

# The Lake As An Urban Ecological Balance In Depok City

Diana Irvindiaty Hendrawan, Melati Feranita Fachrul, Astri Rinanti

**Abstract:** The aims of the study were to identify water quality status, and analysis the function of lake as an ecological balance of the city. Depok city have 20 of lakes which function as a water catchment areas. The high population growth of Depok City give a pressure on the small lake and getting siltation and water pollution. Silting and lake area reduction result in a reduction in the volume of water disposal and the impact is will be a flood as well. The method to calculate the water quality status using the water pollution index (PI). The result show that the quality status of lakes is moderate upto heavy polluted. The main pollutants that enter to lake come from settlement. This is indicated by the high value of BOD, COD, fecal coli due to mostly in the settlement not including the communal waste water treatment plant (WWTPs) to process the greywater. This condition will distrubed of biogeochemical cycle and makes environmental problems also gave a negative impact on community. Integrated management is needed in the management of lakes in Depok City. The action that must be taken to improve its ecological function were to digging the lake more than 3 m, construct the communal WWTPs to treat settlement wastewater and arrangement of lake banks.

**Index Terms:** biogeochemical cycle, environmental problems, flood, siltation, small lakes, water pollution, water quality status

## 1. INTRODUCTION

Lakes in Depok City in recent years have experienced changes in quality and quantity. Depok city has an area of 200.29 km<sup>2</sup> have 20 of lakes. The water quality of small lake decreases due to pollutant load. The most dominant factor affecting in water pollution of lakes from domestic and industrial waste. The quantity of lake decreases with changes in lakes to other places of activity or siltation which results in reduced water catch volume. These changes occur because of the increasing land demand for housing and business needs. The small lakes have a function as water catchment areas, hydrology and cycle balancing in the surrounding area. The 20<sup>th</sup> century, the surface of arable lands decreased nearly 50% and the surface of buildings increased triply. It caused the disappearance of wetlands in the catchment area and changed the shape of the shoreline. The consequence was the reduction in water surface of lakes. This is also changes in the hydrographic network in the catchment area [1]. Rainfall is the main driver of runoff in the catchment as opposed to land cover changes [2]. Water pollution was relatively high as a impact of catchment area activities [3]. Anthropogenic pressure put onto reservoirs will soon grow up owing to cultivated fields, roads and buildings neighbouring these reservoirs [4]. Land management and pollutant interception are likely to remain important in the effective long-term protection of aquatic biota [5]. Actually these lakes have the potential of beautiful landscapes that have not been optimized. The potential a lake becomes a tourist destination if it is managed well and can be an alternative tourism destination for the city.

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The scope of the activities carried out are (1) activities at the surrounding area as a pollutant sources, (2) water quality and water status 3 years, and (3) function of lake for city

## 2 RESEARCH METHODOLOGY

This study was conducted during January-Juni 2019 in 20 small lakes are located in Depok City. To find out the condition of the lake, was conducted by survey a round the lake. Identification is carried out to determine the width of the lake banks, activities around the lake and potential pollutants. Some secondary data obtained from several source. The area and volume of lake obtained from Depok Municipality in Figure, 2018, Result study of Environment Agency and Hygiene 2016-2019. The 3 years water quality of lakes come from environmental services and cleanliness Depok . The status of water quality is determined using the pollution index method in accordance with the Decree of the Minister of Environment No. 115 of 2003 concerning Guidelines for Determining the Status of Water Quality. Calculation of pollution index (PI) is done by using Eq (2). The 11 parameters used for calculate the PI are TDS, TSS, BOD, COD, DO, Phosphat (PO<sub>4</sub>), Nitrate (NO<sub>3</sub>), oil and fat, detergent, total coliform and fecal coliform.

$$PI_j = \sqrt{\frac{(C_i/L_{ij})_M^2 + (C_i/L_{ij})_R^2}{2}} \dots\dots\dots(2)$$

