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by P. Theza E. A. Pellondo'u

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P. Theza E. A. Pellondo'u [a,b*], Rambu Ana Toya [a] and Silphia Novelyn [a]

[a] *Faculty of Medicine, Universitas Kristen Indonesia, Jakarta, Indonesia.*
[b] *General Hospital Universitas Kristen Indonesia, Jakarta, Indonesia.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Drowning is death caused by asphyxia due to the aspiration of fluids into the airways or lungs, resulting in airway obstruction within 24 hours. One of the examinations to establish the diagnosis of drowning victims is a laboratory examination of diatom identification. This research aims to know the morphological description and types of diatoms that live along the Upper, Middle, and Lower Ciliwung Watersheds, to facilitate the identification of drowning victims found in the Ciliwung River. The research design is qualitative descriptive. The data in this study were the results of observations and analysis of Ciliwung river water samples at the Research Laboratory of the Faculty of Medicine, Indonesian Christian University. The study's results found 17 different species at the Katulampa Dam, 19 at the Ciliwung Bridge, and 14 at the Manggarai Sluice Gate. From a

**Corresponding author: Email: theza.pellondoup@uki.ac.id;*

total of 22 species of diatoms found, overall, the widest distribution was *Nitzschia sp, Navicula sp, Fragilaria sp, and Cyclotella sp*. The distribution and types of diatoms found are closely related to current velocity and water discharge, temperature, and river turbidity.

Keywords: Drowning; diatoms; ciliwung watershed.

1. INTRODUCTION

Drowning is death caused by the aspiration of liquid into the airways or lungs due to immersion of all or part of the body in water, causing asphyxia due to obstruction of the airways within 24 hours. Cases of drowning are not only found in deep waters such as seas, lakes, rivers, or swimming pools, it can also be found only in parts of the face that are below the water level in ditches or puddles, if sufficient fluid covering the nostrils and mouth, it is enough reason to be stated as drowning. In this case, medical forensic science plays an important role in determining the cause of death, how, and where the victim's death is located [1]. In 2019 the World Health Organization (WHO) recorded 236,000 people died of drowning, making drowning cases a major public health problem worldwide. In the same year, drowning due to injury accounted for nearly 8% of deaths globally [2]. Drowning is the 3rd leading cause of death from unintentional injuries, with 7% of all injuries-related deaths [3]. In 2020 WHO stated that deaths due to drowning in Indonesia reached 4,518 or 0.27% of the total deaths. The death rate ranks 123rd globally. In determining the cause of death in drowning cases, the examination that can be carried out is a direct examination of the victim's body or a microscopic laboratory examination.

There are various microscopic examinations in cases of drowning, one of which is the examination of diatoms which aims to identify where the victims first drowned [4]. Diatoms are the main contributors to phytoplankton in both freshwater and marine ecosystems. Compared to other microalgae, diatoms have the largest number of species [5]. Currently, it is known that there are more than 260 genera of diatoms and consist of more than 100,000 species [6]. Diatoms are very sensitive or easily affected by environmental conditions (temperature and nutrition supply), so the diatoms' morphology can vary. This trait can greatly assist the forensic team in determining the location of a drowning victim because the cell wall of diatoms is anti-acid, it is easy to separate from body tissues using acidic fluids, so it is often chosen as the standard gold examination in cases of drowning [7]. This study uses an experimental research design in which this research model requires that the sample be treated. In this study, the samples used were water taken from the upstream, middle, and the downstream Ciliwung River Basin. Previous studies have discussed the histopathological features of the lungs, kidneys, and heart under conditions of immersion in seawater and fresh water, so this research focuses on identifying the shape of diatoms according to the sampling location. Because it is sensitive to the environment, diatom examination can be used to identify the location of the waters where the victim drowned. Based on the description above, it is necessary to research the differences in diatom profiles at each sampling location from upstream to the mouth of the Ciliwung River.

In this study, the problem was formulated: What is the description of the morphology and species of diatoms that live in the Katulampa Dam, the Ciliwung Cibinong Bridge, and the Manggarai Sluice Gate? The research aims to identify the species of diatoms that live along the Ciliwung River Basin, which includes the upstream, middle, and downstream of the river.

2. LITERATURE REVIEW

Diatoms are eukaryotic micro-organisms that do not belong to the class of animals, fungi, or plants. A naturalist named Ernst Haeckel grouped diatoms into the kingdom Protista, categorized in the class Bacillariophyceae [8]. Among the classes, Protista, diatoms, and unicellular phytoplankton organisms belonging to the group Stramenopila are also described [9]. Diatoms are a type of plankton that fills most of the fresh and marine waters [10]. Known to have about 260 genera of diatom or more, and it is estimated that there are more than 100,000 living species. It is estimated that there are more than 16,000 species of diatoms worldwide, but they are still being identified in studies [11]. Diatoms can produce cell walls in the form of porous silica and have a distinctive structure, which is divided into two layers, creating various shapes and patterns of diatom pores, thus creating specific-species diversity [12]. Diatoms can be preserved in sediments for a very long time because of their distinctive cell wall construction and anatomy, formed from silica [13]. In general, diatoms have a length or a cell diameter of 40-200 μm, but the smallest sizes are 4-5 μm and can be found up to 1 mm large [14].

Not much different from other algae species, diatoms can carry out photosynthesis for their energy needs. As long as there is enough light and nutrients, diatoms are also renowned as a significant contributor to phytoplankton, making up 25% of it [15]. Regarding movement, diatoms are very limited, some types of diatoms can move slowly, but most depend on water currents. As living things, diatoms also degenerate to death. When they die, marine diatoms sink to the seafloor, which then plays a role in forming mud on the seabed.

