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Preliminary Study of pH, EC, TDS, and Heavy Metals Analysis of Oxbow's Sediments in Bandung Region

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ABSTRACT.

The Oxbow Lake is a vital part of river and it usually used for household, agricultural, and fisheries needs. The oxbow lake faces pollution risks from human activities. This study aims to assess the quality of water and sediment by pH, EC, and TDS of water and sediment as well as heavy metal content in sediment. The results show that the environmental conditions of the oxbow lakes around the Upper Citarum River are generally good because they fall within the safe limits for hygiene and sanitation standards, except for Babakan Patrol Oxbow Lake and Sapan Oxbow Lake. Unfortunately, the heavy metal levels in samples O1-2, O4-2, and O7-1 exceed sediment quality guidelines. These measurements indicate evidence of anthropogenic influence on sediment samples.

1. Introduction

The Citarum River is the longest and largest river in West Java Province. It spans 300 km from its headwaters on Mount Wayang, Bandung Regency, to Karawang Regency, where it flows into the Java Sea. Along the Upper Citarum River, many oxbow lakes are found. Oxbow lakes are formed from abandoned meander bends of the river, characterized by repeated "S" shaped curves or sinusoidal functions, which become isolated from the main river due to sedimentation and erosion. Oxbow lakes along the Upper Citarum River include the Sapan oxbow, Citarum Burung oxbow, Tegalluar oxbow, Babakan Patrol oxbow, and others. These oxbow lakes are often utilized for fishing, fish farming, agriculture, and other purposes by the surrounding communities. Therefore, the presence of oxbow lakes is crucial for the local population, necessitating studies on their environmental conditions. The environmental condition of the main river is related to the water and sediment conditions of the oxbow lakes. If the main river upstream of the oxbow lake is contaminated with metals, it is likely that the oxbow lake also has similar conditions, and vice versa.

Previously, research has been conducted by Ciazela et al. (2017) on tracing heavy metal contamination in oxbow lakes and rivers. Naschan et al. (2017) analyzed heavy metals using the ICP-OES (Inductively Coupled Plasma - Optical Emission Spectrometry) method. In addition to heavy metals, parameters such as EC (Electrical Conductivity), TDS (Total Dissolved Solid), and pH can also be used to determine the initial environmental conditions, as seen in the study by Nasution and Afdal (2016) and Kirana et al. (2019) on river water pollution profiles.

There are two types of material source in sediments: lithogenic sources and anthropogenic sources. Lithogenic sources can originate from rocks or parent materials that eroded by rivers, then entering river water and settling in sediment. Meanwhile, anthropogenic sources can be caused by heavy metal waste discharged into rivers. This includes industrial activities, agriculture, and other human activities. Heavy metals have been shown to be the main contaminants transported by rivers (Rybicka et al., 2005). Heavy metal contaminants discharged into the river enter the oxbow lake and mostly bind to suspended matter. Then, heavy metals accumulate in sediment, causing heavy metal pollution. Furthermore, heavy metal pollution can also occur after the oxbow lake has formed, resulting from anthropogenic sources. This research aims to evaluate environmental condition through pH, EC, and TDS as well as heavy metal content in several oxbow lakes in the upper Citarum River area.

2. Methodology

Sampling was conducted at 7 oxbow lakes located around the Upper Citarum River, with a total of 17 sampling points, as shown in Figure 1. The samples collected were sediment samples located at the edges of the oxbow lakes at each point. Sediment from the edge of the oxbow lake was collected and placed into zip lock bags. These zip lock bags were then labeled to avoid any mix-ups. Here is a general description of the environmental conditions at the research site:

- Oxbow lake Situ Citarum Burung (O1): This lake has a relatively large size and is commonly used for fishing. The environmental condition at this location is lush due to the abundance of trees and vegetation, and there is a small operating factory nearby.
- Oxbow lake Jelekong (O2): This lake also has a considerable size. The environmental condition here is somewhat arid, with a brick factory still in operation and some agricultural activities nearby.
- Oxbow lake O3: This lake has a relatively small size as part of it has undergone narrowing. It is located near residential areas.
- Oxbow lake Babakan Patrol (O4): This lake has a small size as most of it has dried up. The environmental condition here is dry and arid, with a lot of debris and waste, and there are also agricultural activities nearby.
- Oxbow lake Sapan (O5): The lake at this location only has a small amount of water, which is used for nearby rice fields. There is a lot of debris around the lake, and many plants are found in this area.