Where

C<sub>i</sub> = Observed concentration of i parameter

L<sub>i</sub> = Permissible limit of i parameter

M = Maximum value of (C<sub>i</sub>/L<sub>ij</sub>)

R = Average value of (C<sub>i</sub>/L<sub>ij</sub>)

Pollution Index (PI) Value Water Criteria Status

0 < IP < 1,0 Meets Quality Standards (Good), 1 < IP < 5,0 Low Polluted, 5 < IP < 10 Moderate Polluted, IP > 10 Heavily Polluted

## 3 RESULT AND DISCUSSION

Depok City have a 11 district. Population in Depok City increase each year. The population growth rate in Depok City is 3.5 percent and population dencity is 11,256 people/km<sup>2</sup> [6]. Figure 1 shows Depok population growth in the last 3 years and distribution at the district. The high population growth in

Depok City is caused by the many facilities and the speed of economic growth. As a result there is pressure on the environment such as less of sanitation conditions and changing of land use.

degradation of natural resource and loss of biodiversity are the most visible socio-economic and environmental problem and all these put pressures on the water bodies [10].

**TABLE 1**  
**AREA AND VOLUME OF LAKE IN DEPOK CITY**

No	Lake	Area (Ha)- 2015 <sup>1)</sup>	Volume (m <sup>3</sup> )
1	Pengasinan	6	18000
2	Sawangan	2.85	-
3	Bojongsari	28.25	113000
4	Pancoran Mas	0.6	480
5	Citayam	8.25	33000
6	Asih Pulo	8	24000
7	Rawa Besar	17	34000
8	Bahar	2	6000
9	Studio Alam	7.5	-
10	Pangarengan	7	14000
11	Sidomukti	2	6000
12	Cilodong	1	3000
13	Gemblung	7.2	150000
14	Gadog	1.3	19500
15	Jatijajar	6.5	19500
16	Cilangkap	5.75	1500
17	Rawa Kalong	8.25	24750
18	Pedongkelan	6.25	25000
19	Tipar	7.5	33957
20	Ul	17.5	52500
21	Pladen	1.5	1500

Source: <sup>1)</sup> [8]

Catchment areas of lakes are highly degraded and siltation of lakes has been increasing. Loss of ecosystems, modification of ecosystems or ecotones, including community structure and/or species composition is another key factor that may have progressing impact on the water resources [11]. Negative impacts of siltation identified include destruction, of fish breeding areas, flooding, poor water quality affecting human and animal use and increased resource user conflicts [12]. The sediment load re-deposits within a transport distance [13]. Increased sediment loads not only alter biotic assemblage structure and ecological functioning significantly, but frequently result in reduced biological diversity and productivity [14]. Pollutant parameters such as BOD, COD, phosphate, nitrate, fecal coli, total coliform, oil and fat, almost all of the lakes exceed the quality standard. Figure 2 shows the BOD, COD and Fecal coli. The Pollution Index (PI) of lakes in Depok shows at Tabel 2. The main pollutants that enter the waters of the lakes in Depok come from settlements, restaurants, home industries such as tofu and others. The BOD and COD content on all lakes exceeds the quality standard. The quality standard used is Government Regulation No. 82 of 2001 concerning Surface Water Quality, Class 2. The high BOD and COD in the waters come from organic materials that enter the lake. Degradation of organic matter by microorganisms causes oxygen depletion. Low oxygen solubility in the waters indicates that the waters are not healthy so they cannot support aquatic life properly. The type of organism that lives adjusts to low oxygen conditions. Low oxygen solubility is also influenced by the presence of oil and fat layers in the water which prevents the entry of oxygen from the air into the water. At some lakes have a eutrophication, with the water hyacinth plants covering the waters. [9] states that dredging of sediments is one way to control eutrophication. Whereas [10] stated that to control eutrophication carried out through controlling pollutant