Diatoms have a unique structure of cell walls composed of 2 layers of silica, distinguishing diatoms from other algae, making it easy to identify them in sediments. Diatoms are also called golden brown algae because of the dominance of yellow pigment compared to green pigments, like algae. The pigment makes diatoms appear yellow to light brown when viewed under a microscope [16]. Diatoms are unicellular micro-organisms that generally live as solitary organisms, but some species can live in groups [17]. Based on the origin of the word "*diatom*," it has two parts, one part coats the other part, and the diatom cell wall is a hard wall formed from pectin and silica, known as frustule [18]. Wall (Frustule*)* includes epitheca (valve on the top side) and the mortgage (valve on the bottom side). A girdle band connects the two valves. The valves and girdle bands unite and bind very tightly to prevent the entry of particles or material from outside the cell into the cell wall [19]. Entry and exit of material can only be through the pores and frustule gaps when they are open. The epitheca is larger and has a binding part called the cingulum. Chloroplasts are useful for photosynthesis and have a yellow pigment. The results of photosynthetic production are stored in lipid droplets, the product in the form of an oily substance. Diatoms have a cell nucleus protected by a nuclear membrane, and the coordination center that regulates the movement of diatoms is called the vacuole [20].

In general, based on their morphological characteristics, diatoms are divided into two types, namely diatoms of the order Pennales, which are in the form of elongated valves or also called bilateral symmetry, which is benthic, and diatoms centric or Centrales which are radially symmetrical and circular which live planktonically. The Centrales diatoms live floating in the waters so that water currents influence their survival, while the Pennales diatoms live by sticking to a substrate [9].

Generally, centric or pennate diatoms can be found in fresh or marine waters, but it is known that centric forms tend to be more abundant in environments with high salinity, namely the sea, while pennate diatoms are typically found in freshwater environments [21].

Based on their morphology, diatoms have apexes or apices, namely the ends, the valves, and the cell body. In the valve, there are structures called Raphe and Striae, which are one of the keys to identifying the type of diatom [22]. Striae are described as a row of pores *(*areolae) on the valve, and raphes are a line of slits through the valve and located on the apical axis, divided into monoraphids and biraphids. This structure helps diatoms to move between substrates. Some of the Pennales have raphes or gelatinous extrusion pathways that make it easier for the diatoms to stick to their substrates.

The process of reproduction in *Bacillariophyta* (diatoms) occurs through two mechanisms, namely asexually (vegetatively) by dividing cells and sexually (generatively) that is by oogamy. Most of the reproductive processes in diatoms are asexual, and the cells are formed inside the parent cell by mitosis. Diatom divides itself with the separation of epitheca and hypotheca. Furthermore, each of them will form its epitheca and hypotheca so that later it will form diatom cells. The hypothetical section will form an epithecal, and the epithecal section will form a smaller hypothecal. Division causes the cells to decrease in size. The cell will continue to divide, again with the same process until the cell is too small to divide. At the smallest cell size level and cell division can't occur, the protoplasm will come out of the cell wall and form auxospores which will grow and restore the cell size to its original size. Reproduction is continued generatively through the process of oogamy, namely fertilization of the egg by male gametes then forms a zygote.

Environmental factors and the nutrients around them influence the distribution of diatoms with various shapes and types. The following factors affect the growth of diatoms [23] temperature, water flow, and turbidity.

In general, diatoms can be found in various types of natural environments, namely in fresh waters (lakes or rivers), estuaries (semi-enclosed waters), and sea waters (waters with high salinity). Diatoms are widely distributed in all types of waters; few species live in standing water on land, such as puddles. Based on the way of life, diatoms attached to the substrate are grouped into endolitic, *endopelic, epilithic* diatoms, e*pipelic, fouling diatoms, episamic, and epizoic.*

A river is a part of the earth's surface in the form of a cavity or land that is lower than the mainland; in particular, it is a place where freshwater passes from upstream to its estuary, namely: oceans, lakes, swamps, or connected to other rivers. The flow of water can come from springs or be influenced by rainfall. A river basin area or a watershed is an area bounded by natural boundaries, such as a mountain or hill ridges, and rock boundaries, namely embankments or roads, which causes rainwater to flow down into the area to form flow to the control location point. The river basin is a unified area/region of the whole water, namely the river and its tributaries, where watersheds are formed naturally by rainfall, which traps water and will flow into the rivers that connect. The area is referred to by another designation, namely the Watershed Area or the Water Catchment Area.

Watersheds are separated by topographical forms that collect and drain rainwater into rivers that end at their estuaries, namely lakes or seas quoted from Government Regulation 37 of 2012 concerning managing river basins. Topographical separators on land are the highest areas, usually ridges, which are the boundaries between one watershed and another [24]. A watershed is another name for an ecosystem that includes the primary components of soil, water, vegetation, and people along with all their activities. As befits an ecosystem, in a watershed, there are various interactions between physical and biotic factors that are important in maintaining balance erosion and sedimentation [25].