- Oxbow lake Tegalluar (O6): This lake has a relatively large size and is commonly used for natural fishing. Its water is also utilized for surrounding agricultural purposes. The environmental condition here is lush due to the presence of many trees and vegetation.
- Oxbow lake (O7): This lake has a considerable size and is commonly used for fish farming and fishing. There is a factory nearby that previously discharged factory waste into the lake.

Sampling for water quality testing was conducted simultaneously with the sampling stage at each point. Water quality testing was performed in-situ by collecting water from the edge of the oxbow lake using a plastic glass, and then pH, EC, TDS, and temperature were measured using a Hanna Combo Meter type HI-9813-6 PH/EC/TDS/ºC.

The pH, EC, and TDS measurements of sediment, the sieved sediment samples using a 10-mesh sieve were dissolved in aquabides with comparison 1:2 (see Kirana et al., 2024). Measurements were made by dipping the probe of the instrument into the dissolved sample. The instrument used for these measurements was the Hanna Combo Meter type HI-9813-6 pH/EC/TDS/($^{\circ}C$).

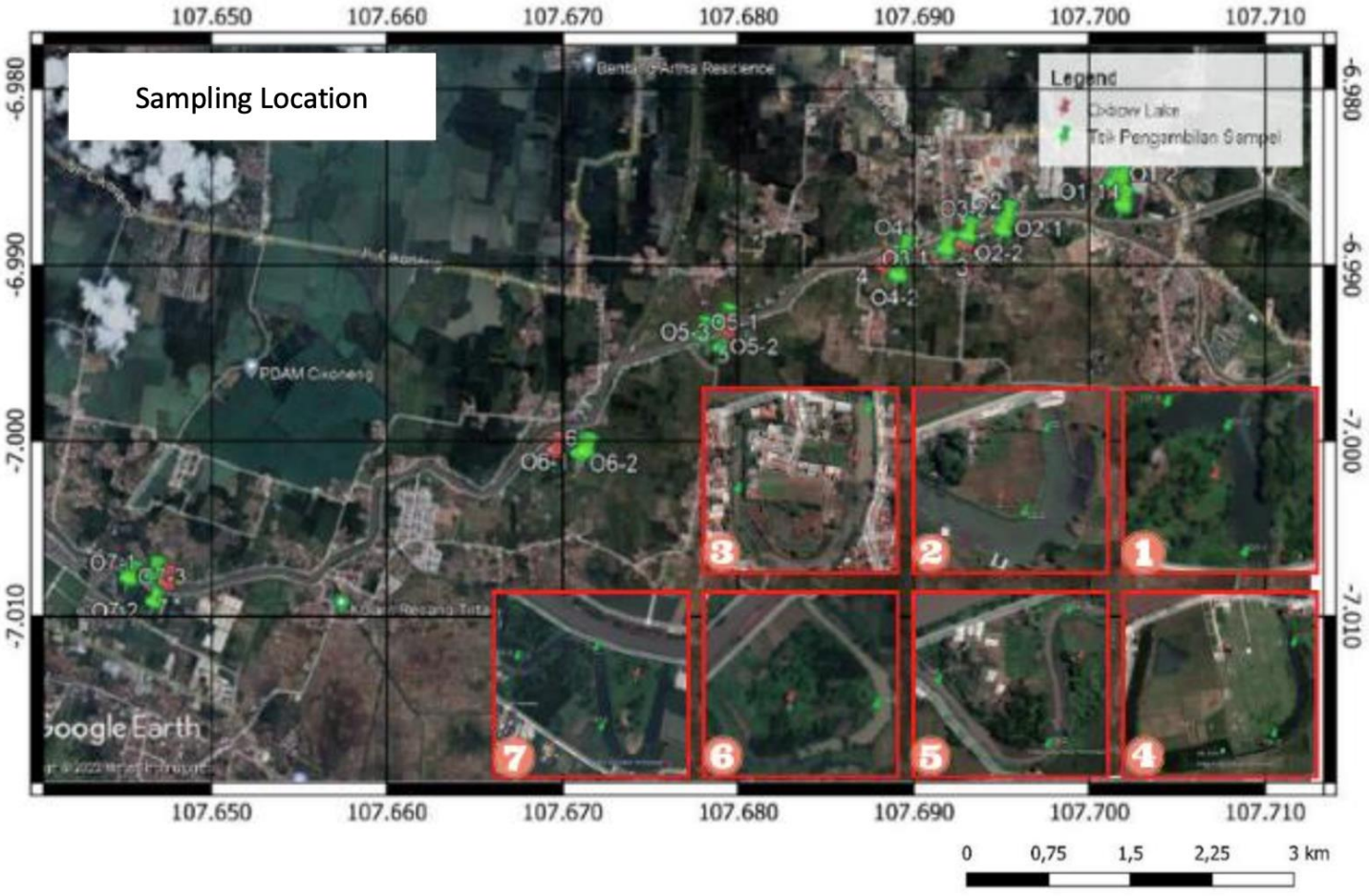

Figure 1. Sampling locations (Google Earth)

Next, sample preparation was carried out to prepare the samples for laboratory measurements. The sediment sample preparation in this study aimed to obtain homogeny grain sizes with mesh-10. The grain size used for pH, EC, TDS measurements in sediment and ICP-OES measurements. The sieved sediment samples were placed into labeled zip lock bags at 5 g/sample. Then, Sediment samples measured by ICP-OES were samples

from 3 different oxbow lakes with different environmental characteristics, namely samples O1-2, O4-2, and O7-1. ICP-OES measurements were performed using the Agilent 725 Series instrument.