**Fig. 1. Total Population in Depok City 2015-2017 and Distribution of Population Each Eistrict. Source: [6, 7, 8]**

The lakes in Depok City are aquatic ecosystems that function as a city balance. Some of the lakes in Depok are designated as ecosystems that must be conserved. Lakes at Depok City are natural lakes. The source of water comes from springs, and some of the river around it. Table 1 shows the area and volume of lakes in Depok City. Many residential areas are located around the lake. 50% of the catchment area of the lakes is a settlement on average. Changes in land use and sediment carried by the flow of river or runoff from its banks cause the area of the lake to decrease and become shallow. It's causing the lake's volume to be reduced. Reduction in volume will cause flooding. In addition, the waste carried by the flow of water entering the lake or intentionally dumped into the lake will cause siltation and contaminate the water when the degradation process occurs. Land Use and Land Cover Changes (LULCC) are interrelated with other global processes like global climate change, population growth, land degradation etc. The relationship between climate change and land use change is very significant [9]. Rapid population growth, agricultural expansion, environmental fluctuations,

sources, ecological restoration and management of water catchment areas. This condition is to control the entry of excess nutrients physically, chemically and biologically. Total total coliform is sourced from the environment and does not originate from fecal contamination. Meanwhile, fecal coliform is caused by fecal contamination. The value of fecal coliform and total coliform in most of them exceeds the quality standard. The high value of fecal coliform is caused by the presence of latrines on the side, chicken farms, leaks from septic tanks and manure that are carried by runoff. That human activities, represented by waste water discharge, have affected the quality of water of lake. Domestic and agricultural activities in the surrounding area to the lake have remarked a great impact on the nutrient concentrations [15]. Generally, the lake is an important water resource for domestic and industrial water supply and recreation when its quality and clarity are good enough. Lake when the nutrients loading rates were changed. [16]. The discharge of untreated dye industry waste water and untreated sewage water which has deteriorated the lake [17]. The causes of pollution in lakes in Depok are from residential activities in the catchment area. The source of pollutants that enter the water body comes directly from activities around the lake and is carried by the river flowing into the lake. The pollution in lakes is caused by the alternation of stream or lake corridors into built areas. Though the stream corridors has a function as a barriers to protect from pollution, prevent flooding, minimize sediment transport. The impact of the decrease of water quality is that it is no longer suitable for the type of water designation as a function of fisheries, tourism, and so on. The negative impact caused by the ecological aspect is triggering a decrease in even the loss of native species that inhabit the waters there and the decreasing biodiversity of the lake waters.