Studying the watershed and its ecosystem has been divided into three main constituent parts of River Basin Areas: the upstream, middle, and downstream areas [26]. The following are the three main parts that make up a water basin: a) the upstream part of the river is a part that has the following characteristics, namely: has a fast current in the direction of river erosion (especially at the bottom of the river) river) is vertical with great erosional power. Convex river slopes with V-shaped troughs sometimes can form waterfalls and or rapids, and no sedimentation occurs; b) The middle part of the river has the following characteristics: the water current is not too heavy, erosion leads to the bottom, and the lateral sides river (vertical and horizontal), the erosion power is starting to decrease, the riverbed is concave, and it is known that it is starting to occur deposition or sedimentation and bends are often found that reach an angle of up to 180° or more; and c) The downstream part of the river has the following characteristics: a quieter current, low erosion with the direction of erosion to the lateral side of the river (horizontal), lots of sedimentation found, deltas are sometimes formed in the estuary, and wide trough.

Ciliwung River Basin has an area of 370.8 square kilometers, with the length of the main river flowing 124.1 kilometers from upstream to downstream. Based on the toposequence, the Ciliwung watershed is divided into three parts: upstream, middle, and downstream. Each location has a main observation station or post for river flow at Katulampa Dam, Bogor; Ratujaya, Depok; and the Manggarai Sluice Gate, South Jakarta. The lower reaches of the Ciliwung River start from the Manggarai Sluice Gate and extend to the Java Sea, which is also known to be connected to the West Flood Canal. The total length of the Ciliwung watershed is 1,076.1 kilometers.

Administratively, it is known that the Ciliwung watershed area has boundaries, namely: in Bogor Regency, Bogor City, Depok City, and DKI Jakarta Province. Based on its shape The Ciliwung river from the upstream to the Katulampa area is categorized as a dendritic river. It shows the characteristics of increasing and decreasing flow when a flood occurs and has a balanced duration in contrast to the downstream, which is parallel and conical or narrower, thus affecting the current speed and water discharge. The Ciliwung river basin is divided into 18 sub-river basins. The following table shows the division of the Ciliwung watershed and its area [27].

Drowning is death due to aspiration of liquid into the respiratory system caused by partial or complete immersion of the body in liquid, and there is also the term near drowning. Which describes the condition of the body's physiological disorders due to drowning, but not to the point of causing death [28]. In diagnosing death caused by drowning, the whole body does not have to be submerged in water. The main requirement for a drowning event is that it is sufficient that the nostrils and mouth are below the surface of the water. Based on this understanding, drowning events can occur in the sea or river and in a sink or bucket filled with water. The amount of water that can be fatal if inhaled is 2 liters for adults and 30-40 ml for children.

Wet and dry drowning are distinguished based on the lungs' morphology at the autopsy time. Cause of death in people who drown can be laryngeal spasm asphyxia, asphyxia due to suffocation or choking, vagal reflexes, ventricular fibrillation in freshwater drowning, and pulmonary edema in saltwater drowning [29]. Other mechanisms that cause death in drowning are as follows [30]: laryngeal spasm and vagal reflex.

Wet drowning is a type of drowning caused by the activity of aspiration or inhaling liquid into the lungs. Significantly, water aspiration as much as 1-3 ml/kg body weight will cause a reduced air change. Water at the location of the sinking is divided into two types, namely as follows: freshwater and saltwater.

Overall, 15-20% of cases of death due to drowning are classified as dry drowning, namely drowning without aspiration or inhalation of liquid [29]. Death in this type of drowning occurs spontaneously, suddenly, and seemingly without a sign of resistance. Dry drowning is known to occur frequently in children or adults who experience alcohol or drug intoxication, especially hypnotics - sedatives, which are not found there are signs of panic or trying to save oneself when drowning. In addition, the important sign found was no water aspiration entering the lower respiratory tract. Death occurs in a very short duration due to the emergence of a vagal reflex that causes cardiac arrest or laryngeal spasm due to the sudden ingress of water into the upper respiratory tract.

Alcohol intoxication causes suppression of cortical activity, the presence of disorders or co-morbidities such as atherosclerosis or sudden immersion and excessive fear or physical exertion leading to elevated catecholamine levels and oxygen deficiency leading to cardiac arrest. These things are the predisposing factors for death in dry drowning cases. The fluid that enters the upper respiratory tract suddenly can cause two mechanisms of death. Deaths due to drowning can occur for various reasons/causes, some of which are as follows [31]: a) Accidents are the cause of drowning, which often occurs because the victim accidentally falls or is carried away by the current in the sea, river, or lake. Accidental drowning in children is often found in swimming pools or water-filled pits. In addition, predisposing factors such as drunkenness or the onset of epileptic seizures are known to be the most frequent causes of accidents [32]; b) Suicide by dropping into the water, especially in rivers. Sometimes often found the body of the perpetrators of suicide ballast bound, with the aim that the body can sink more easily [33]; and c) Murder in various ways, such as throwing the victim's body into waters such as seas, lakes, or rivers, or immersing the victim's head in a tub or container filled with water [34]. In the case of finding a drowning victim whose body has decomposed, will it be very difficult to identify, or the location of the sinking is unknown, and if it is known that there are no witnesses, then it cannot be declared an accident, suicide, or homicide [35].

In cases of drowning, it is possible that the victim died before entering the water. Drowning does not just happen in deep water, such as in seas, lakes, rivers, or swimming pools, but can also be in the ditches or puddles, as well as in containers filled with water with the condition that only the face is immersed in the water.

During a post-mortem examination or autopsy, fine foam and foreign bodies can be found on the victim's body and airways, such as grains of sand or algae and aquatic plants. The bodies of victims drowned in freshwater are usually found to be swollen or bloated but not heavy. However, because the fluid may have been ingested, the lung disease is typically discovered in a normal state. When the lung is removed from the chest cavity, the shape of the lung remains normal and does not collapse. Lungs with dry emphysema will produce a crepitus sound when cut.