Data interpretation was conducted based on pH, EC, TDS, and ICP-OES measurements. The pH, EC, and TDS values in sediment and water samples can be used as initial identification of environmental conditions. ICP-OES measurement data were used to determine the content of various heavy metals in sediment samples, which were then correlated with other parameters to obtain an overview of the environmental conditions at the research site.

3. Result and Discussion

Table 1 shows the pH, EC, and TDS values in water and sediment to assess environmental conditions. The pH values of the water shown in Figure 5 range from 6.1 to 7.9, with 5 points of them below the standard quality. The pH measurement points that do not meet the standards are in Babakan Patrol oxbow lake at sample points O4-1 and O4-2, and in Sapan oxbow lake at sample points O5-1, O5-2, and O5-3. This could be due to the environmental conditions at each sampling point. Sample points O4-1 and O4-2 have dry and arid environmental conditions. Meanwhile, at sample points O5-1, O5-2, and O5-3, the environmental conditions are lacking in water and have a lot of litter. The pH values in the sediment range from 5.7 to 6.9. The pH values in the sediment have an average value lower than that of water. This indicates that the sediment samples tend to be acidic.

Table 1. Data of pH, EC, and TDS measurements on water and sediment sample

Sampel ID	Water Sample			Sediment Sample		
	pH	EC (µS/cm)	TDS (ppm)	pH	EC (µS/cm)	TDS (ppm)
O1-1	7.9	480	345	6.7	290	221
O1-2	7.1	500	355	6.5	330	241
O1-3	7.3	480	342	5.7	390	284
O2-1	7.5	250	185	6.6	170	130
O2-2	7.4	260	187	5.7	320	229
O3-1	7.3	170	122	6.3	180	136
O3-2	7.3	160	121	6.2	150	113
O4-1	6.1	380	270	6.2	160	118
O4-2	6.2	390	281	6.7	100	80
O5-1	6.4	190	141	6.2	220	160
O5-2	6.2	190	142	6	150	110
O5-3	6.1	220	164	6.5	150	112
O6-1	7.8	440	314	6.6	330	238
O6-2	7.4	440	318	6.6	610	467
O7-1	6.6	300	217	6.4	640	454
O7-2	6.8	260	191	6.4	300	211
O7-3	7	280	203	6.8	400	286

Based on the data in Table 1, the pH values for sediment and water are plotted in Figure 2. The red line indicates the lower limit of the standard hygiene requirements based on the Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017.

