause the expansion of the urban areas to the rural and agricultural areas. Several cases found where the lakes with very large area in the rural and agricultural areas had been sacrificed for residential area development and infrastructure. The urban lakes in the rural and agricultural areas will likely be sacrificed for the residential area in the future if they are not included in the urban planning as part of urban landscape feature that has very important function as water resources. The lakes in the planned residential, high rise residential and industrial areas which have good management program with the lake front area protection, the case of shoreline encroachment or significant area change will not occur.

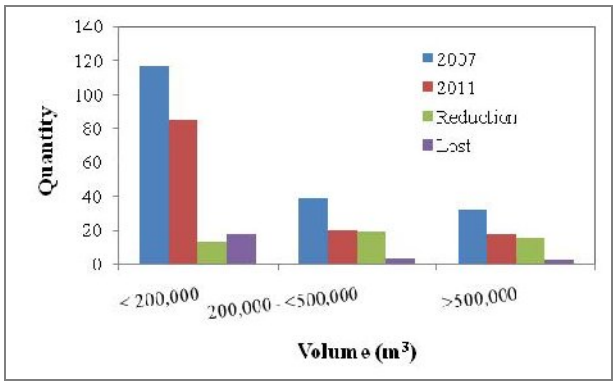


Figure 2. Existing urban lakes conditions based on the volume calculated from BBWS-CC and other government agency database.

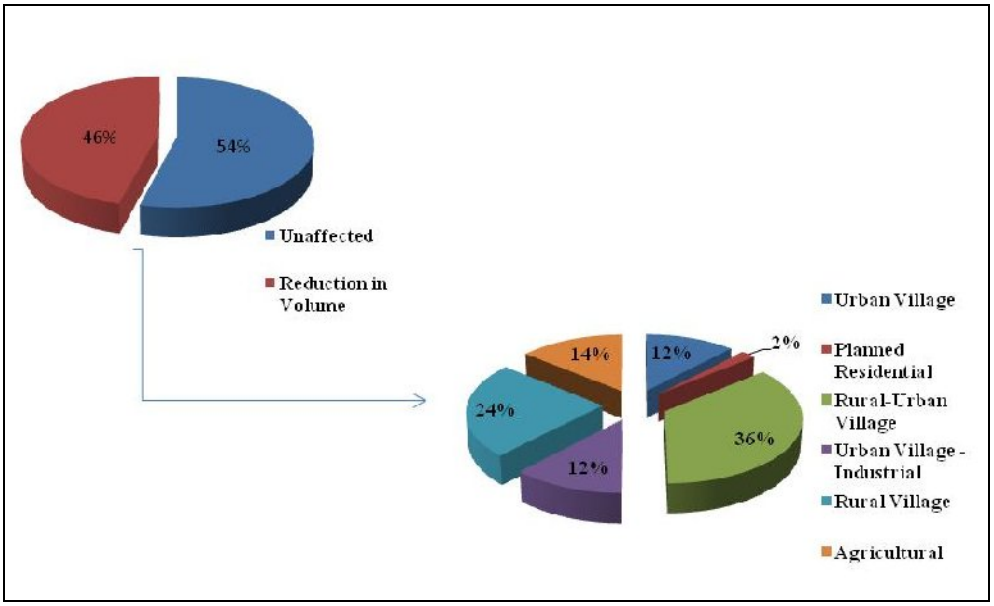
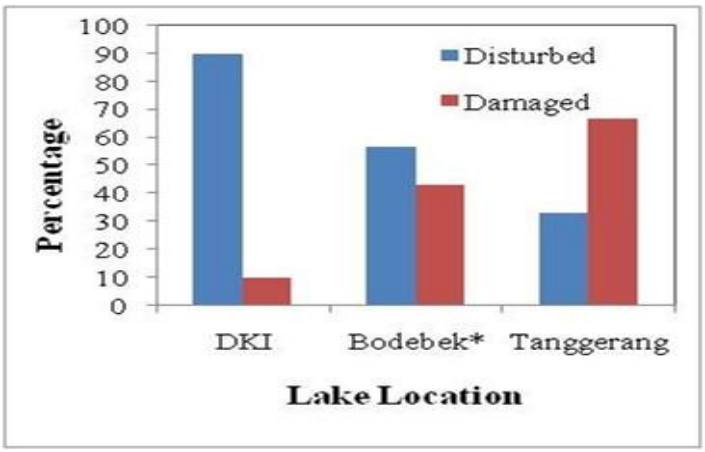


Figure 3. Distribution of lakes with reduced volume according to watershed types in megacity Jakarta calculated from BBWS-CC and other government agency database



* DKI-Jakarta City Area
* Bodebek (Bogor Depok Bekasi) West Java

Figure 4. Existing urban lakes conditions based on the environmental conditions calculated from BBWS-CC and other government agency database.