After being cut, each part of the lung parenchyma will maintain its normal shape and tend not to be sluggish, and when pressed, a little froth appears, and no liquid or gas is found, except when pulmonary edema occurs. So the conclusion is that in drowning in fresh water, the lungs will remain dry. In drowning in salt water, such as the ocean, the lungs are usually found to swell like balloons, heavier than normal, and sometimes to cover the heart. During surgery, there is a lot of fluid; sometimes, the weight of the lungs can exceed 2,000 grams. Because the lungs are very edematous, it will use *overlap* between the edges in front of the lung and the mediastinum to form a rib-like impression on the lung. The movement of fluid from the blood vessels to the lungs, usually causes a purplish or bluish color with a shiny surface on the lungs. Moist or wet lung conditions and the consistency is chewy like jelly and disappears after pressing. When the lung organs are removed from the body and moved to the cutting table, the lung will tend to be flat and not maintain its normal shape. Even without applying any pressure at the time of cutting, it was anticipated that a large amount of liquid would leak. Thus the conclusion is that in cases of drowning in salt water or sea, the lung tissue becomes moist and wet [30].

Petechiae can also be found in lung tissue, but sub-pleural petechiae and emphysema are not usually found and are not a specific or a typical sign of drowning, but rather as respiratory efforts. Very minimal petechiae can be due to pinched capillaries in the interalveolar septum, known as Paltauf spots. Furthermore, identifying water objects that enter the respiratory tract, it can be done by dissecting the respiratory tract starting from the trachea and bronchi to the hilus and bronchial branches. If the inspection results show objects such as aquatic plants, sand, mud, gravel, etc., it can be ascertained that the victim was still breathing when he entered the water. Vital organs, such as the brain, liver, spleen, and kidneys, can experience containment, and digestive organs, such as the mouth and small intestine, can be very swollen and filled with fluid or mud [30].

When a drowning victim inhales or swallows' water, diatoms and other planktonic elements enter the respiratory or digestive tract. Then the diatoms will enter circulation through the capillary walls, damaged while the victim was still alive, and will be carried throughout the body tissue. After death, the blood circulation will stop so that bodies submerged in water are not found to have diatoms in the internal organs that are further away, even though; In fact, diatoms can enter into the lower respiratory tract passively [30].

Examination of diatoms generally uses specimens, namely fresh corpse lung tissue. However, if the corpse's condition has decomposed, the diatoms examined are in kidney tissue, striated muscle, or femoral bone marrow. Examination of diatoms in the liver and spleen is considered less significant because they can originate from abnormal absorption of drinking water or food in the digestive tract [30]. Examination of diatoms using the acid digestion method in the lungs was carried out by taking 100 grams of peripheral lung tissue, then placing it in a Kjeldahl flask and adding concentrated sulfuric acid until the lung tissue was submerged, then allowed to stand for approx. Twelve hours for the tissue to dissolve. After that, the sediment is heated in a fume hood while dripping with concentrated nitric acid until it turns into a clear liquid, then cools down to make a precipitate using a centrifuge [30]. The sediment that is formed is added with sufficient distilled water, which has been distilled twice, then precipitated again identified using a microscope. The diatom examination is positive if there is a sufficiently large amount of diatoms in the lung tissue, 4-5/LPB or 10-20 per one preparation, or on bone marrow examination, one diatom is sufficient [30]. In addition, lung saps can be examined by washing the lung surface using clean water, then slicing the edges. A little liquid is taken from the tissue at the edge of the lung, put on the glass object, covered using a coverslip, and then looked at at the microscope. In addition to discovering diatoms, algae and other aquatic plants can also be found [36]. Laboratory testing of diatoms can be negative, even in cases where it is known that drowning in water contains a lot of diatoms, and there are known to be many false positive results due to technical problems. So this test becomes less reliable, so this technique needs to be done, and the results need to be interpreted by considering other conditions.

3. METHODOLOGY

The method used in this research is descriptive qualitative research, which is carried out by identifying the types of diatoms that live in the Upper, Middle, and Lower Ciliwung watersheds and analyzing the factors that influence the diversity of diatom species. Then the research data are reported as it is. The research was carried out by looking at diatoms using a microscope at the Research Laboratory of the Faculty of Medicine at the Christian University of Indonesia sampling locations in the Upper, Middle, and Lower Ciliwung watersheds, namely: in the Katulampa Dam area, Ciawi, Bogor

Regency; the Ciliwung Bridge area, Cibinong, Bogor Regency; as well as the Manggarai Sluice Gate area, Menteng, Central Jakarta. The time needed to conduct this research is ten days, from 13-23 August 2022. Sampling was carried out on 14 August from 9 to 11 AM, 3 to 4 PM, and 7 to 8 PM. The population in this study was diatoms along the Ciliwung-Cisadane river area, which covered three provinces: West Java, Banten, and DKI Jakarta. The samples in this study were river water taken from 3 areas traversed by the Upper Ciliwung Watershed, namely: in the Katulampa Dam area, Ciawi, Bogor Regency; Central Ciliwung Watershed, namely: Ciliwung Bridge area, Cibinong, Bogor Regency; and the Upper Ciliwung Watershed, namely: in the Manggarai Sluice Gate area, Menteng, Central Jakarta.