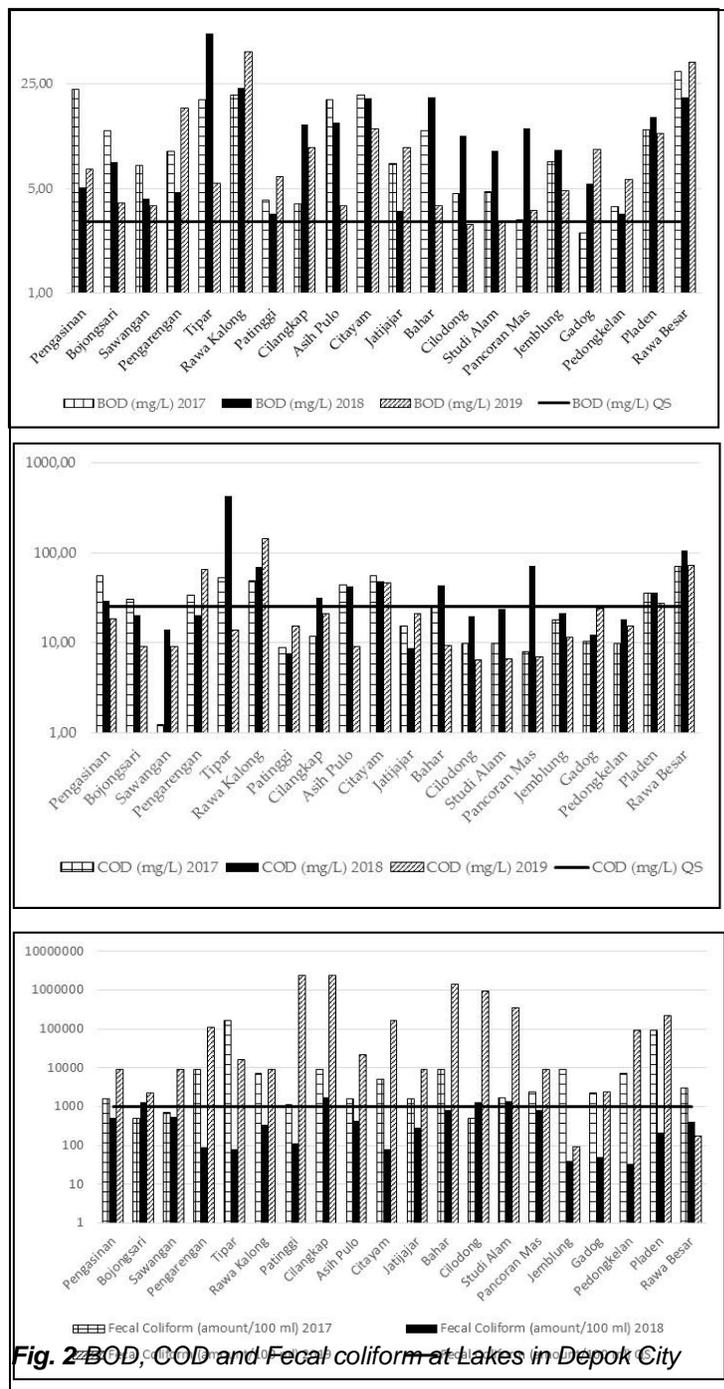


Fig. 2 BOD, COD and Fecal coliform at Lakes in Depok City

TABLE 2  
POLLUTION INDEX OF LAKES IN DEPOK CITY

No	Name of Lake	2017		2018		2019	
		Quality Status	Quality Status	Quality Status	Quality Status		
1	Pengasinan	5.53	Moderate Polluted	1.92	Low Polluted	6.6	Moderate Polluted
2	Bojongsari	2.95	Low Polluted	2.02	Low Polluted	1.6	Low Polluted
3	Sawangan	4.31	Low Polluted	2.16	Low Polluted	6.6	Moderate Polluted
4	Pengarengan	6.51	Moderate Polluted	3.27	Low Polluted	79.0	heavily polluted
5	Tipar	113.88	heavily polluted	13.01	heavily polluted	11.4	heavily polluted
6	Rawa Kalong	5.18	Moderate Polluted	5.63	Moderate Polluted	10.0	heavily polluted

7	Patinggi	3.45	Low Polluted	0.89	Good	1706.9	heavily polluted
8	Cilangkap	6.45	Moderate Polluted	29.22	heavily polluted	1705.6	heavily polluted
9	Asih Pulo	7.20	Moderate Polluted	3.30	Low Polluted	15.8	heavily polluted
10	Citayam	42.67	heavily polluted	4.83	Low Polluted	113.8	heavily polluted
11	Jatijajar	22.75	heavily polluted	2.20	Low Polluted	6.6	Moderate Polluted
12	Bahar	6.52	Low Polluted	4.89	Low Polluted	1315.1	heavily polluted
13	Cilodong	1.14	Low Polluted	2.72	Low Polluted	655.8	heavily polluted
14	Studi Alam	2.33	Low Polluted	2.22	Low Polluted	249.5	heavily polluted
15	Pancoran Mas	1.74	Low Polluted	3.09	Low Polluted	6.6	Moderate Polluted
16	Jemblung	6.46	Moderate Polluted	2.18	Low Polluted	1.2	Low Polluted
17	Gadog	2.35	Low Polluted	1.30	Low Polluted	2.3	Low Polluted
18	Pedongkelan	5.03	Moderate Polluted	1.26	Low Polluted	497.2	heavily polluted
19	Pladen	64.11	heavily polluted	35.53	heavily polluted	228.6	heavily polluted
20	Rawa Besar	7.23	Moderate Polluted	4.98	Low Polluted	228.6	Moderate Polluted