Water Quality of Urban Lakes

Water quality data based on field measurements is represented in Table 2. The other lake's data which are from other sources are presented as the comparison. Lakes in industrial, rural and agricultural area were not included in this study. The lakes with watershed types of rural and agricultural area are many present in Bogor area. Direct measurements of physical and chemical properties of lake's water in each buffer zone type indicate different water quality. Lake water pH values are in the range from neutral to alkaline. Although in the acceptable values range, slightly high values of conductivity, total dissolved solids (TDS) and turbidity indicate that the water contains more dissolved ions which can be sign that water is polluted. Only Lake Kelapa dua wetan which is in urban village area has very high TDS. Turbidity for clear unpolluted water is usually < 30 NTU (Weiner, 2000), and most of lakes have higher turbidity values. High dissolved oxygen (DO) of > 6 mg/L indicates the water is in good condition to support aquatic lives. Water quality standard for fishery is around 3 mg/L (PP no.82, 2001), however to sustain better aquatic lives especially for sensitive fish, DO should be maintained at least 5 mg/L for tropical water (Weiner, 2000). Below 3 mg/L of DO indicates the water is anoxic and polluted by organic matter. Eutrophic lake usually will give high DO during the day in the sunny condition due to photosynthesis by phytoplankton (green algae) that produces high oxygen level. However, during the night time when all aquatic organisms including green algae consume oxygen causing rapid depletion of oxygen that can kill fish in the lakes. Case of fish kill occurs frequently at Lake Maninjau when the water condition become hypereutrophic with nuisance cyanobacteria blooms (Sulastri et al, 2001). The lakes observed in this study have higher DO values during day sampling especially in the lakes with obvious green water color in almost all watershed types except the lake in industrial area. The lakes in all types of watershed also experienced very low DO except the lake is in high rise residential. The water in the lake's inlet has very low DO level due to garbage dump and domestic waste water effluent. The inlet water of Lakes Gintung and Cangkring contained < 1 mg/L DO values (Kristiana, 2003; Priadie, 2011).

Table 2. Physical and chemical water quality of urban lakes

Surrounding (Buffer zone) Type	Lakes	Temp (°C)	pH	Cond. (mS/cm)	TDS (mg/L)	Turbidity (NTU)	DO (mg/L)	ORV (mV)	Source
Urban Village	Kelapa dua wetan	28.24 - 28.42	8.15 - 8.37	0.195 - 0.204	127 - 131.5	44.8 - 53	8.49 - 9.1	46 -102	
	Rawa Badung*	25.5	7.3 - 7.4	0.720 - 0.750	456 - 481	34 - 130.5	0.32 - 0.47	-	BPLH DKI, 2012
	Teuk Cong	28.87 - 28.96	7.86 - 8.22	0.628 - 0.637	403 - 408	71.3 - 116	1.07 - 4.3	0.153 - 0.14	
	Mangga Bolong*	25.3 - 25.5	6.8 - 6.9	0.207 - 0.435	136 - 291	29.5 - 49	2.59 - 3.14	-	BPLH DKI, 2012
Planned Residential	Gintung	30.5 - 31.1	7.88 - 9.05	0.176 - 0.189	119 - 131	37.7 - 55.5	3.6 - 5.12	64 - 127	
	Situ Lembang	27.33	9.08	0.273	177	56.8	4.2	173	
	Rawa Dongkal	29.14	9.2	0.122-0.123	80 - 790	84.3 - 97	0.07 - 9.1	28-53	
High Rise Residential	Cede, Tangerang	28.3 - 29.05	8.5 - 8.7	0.31- 0.313	202 - 203	37.1 - 66.8	6.15 - 8.56	30 - 70	
	Elok*	24.3	8.9 9.6	0.473 - 0.509	332 - 362	25.5 - 55.5	8.35 - 10.23		BPLH DKI, 2012
Rural-Urban Village	Cipondoh	28.82 -29.22	7.51 - 7.53	0.245 - 0.255	159 - 163	42.5 - 75.4	1.93 - 9.03	-51 - 103	
	Joglo	27.25 - 27.27	7.75 - 7.8	0.26 - 0.27	169 - 176	14.5 - 20.7	1.84 - 8.12	Jun-99	
	Babakan	29.58 - 29.91	7.85 - 7.90	0.22 - 0.24	146 - 155	12.7 - 13.5	3.12 - 3.42	163 - 177	
	Taman Hutan Kota	27.31 - 27.52	7.7 - 7.76	0.217 - 0.246	141 - 160	17.8 - 23.5	5.65 - 5.69	0.26 - 74	
Industrial	Rawa Gelam*	25.7 - 26	6.6 - 7.4	0.646 - 0.93	405-511	13.5 - 45	0.41 - 0.47	-	BPLH DKI, 2012
Urban Village-Industrial	Pedongkelan*	25 - 25.4	7.1 - 8.1	0.342 - 0.442	214 - 500	46 - 96	8.62 - 13	-	BPLH DKI, 2012
	Rawa Kepa	26.78	7.85	0.732	1.05	1.23	0.469	0.361	
Rural Village	Bojongsari**	31 - 31	6 - 7.5	0.18 - 0.24	100 - 140	-	2.5 - 6.8	-	Suryoto et al.2011
Agricultural	Burung**	28 - 30.1	6 - 7	0.05 - 0.213	100-110	-	5 - 6	-	Suryoto et al.2011
Water Standard (Class ***))		deviasi 3	6 - 9	-	1000	-	3	-	PP no. 82, 2001