Samples were taken at a depth of 0.5 to 1 meter from the river's surface. In one area, the water was taken four times at the same depth (1 meter) at four different adjacent points. Take 500 ml of water and as many as four bottles in one area. This study used one control group, aquabides liquid used to sterilize sample bottles, and four groups will be given treatment, namely samples taken from each region. So that in the Katulampa Dam area, Ciawi 4 samples, Ciliwung Bridge area, Cibinong 4 samples, and in the Manggarai Sluice Gate area, Central Jakarta 4 samples. So that the total sample obtained in this study was 12; the inclusion criterion is generally in the study, which can fulfill Sampling requirements, among others. Samples that meet the inclusion criteria but, due to certain circumstances, are excluded from the sample, including a) water that has been collected and stored in sterile containers is contaminated with tap water or seawater and other types of liquids that possibly contain different diatoms; b) Ciliwung river water taken during flood conditions (increased water level from normal); c) Ciliwung river water taken at low tide (decrease in water level from normal limits); and d) Uncertain results are diatoms or not (ambiguous). The research tools used in this study are a) Brown glass bottles and transparent glass bottles with a capacity of 500 ml, a meter, *stopwatch,* raffia rope, siphon, hose, water thermometer, permanent marker, scissors, label, *styrofoam*, dropper, test tube, lab coat, mask, *gloves*, centrifugal, Bunsen, 20 ml beaker; and b) Microscopic examination tool. The tools used are a light microscope, glass objects, covers, oil receipts, blanks, labels, pens to record data, and a camera to document research results.

4. RESULTS AND DISCUSSION

The results of research conducted on river water taken from 3 Ciliwung river basin areas in the upper reaches, namely the Katulampa Dam, Ciawi, Bogor Regency; the Central part, namely the Ciliwung Bridge, Cibinong, Bogor Regency; as well as the Downstream section, namely the Manggarai Sluice Gate, Menteng, Central Jakarta. Based on temperature measurements using a water thermometer and measurements of water discharge/water flow velocity, which were carried out on August 14, 2022, the following results were obtained:

1. **Katulampa Dam**
- Average water temperature : 25° c
- Average current speed : 3.5 seconds/meter
- Water discharge : 125.9 dm^3/second

2. **Ciliwung Bridge, Cibinong**
- Average water temperature : 26°c
- Average current speed : 4 seconds/meter
- Water discharge : 39.25 dm^3/second

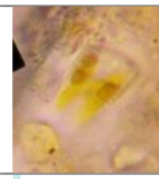
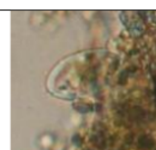
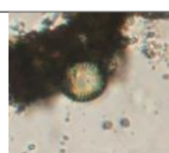
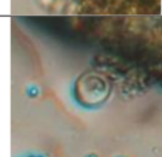
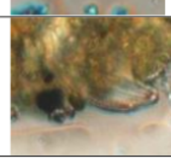
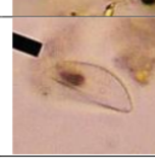
3. **Manggarai water gate**
- Average water temperature : 20°c
- Average current speed: 3.55 seconds/meter
- Water debit : 273.7 dm^3/second

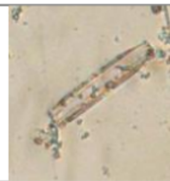
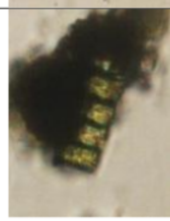
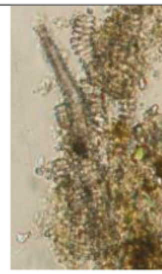
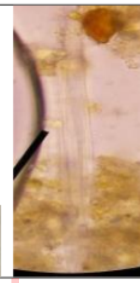
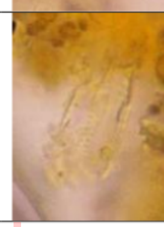
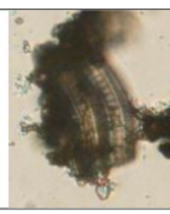
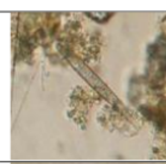
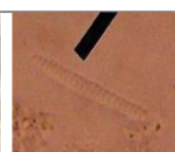
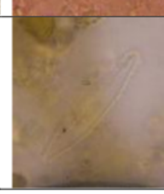
The average water temperature is obtained by calculating the average of 5 measurements using a water thermometer; the average current speed is obtained from an average of 5 measurements using a simple method, namely observing the speed of styrofoam drifts in the water with a measurement distance of 100 meters and then calculating it using a stopwatch. At the same time, the water discharge at the drifting.

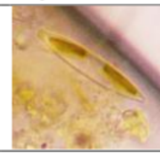
These three locations (Katulampa Dam, Ciliwung Bridge, Cibinong, and Manggarai Sluice Gate) were obtained from the data of the daily water debit recorder belonging to the Central Jakarta Administrative City Water Resources Office at the Manggarai Sluice Gate. Water turbidity was not measured using a method or a water turbidity meter, but by the naked eye through observations made for 5 minutes, the water turbidity at the three sampling locations was not much different, namely: light brown in color and at a depth of 1 meter, the river bed was not visible.

After measuring temperature, current velocity, discharge, and water turbidity, samples were taken, namely water at a depth of 1 meter at 4 points at each watershed location with different distances between points and considering current velocity and water temperature (picture attached). Then each sample was made into three *slide* preparations. Counting the number and identifying the types of diatoms at the three sampling locations resulted in 36 *slides of the* preparations studied. The following is a description of the diatoms found.