Table 2 shows about the PI in lakes at last 3 year (2017-2019). In 2017, 40% of lakes were heavily polluted and in 2019, 60% of lakes were heavily polluted. This condition is influenced by the rapid population growth of Depok City, where there is a change in land use management from open space to built land. In addition, overall management of wastewater in settlements has not yet been implemented. Damage of lakes with a reduction in lake area, siltation and water pollution will disturb the biogeochemical cycle and makes environmental problems also gave a negative impact on community. [18] said the biogeochemical cycle of each element is thus represented as a set of interconnected reservoirs and, at any time, its state is characterized by the reservoir sizes or contents. The concept of pollution prevention planning, is directed at the catchment area. Communal WWTP planned to treat domestic wastewater follows the characteristics of domestic wastewater. Waste water from activities other than households, such as workshops/car wash, laundry, restaurant and food industry, then local processing must be carried out in advance to reduce certain parameters, such as oil and grease from oil and detergent from laundry, phenol from disinfectant and carbolic cleansers. This local processing is a specific and small-scale processing, so socialization and assistance are needed. An ecological city must have the concept of providing housing, workplaces, open spaces for recreation, transportation systems, supply of water/energy supply/ distribution, food & waste handling. Based on Presidential Decree No. 114 of 1999, there were 3 sub-districts in Depok City designated as water and soil conservation areas, that are Limo, Cimanggis and Sawangan Districts. Determination of the area is intended to ensure the continuation of water conservation and ensure the availability of water and flood prevention. The rapid population growth causes a lower rate of yield growth, which can be seen from the high poverty rate. City growth affects and threatens the existence of ecosystems. Urban systems tend to have little ability to recycle, energy use is inefficient and continues to grow outward and economically. The city reflects a waste of land and natural resource use. City activities cause damage that is sometimes permanent (irreversible) on natural landscapes and habitats, as well as flora and fauna. To control the environmental engagers performance with material flow analysis, energy flow analysis, wise use of chemicals, utilization of living organisms, material

distribution, integrated system and policy. Sustainable City should have a concept the city carrying capacity limits are natural resources, cities that care about ecological boundaries can reduce their impact on other cities and their communities, urban development planning with an ecological concept requires buildings that are adjacent to the recipient's water body to be protected by regulations to protect water levels and reduce pollutants, technological innovation is needed to maintain the carrying capacity of the city. In urban areas, waste must be processed. To control urban ecosystems regarding to biochemical functions. The carrying capacity of the environment of the city is expected to be a basis for recognizing the limits of city residents' feasibility. Therefore, the determinants of carrying capacity need to be adjusted to the characteristics of urban land. To protect the lake from the damage should pay attention to pollution load carrying capacity. The capacity of lake water pollutant load is the ability of lake water to accept input of pollution loads without causing the water become polluted. The important function of the lake for the ecological balance of the city are as a source of water for life, regulating water systems and suppliers of ground water, flood control, regulating of microclimate through evapotranspiration processes so as to maintain humidity in the surrounding area, water catchment area, habitat for flora and fauna and recreation area.

#### 4 CONCLUSION

Residential areas are located around the lake. 50% of the catchment area of the lakes is a settlement on average. The main pollutants that enter the waters of the lakes in Depok come from settlements, restaurants, home industries such as tofu and others. Pollution Index (PI) of lakes in Depok low polluted-heavily polluted where in 2017, 40% of lakes were heavily polluted and in 2019, 60% of lakes were heavily polluted. This condition is influenced by the rapid population growth of Depok City, where there is a change from open space to built area. The action that must be taken to improve its ecological function were to digging the lake more than 3 m, construct the communal WWTPs to treat settlement wastewater and arrangement of lake banks. The lakes in Depok City should be conserved related of their function as a ecological balance of the city.

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