*The data from other source

Concentrations of chemical oxygen demand (COD) as organic material contaminant, inorganic nitrogen and phosphor as nutrient contaminants in lake water is presented in Table 3. Coliform data and several lakes data are from other sources are presented as comparison. Highlighted values indicate the values are higher than the acceptable values according to PP no.82 (2001). The lakes in urban village areas considered are polluted and not only have high COD, but also N-NH_3 and coliform concentrations. High organic and ammonia concentrations also reported in Situ Gintung (Kristiana, 2003). The results are consistent with previous measurements reported that the lakes in urban village area such as Rawa Badung and Mangga Bolong also have high those contaminants concentrations. The lakes selected in this study in megacity Jakarta almost all lakes have high COD and coli form concentrations indicate that the lakes receive untreated domestic waste water, sewage effluent in addition to urban runoff and garbage dump. Sewage pollution is considered major cause of decreasing water quality in lakes. Sedimentary records indicated the sign of sewage pollution in shallow urban lakes in UK where the sediments have been contaminated by organic matter and coli form bacteria (Vane et al, 2010). According to Hendrawan (2005) water quality of 79% urban lakes in Jakarta city area are in bad conditions. The study indicates that deteriorating lake's water quality due to lack of public concern and lack of management by government to maintain the environmental conditions of lakes.

Nutrient pollution from N and P loadings have been causing severe utophication problem in most of lakes especially shallow urban lakes which indicated by dark green water color as a sign of green algae blooms and excessive macrophyte coverage on the water surface. The green scum spotted in some lakes in urban village area indicated the presence of

nuisance blue green algae cyanobacteria. Several lakes in urban village, rural village and agricultural area such as Lakes Rawa Badung, Mangga Bolong, Cipondoh, Cangkring and others have faced problem with cyanobacteria contaminated and invasive floating macrophyte coverage from the type of *Eichornia sp.* (Priadie, 2011; Prihantini et al, 2008; Kristiana, 2003; Suawesty et al, 2012). Agriculture and urban runoff usually carry high loads of N and P from the fertilizer. Eutrophication problem has known to reduce water clarity, decline in fish community, increase nuisance algal blooms and fish kills due to low dissolved oxygen and decrease the health of lake's ecosystem by far decreasing the amenity of urban lives.

The urban lake waters in megacity Jakarta have suffered notonly from nutrient, organic material and bacterial contamination but toxic metals as well. Previous study reported the lakes near industrial area and urban village contain phytoplankton with high concentrations of Cd and Pb contamination (Satya et al 2011). Suryono et al (2011) has studied on the assessment of metals in several lakes sediments in megacity Jakarta. The toxic level of sediments of lakes data after categorised based on the watershed types can be seen in Table 4. The results showed that the lakes in distinct watershed types contained high metal concentration of Hg, Cd, As and Pb in the sediment and the values above the effect range low (ERL) and the sediments were classified less toxic to toxic (Table 4). The lakes with metals contaminations in distinct watershed types could have potential threat to human beings, especially for the lakes used for fishery or fishing activity.