Table 1. Diatom species in the Upstream of Ciliwung River Basin, Katulampa Dam, Ciawi, Bogor Regency

No	Diatom Spesies	Picture			
		K1	K2	K3	K4
1	*Achnanthes sp*	-	-		
2.	*Amphora sp*	-	-		-
3	*Asterionella sp*			-	-
4	*Aulacoseira sp*	-	-	-	
5	*Cocconeis sp*			-	
6	*Cyclotella sp*				-
7	*Cymbella sp*				-

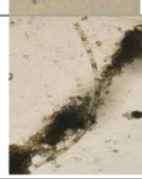
No	Diatom Spesies	Picture			
		K1	K2	K3	K4
8	*Eunotia* sp		-	-	-
9	*Fragilaria* sp				
10	*Frustulia* sp	-	-		-
11	*Gomphonema* sp	-	-		-
12	*Mastogloia* sp		-	-	-
13	*Melosira* sp	-			-
14	*Navicula* sp				-

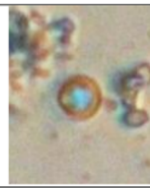
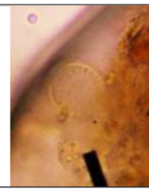
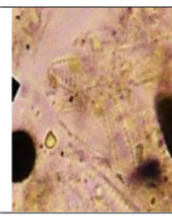
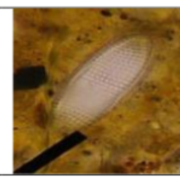
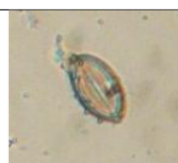
No	Diatom Spesies	Picture			
		K1	K2	K3	K4
15	*Nitzschia sp*				
16	*Pinnularia sp*		-	-	-
17	*Synedra sp*		-	-	-

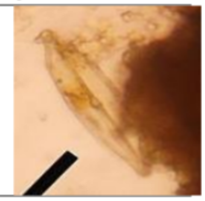
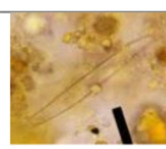
Information:
K: Katulampa (4 points of sampling locations)

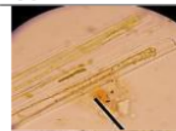
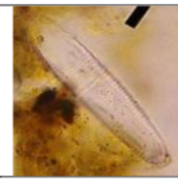
Based on Table 1 above, it can be concluded that at the Katulampa Dam, the types of diatoms found were: *Achnanthes sp, Asterionella sp, Aulacoseira sp, Amphora sp, Cocconeis sp, Cyclotella sp, Cymbella sp, Eunotia sp, Fragilaria sp, Frustulia sp, Gomphone ma sp, Mastogloia sp, Melosira sp, Navicula sp, Nitzschia sp, Pinnularia sp, and Synedra Sp.* Based on a rough count on the three *slides* of preparations examined at each location point, the highest number of species in the Upper Ciliwung Watershed, Katulampa Dam, were *Nitzschia sp and Fragilaria sp.*

Table 2. Diatom species in the Middle Ciliwung River Basin, Ciliwung Bridge, Cibinong, Bogor Regency

No	Diatom Spesies	Picture			
		C1	C2	C3	C4
1	*Achnanthes sp*		-	-	-
	Aulacoseira sp		-	-	
3	*Bacillaria sp*	-	-	-	

No	Diatom Spesies	Picture			
		C1	**C2**	**C3**	**C4**
4	*Cocconeis sp*		-	  	-
5	*Cyclotella sp*				
6	*Cymbella sp*	-	-		
7	*Diatoma vulgaris*	-	-	-	
8	*Diploneis sp*		-	-	
9	*Eunotia sp*		-	-	-
10	*Fragilaria sp*			-	

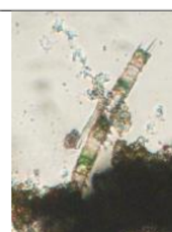
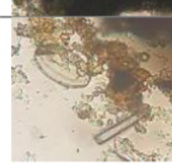
No	Diatom Spesies	Picture			
		C1	C2	C3	C4
11	*Frustulia sp*	-	-	-	
12	*Gomphonema sp*		  		-
13	*Gyrosigma sp*	-	-	-	
14	*Hantzschia sp*	-	-	-	
15	*Melosira sp*	-	-		-
16	*Navicula sp*	 	-	 	
17	*Nitzschia sp*	  			

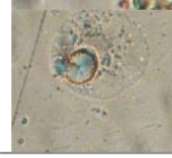
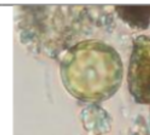
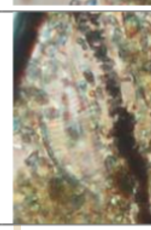
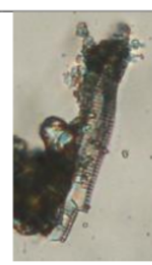
No	Diatom Spesies	Picture			
		C1	C2	C3	C4
18	*Synedra sp*	-	-	 	-
19	*Pinnularia sp*	-	-	-	

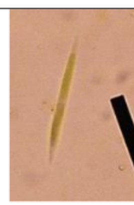
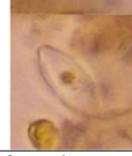
Information:
C: Cibinong (4 points of sampling locations)