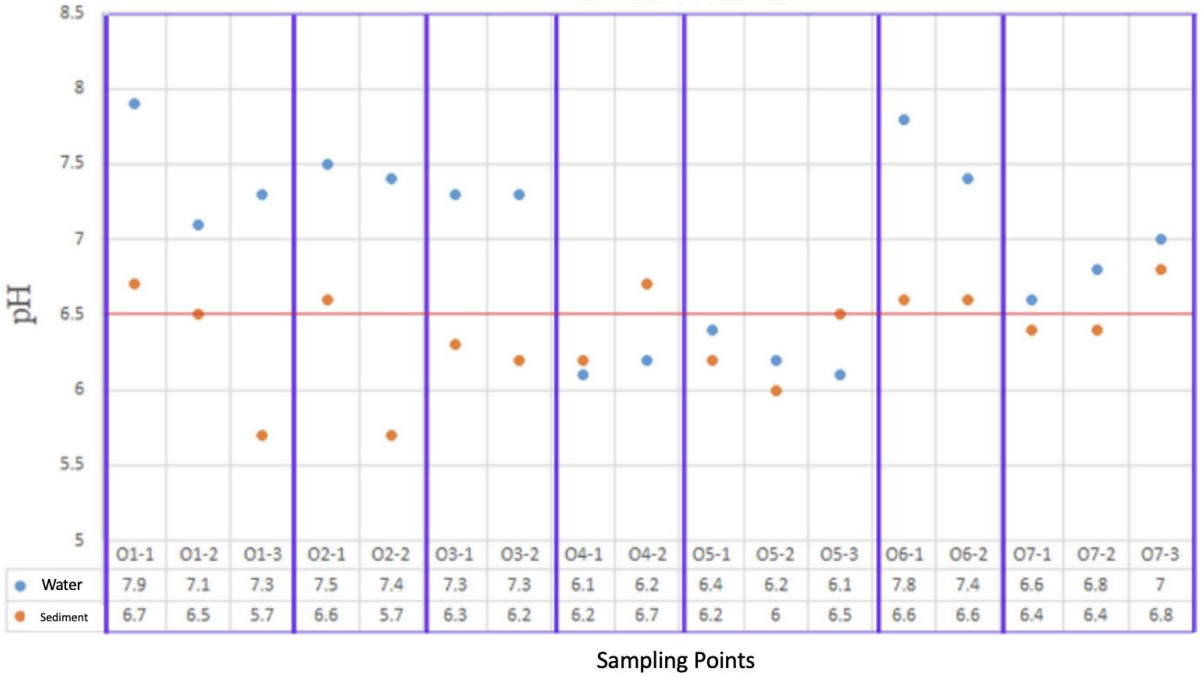

Figure 2. pH value graph of water and sediment samples in oxbow lakes around the Upper Citarum River