Tabel 3. Chemical and biological water quality of urban lakes

Surrounding (Buffer Zone) Type	Lake	COD	$N\text{-}NH_3$	$N\text{-}NO_3$	$P\text{-}PO_4$	Coliform* (cells/100 ml)	Conditions*	Source
Urban Village	Kelapa dua wetan	192.77 - 214.19	0.04 - 1.19	0.26 - 0.4	0.52 - 0.57	$70 - 28 . 10^3$	Disturbed	
	Rawa Badung*	98.64 - 303.69	-	0.23 - 0.27	1.48 - 1.5	$70 . 10^4 - 17 . 10^5$	Damaged	BPLH DKI, 2012
	Teluk Gong	120.48 - 268.73	9.95 - 10.11	0.61 - 0.67	1.34 - 1.61	$28 . 10^3 - 60 . 10^3$	Disturbed	
	Mangga Bolong*	40 - 9..34		0.11 - 0.53	0.0.. - 0.46	$70 . 10^3 - 35 . 10^5$	Disturbed	BPLH DKI, 2012
Planned Residential	Gintung	36.77 - 37.48	0.07 - 0.17	2.36 - 2.37	0.16 - 0.2		Good	
	Situ Lembang	13.39 -54	0.01 - 0.02	0.58 - 1.5	0.03 - 0.05	$10 . 10^3 - 90 . 10^3$	Good	
	Rawa Dongkal	93.7 - 192.78	0.04 - 1.07	0.12 - 2.72	0.2 - 0.32	50 - 80	Disturbed	
High Rise Residential	Gede	30.49 - 84.7	0.01 - 0.05	0.03 - 1.43	0.2 - 0.59	-	Disturbed	
	Elok*	92.43 - 93.48	-	0.15 - 0.34	0.52 - 1.13	$200 - 70 . 10^3$	Disturbed	BPLH DKI, 2012
Rural-Urban Village	Cipondoh	200.8 - 227.57	0.01 - 0.02	0.31 - 1.35	0.19 - 0.3	-	Disturbed	
	Jurang	138.87 - 187.41	0.01 - 0.02	0.58 - 1.6	0.03 - 0.05	-	Disturbed	
	Babakan	187.41 - 294.51	0.06 - 0.07	0.03 - 0.03	0.16 - 1.20	$80 . 10^3 - 30 . 10^5$	Disturbed	
	Taman Hutan Kota	58.5 - 187.41	0 - 0.01	0.18 - 0.73	0.16 - 0.32	$17 . 10^3 - 16 . 10^5$	Disturbed	
Industrial	Rawa Gelam*	40	-	0.37 - 0.39	0.55 - 1.49	$24 . 10^4 - 11 . 10^5$	Disturbed	BPLH DKI, 2012
Urban Village Industrial	Pedengkelan*	57.30 - 99.55		0.02	0.52 - 0.58	$11 . 10^3 - 23 . 10^5$	Disturbed	BPLH DKI, 2012
	Rawa Kepa	172.79 - 307.89	0.02 - 0.08	9.41 - 10.63	1.53 - 2.24	-	Disturbed	
	Cangkring**	48.6 - 65	-	-	1.8 - 2.7	-	Disturbed	Priadie, 2011
Water Standard (Class II)		50	<0.02 for Fish	20	1	10000		PP no 82, 2001

*The data from other source. Coliform data from BPLH DKI, 2012.

Table 4. Sediment toxic level of several lakes in distinct watershed types (Classified based on data of Suryono et al, 2011)

Surrounding (Buffer zone) Type	Lakes	Level
Urban Village	Rawa Besar	Toxic
	Babakan	Toxic
Rural-Urban	Cikaret	Less toxic
Urbanvillage-industrial	Rawa Kalong	Toxic
Rural Village	Bojongsari	Toxic
Agricultural	Lido	Toxic
	Burung	Less toxic

CONCLUSION

Half of urban lakes have lost their water quantity due to shrinkage in area, siltation/sedimentation and invasive macrophyte coverage caused by the human disturbances in lake surrounding areas. Most lakes lost their water quantity are in the rural-urban village, urban village and agricultural areas. High organic and nutrient contaminants even coliform bacteria are also observed. Most of lakes in megacity Jakarta are at least in disturbed to damaged environmental conditions.

Impacts of urbanization to the urban lakes include shrinkage in area, lake's volume reduction due to siltation/sedimentation, eutrophication condition by algal blooms and excessive growth of invasive macrophyte, and water pollution which affect the lakes water quantity and quality. The urban lakes in megacity Jakarta continuingly have been degrading physically and ecologically affecting its water quantity and quality which is increasing the threat to human's health and impact future human's resilience in urban megacity Jakarta. Furthermore, the lakes have lost their function for human needs. The lack of legal control on the lake shoreline development, lack of solid waste management, lack of adequate water treatment, sewerage and storm water flow management are the big issues that accelerate urban lakes water quantity and water quality problems. Lack of concern and management by public especially the government has been the main cause of the problems.

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