Based on Table 2 above, it can be concluded that at Ciliwung Bridge, Cibinong, the types of diatoms found were: *Achnanthes sp, Aulacoseira sp, Bacillaria sp, Cocconeis sp, Cyclotella sp, Cymbella sp, Diatoma Vulgaris, Diploneis sp, Eunotia sp, Fragilaria Sp, Frustulia sp, Gomphonema sp, Gyrosigma sp, Hantzschia sp, Melosira sp, Navicula sp, Nitzschia sp, Pinnularia sp, and Synedra sp*. Based on a rough count of the three *slides* of the preparations studied at each of the 4 location points, the highest number of species in the Central Ciliwung Watershed, Ciliwung Bridge, Cibinong, were *Cyclotella sp, Nitzschia sp, and Fragilaria sp.*

Tabel 3. Diatom species in Downstream of Ciliwung River Basin, Manggarai Sluice Gate, Menteng, Central Jakarta

No	Diatom Species	Picture			
		M1	M2	M3	M4
1	*Achnanthes sp*		-	-	-
2	*Aulacoseira sp*	-	-		-
3	*Cocconeis sp*	-			-

No	Diatom Species	Picture			
		M1	M2	M3	M4
					
4	*Cyclotella sp*	-		 	 
5	*Cymbella sp*	-	-	-	
6	*Diatoma vulgaris*	-	-		-
7	*Eunotia sp*	-	-	 	-
8	*Fragilaria sp*	 			

No	Diatom Species	Picture			
		M1	M2	M3	M4
9	*Frustulia sp*	-	-		-
10	*Gomphonema sp*		-	-	
11	*Melosira sp*	-	-		-
12	*Navicula sp*				
13	*Nitzschia sp*		 		

Information:
M: Manggarai (4 points of sampling locations)

Based on Table 3 above, it can be concluded that at the Manggarai Watergate, the types of diatoms found were: *Achnanthes sp*, *Aulacoseira sp, Cocconeis sp, Cyclotella sp, Cymbella sp, Diatoma Vulgaris, Eunotia sp, Fragilaria sp, Frustulia sp, Gomphonema sp, Melosira sp, Navicula sp, Nitzschia sp, and Synedra sp*. Based on a rough count of the 3 preparation *slides* examined at each location point, the highest number of species in the Ciliwung Downstream Watershed, Manggarai Sluice Gate, Central Jakarta were *Nitzschia sp, Navicula sp, and Fragilaria sp.*

From Table 4, it can be concluded that there were differences in the diatom species found in each watershed. However, the same diatom species were found at the sampling locations. The distribution of several diatom species, such as *Nitzschia sp*, *Navicula sp*, *Fragilaria sp, and Cyclotella sp*, is the widest among other species, where these four species are evenly distributed in 3 Ciliwung watersheds, namely Upper, Middle, and Lower.

The average diatom size on a microscope with 40 times magnification is 20 micrometers, so it is estimated that when viewed on a microscope with 100 times magnification (40 times 2.5), the average diatom size is 8 micrometers, obtained from 20 micrometers divided by 2.5. The following is an overview of the average diatom cell size:

Table 4. Distribution of diatom species in the Ciliwung River in the Upper, Middle, and Lower Watersheds

No	Diatom Species	Watershed (DAS)											
		upstream (Katulampa Dam, Ciawi)				Middle (Ciliwung Bridge, Cibinong)				Downstream (Manggarai Watergate, Menteng)			
		K1	K2	K3	K4	C1	C2	C3	C4	M1	M2	M3	M4
1.	*Achnanthes sp*	-	-	+	+	+	-	-	-	+	-	-	-
2.	*Amphora sp*	-	-	+	-	-	-	-	-	-	-	-	-
3.	*Asterionella sp*	+	-	-	-	-	-	-	-	-	-	-	-
4.	*Aulacoseira sp*	-	-	-	+	+	-	-	+	-	-	+	-
5.	*Bacillaria sp*	-	-	-	-	-	-	-	+	-	-	-	-
6.	*Cocconeis Sp*	+	+	+	-	+	-	+	-	-	+	+	-
7.	*Cyclotella Sp*	+	+	+	-	+	+	+	+	-	+	+	+
8.	*Cymbella sp*	+	+	+	-	+	-	-	+	-	-	-	+
9.	*Diatoma Vulgaris*	-	-	-	-	-	-	-	+	-	-	+	-
10.	*Diploneis sp*	-	-	-	-	+	-	-	+	-	-	-	-
11.	*Eunotia sp*	+	-	-	-	+	-	-	-	-	-	+	-
12.	*Fragilaria sp*	+	+	+	+	+	+	-	+	+	+	+	+
13.	*Frustulia sp*	-	-	+	-	-	-	-	+	-	-	+	-
14.	*Gomphonema sp*	-	-	+	-	+	+	+	-	-	+	-	+
15.	*Gyrosigma sp*	-	-	-	-	-	-	-	+	-	-	-	-
16.	*Hantzschia sp*	-	-	-	-	-	-	-	+	-	-	-	-
17.	*Mastogloia sp*	+	-	-	-	-	-	-	-	-	-	-	-
18.	*Melosira sp*	-	+	-	-	-	-	+	-	-	-	+	-
19.	*Navicula Sp*	+	+	+	+	+	-	+	+	+	+	+	+
20.	*Nitzschia sp*	+	+	+	+	+	+	+	+	+	+	+	+
21.	*Pinnularia sp*	+	-	-	-	-	-	-	-	+	-	-	-
22.	*Synedra sp*	+	-	-	-	-	-	+	-	-	-	-	+