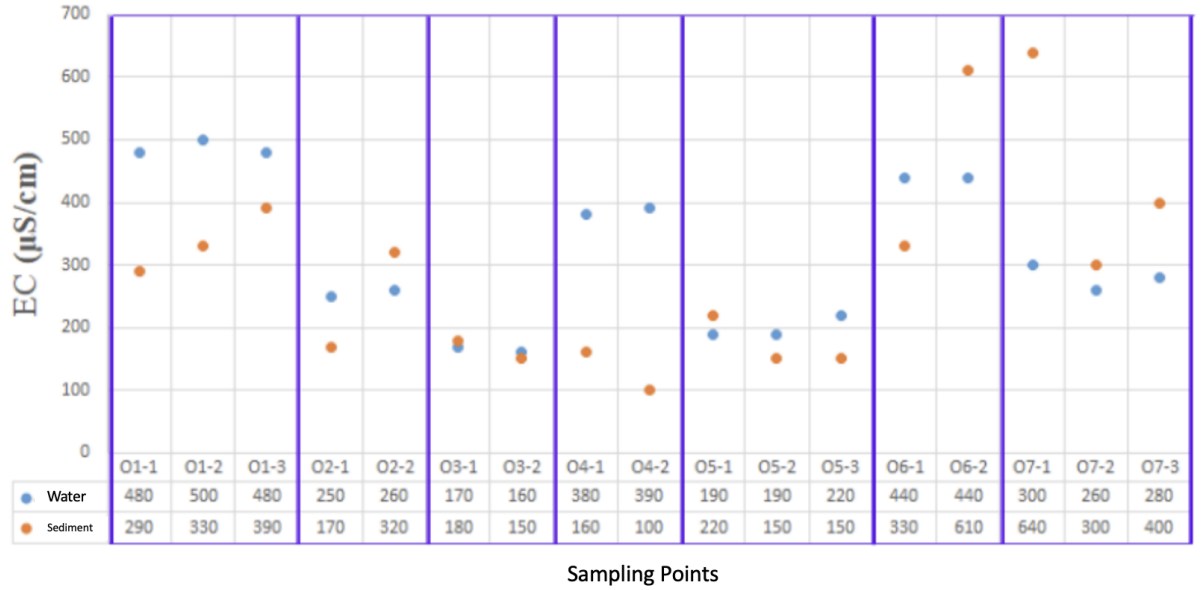

Figure 3. Electrical conductivity value graph of water and sediment samples in oxbow lakes around the Upper Citarum River

The electrical conductivity values in Figure 3 are in the range of 160-500 µS/cm for water samples, while sediment samples are in the range of 100-640 µS/cm. According to the World Health Organization (2011), the standard set for water and sediment samples is 1500 µS/cm. This indicates that the electrical conductivity in all oxbow lakes is still below the standard. In the same oxbow lake, the EC values at each sampling point are not significantly different. However, in different oxbow lakes, there are significant differences in EC values. This is likely due to the different characteristics of electrical conductivity in each oxbow lake.

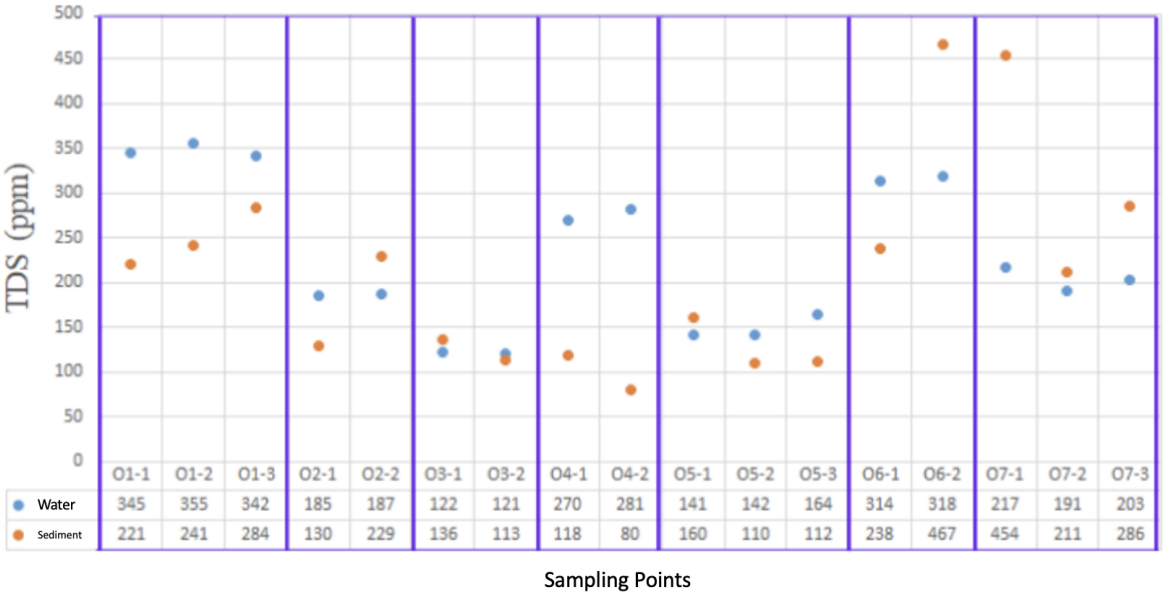

Figure 4. Total Dissolved Solid value graph of water and sediment samples in oxbow lakes around the Upper Citarum River

Table 2. Data of ICP-OES measurements and Sediment Quality Guidelines

Heavy Metals (mg/kg)	Sample			Sediment Quality Guidelines
	O1-2	O4-2	O7-1	
Al	210141.63	176146.53	123063.41	-
As	46.42	37.89	17.74	20
Cd	15.87	7.57	11.53	1.5
Co	81.44	27.22	35.68	-
Cr	139.49	109.46	106.37	80
Cu	437.77	229.71	465.36	65
Fe	29973.94	18140.12	15935.00	20000
K	3393.66	1831.25	2171.03	-
Mg	915.95	1740.62	776.92	-
Mn	13724.90	6657.28	7681.41	248.77
Ni	51.32	66.15	73.81	21
Pb	165.91	137.08	1125.70	50
Sn	0.00	0.80	2.23	-
Zn	511.39	531.22	648.07	200

The Total Dissolved Solid (TDS) values in Figure 4 range from 121-355 ppm for water samples, while for sediment samples, they range from 80-467 ppm. The standard set by the Indonesian Ministry of Health is 1000 ppm. This indicates that the TDS values in each oxbow lake are still below the standard, making them safe for hygiene and sanitation purposes. In the same oxbow lake, the TDS values at each sampling point are not

significantly different. However, in different oxbow lakes, there are significant differences in TDS values. This is likely due to each oxbow lake having different TDS characteristics. The higher the TDS value, the more ions are present in a solution, leading to an increase in EC value. Therefore, TDS values are directly proportional to EC values. EC and TDS measurements with the same trend value indicated high accuracy in the results (Rusydi, 2018).

The ICP-OES measurements were conducted on samples O1-2, O4-2, and O7-1 from three different oxbow lakes with different environmental characteristics. The purpose of the ICP-OES measurements on these three samples was to determine the heavy metal content in different environmental conditions. The data from the ICP-OES measurements are shown in Table 3. The results of the ICP-OES measurements indicate the presence of heavy metal contents consisting of 14 elements, namely Al, As, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Ni, Pb, Sn, and Zn. Based on Table 3, it is known that the heavy metal content in each sample varies. According to various literature, sediment quality can be assessed based on the abundance of heavy metal content in the sediment and it has threshold effect level (see Burton, 2002; Shafaria et al., 2023). The heavy metal quality standards shown in Table 3 are obtained from the National Sediment Quality Survey US EPA, Australian and New Zealand Environment and Conservation Council (ANZECC ISQG-Low), and Canada (Canadian Sediment Quality Guidelines for the Protection of Aquatic Life). Based on Table 4, the sediment quality has exceeded the existing quality threshold except for Fe metal in samples O4-2 and O7-1. This indicates that the sediment quality based on heavy metal content is quite poor.

4. Conclusion

Based on the pH, EC, and TDS measurements of water and sediment samples, the environmental conditions of the oxbow lakes around the Upper Citarum River are generally good because they fall within the safe limits for hygiene and sanitation standards, except for Babakan Patrol Oxbow Lake and Sapan Oxbow Lake, which have pH values below the standard, i.e., below 6.5. This could be due to the presence of a large amount of garbage in these oxbow lakes. The heavy metal content in sediment samples O1-2, O4-2, and O7-1 exceeds the Sediment Quality Guidelines threshold. These measurements indicate evidence of anthropogenic influence on sediment samples.

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Author Contribution

SPA, RAF, and MS written manuscript, analyzed the data, performed the measurement, KHK provides the main idea, written manuscript, analyzed the data.

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