Information:
+ : found
- : not found

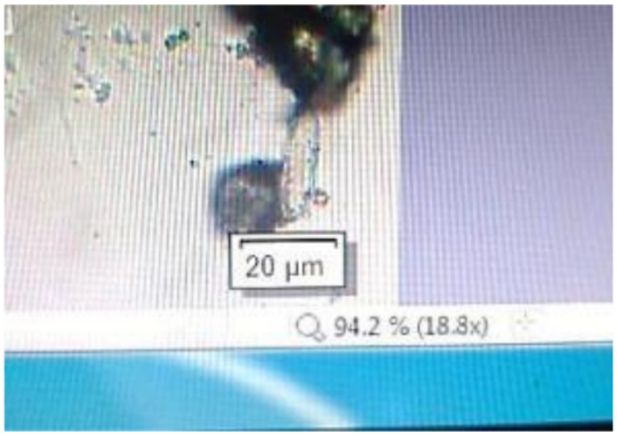


Fig. 1. A figure of The size of diatoms on a microscope with 40 times magnification

In general, the distribution of phytoplankton, especially diatoms, is influenced by sufficient oxygen and nutrients. The availability of these metabolic materials varies for each type of water, such as in flowing or stagnant, cloudy, or clear waters. Water quality affects pH, temperature, and elemental content such as nitrogen and phosphorus as well the main nutrient requirement for phytoplankton.

In this study, as stated in the results, it can be seen that in the Katulampa Dam, 17 species were found, namely as follows: *Achnanthes sp, Asterionella sp, Aulacoseira sp, Amphora sp, Cocconeis sp, Cyclotella sp, Cymbella sp, Eunotia sp, Fragilaria sp, Frustulia sp, Gomphonema sp, Mastogloia sp, Melosira sp, Navicula sp, Nitzschia sp, Pinnularia sp*, and *Synedra Sp*. The highest number of species is *Nitzschia sp and Fragilaria sp.* At Ciliwung Bridge, Cibinong, there are 19 species, namely: *Achnanthes sp, Aulacoseira sp, Bacillaria sp, Cocconeis sp, Cyclotella sp, Cymbella sp, Diatoma Vulgaris, Diploneis sp, Eunotia sp, Fragilaria sp, Frustulia sp, Gomphonema sp, Gyrosigma sp, Hantzschia sp, Melosira sp, Navicula sp, Nitzschia sp, Pinnularia sp*, and *Synedra sp*. The highest number of species is *Cyclotella sp, Nitzschia sp, and Fragilaria sp.* At the Manggarai Sluice Gate, 14 species were found, namely: *Achnanthes sp, Aulacoseira sp, Cocconeis sp, Cyclotella sp, Cymbella sp, Diatoma Vulgaris, Eunotia sp, Fragilaria sp, Frustulia sp, Gomphonema sp, Melosira sp, Navicula sp, Nitzschia sp, and Synedra sp*. The highest number of species is *Nitzschia sp, Navicula sp, and Fragilaria sp.*

In Table 4, the distribution of each diatom species was different in the 3 Ciliwung watersheds, but almost all species were found at each sampling location. It can happen because the water discharge and speed of the water flow greatly influence the distribution of diatoms, especially in flowing waters such as rivers. This study shows that the water discharge at the Katulampa Dam is 125.9 cubic decimeters per second; on the Ciliwung Bridge, Cibinong is 39.25 cubic decimeters per second; and at the Manggarai Watergate is 273.7 cubic decimeters per second. There are significant differences in water discharge between the three sampling locations, so it can be concluded that this most likely caused different types of diatoms and caused several species to be carried along the river flow so that they could be found at each location due to accumulation in a certain place or distributed randomly.

In this study, the temperature at the three locations described the normal temperature of the tropics, namely: 20-30° *Celsius,* the turbidity of the water, the current speed, and water discharge which were still included in the normal state of the Ciliwung River, and the time of sampling affected nutrient availability, chlorophyll production, and the process of photosynthesis of diatoms so that the research results found various shapes, sizes, and colors of diatom cells. At Katulampa Dam, more green diatoms were found compared to the other 2 locations because the samples were taken at 09.00-11.00 WIB, which is the ideal time for diatoms to carry out photosynthesis so that the chloroplasts produced by cells increase for photosynthetic needs.

5. CONCLUSION

The results showed a diversity of morphology, type or species, and size of diatoms scattered along the upper, middle, and the lower reaches of the Ciliwung river. In the three watershed locations studied, there were several different types of diatoms, and some of the same types of diatoms were found in almost all three locations. It is because some diatoms can adapt quickly, influenced by the availability of photosynthetic needs and nutrients, so they can live in various environments. The distribution of several species, such as *Nitzschia sp, Navicula sp, Fragilaria sp, and Cyclotella sp,* is the widest among the other species, where these four species are evenly distributed in the 3 locations studied. The results of the identification of the types of diatoms found in the Katulampa Dam, Ciliwung Bridge, and the Manggarai Sluice Gate are following the data on the distribution of diatoms in the Ciliwung river basin so that they can be used as a guide for other researchers for further research on the different descriptions of diatoms living in the Upper Ciliwung river basin. Middle, and Downstream, as a diagnostic tool for drowning victims, as reference data in determining the crime scene if a drowning victim is found along the Ciliwung river basin, as well as adding insight for investigators in helping identify the crime scene of drowning victims. The diversity of diatom species found was influenced by river conditions when investigated. The conditions referred to are temperature, current velocity, and different water debits, as well as water turbidity, which affects the availability of nutrients and metabolic processes as well as the distribution of diatoms which ultimately gives rise to various types, sizes, and shapes of diatom cells. In addition, the research results obtained can also be influenced by the process of taking and processing samples, such as the time of collection, the method of collection and processing, to the identification process.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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