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THE POLLUTION PROFILE OF CITARIK, CIMANDE, AND CIKIJING RIVERS IN RANCAEKEK DISTRICT, WEST JAVA, INDONESIA

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ABSTRACT

Aim: The objective of this study was to determine the heavy metals pollution profile of Citarik, Cimande, and Cikijing Rivers. **Methodology and Result:** The method of this research to measured heavy metals was cadmium, chromium, copper and zinc. Determination of sampling point refers to SNI 03-7016-2004. The river water sampling procedure refers to SNI 6989.57-2008 on Water and Wastewater - Section 57. The water sample extraction method refers to Standard Method for the Examination of Water and Wastewater. Sediment sample extraction method refers to EPA Method 200.2-1994. The water sample extraction method refers to Standard Method for the Examination of Water and Wastewater. Sediment sample extraction method refers to EPA Method 200.2-1994. Based on test result and comparison to quality standard of Indonesian Government Regulation No. 82of 2001 on Water Quality Management and Water Pollution Control. The metal concentrations in the sediments were much higher than the concentrations of metals contained in water. This is due to the accumulation of metals in sediments that occur continuously. **Conclusion, significance and impact study:** The concentrations of four metals in water and sediments after river points higher than before passing the industrial area, it indicates that anthropogenic arising from agricultural activities and textile industry near the rivers of Citarik, Cikijing, and Cimande rivers. The degree of contamination and seasonal variation of heavy metals were high in water and sediment.

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1. INTRODUCTION

One of the industrial areas in West Java is in Rancaekek District. Rancaekek District is an industrial area that has been operated since several decades ago and continues to grow until now. The presence of industrial areas in Rancaekek District can have a positive impact on the community economies, which is employment either from within Rancaekek itself or from outside. Nevertheles there are also negative impacts, such as the changes in land functions in Rancaekek Districtfrom agricultural area become industrial estate and an increasingly crowded settlement. The decline in the number of agricultural areas will continue to occur every year as the development never stops in the Rancaekek District (Wahyunto, 2001).

Rancaekek District is center of textile industry. According to Bandung Regency Government, there are 42 textile factories located in there. Industrial area developed since 1978. The area which is part of the Citarik sub-watershed is actually a fertile rice field area. However, industrialization causes wetlands to decrease. According to Martin (1993) in Wahyunto (2001), the change in land use or utilization is the addition of a land use from one side of use to another, followed by decreasing other types of land use over time, or changing of a land function in an area at different times. The dominant land use was the area of paddy fields that nowadays converses into settlements or industrial estates. This changes in land use occurs mainly in areas close to highways.

The abundance of these industries resulted in the adverse effects on the environment caused by wastewater generated by industrial activities. The contamination of rice fields by industrial wastewater due to industrial waste directly to water bodies used by farmers to irrigatee rice fields. In addition, industrial waste water contaminates the well-water as well. The discharged waste may contain a wide variety of chemicals used during the production process, for example heavy metals used in the dyeing and printing processes in the textile industry (Halimoon and Yin, 2010).

Based on Andarani (2009) research results, one of the textile industries PT X in the Rancaekek District drain wastewater into the Cikijing River. The results of that study showed that the concentrations of metals in the water after receiving the main effluent of PT X has increased very high. It is known that Cikijing River and Cimande River in the Rancaekek District has been contaminated by wastewater discharge from various industries to the rivers. Heavy metals with the highest concentrations being measured are cadmium (Cd), chromium (Cr), copper (Cu) and

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zinc (Zn) (Putri, 2015). The waste from the industries not only pollutes the river water, but also pollutes the well-water around that area, proven in Tambun (2015) research.

Based on these studies, it has been proved that water bodies and ground water in the surrounding Rancaekek area has been polluted by heavy metals. Heavy metals are elements contained in the water in the form of colloidal, particulate and dissolved phase. Recently, metal contaminant in sediments, water, and biota is a hot issue, in connection with their toxicity, persistence, non-degradable, and bio accumulative nature (Arain *et al.*, 2008). In conjunction with morphological and hydrological conditions, dissolved materials such as metals can accumulate along the waters, which occur even several kilometers after the sources of pollution. Heavy metals are difficult-degraded pollutants in the environment. If the heavy metals come into the water body, they would be accumulated in biota and could be ingested by humans. When exposed to the organism, the concentration of heavy metals in a considerable period of time could be toxic and tend to accumulates in vital organs (Zang, *et al.*, 2015). Therefore, the research study of heavy metals is important since rivers water plays important role to the daily life of people.

2. RESEARCH METHODOLOGY

Determination of Sampling Points

Determination of sampling point refers to SNI 03-7016-2004 (Indonesian National Standard) on Sampling Procedures in the Framework of Water Quality Monitoring in a River Drainage Area. The measurements of heavy metals concentration are done at river points before and after passing pollutant sources. The sampling points of the Citarik, Cimande and Cikijing Rivers are shown in Figures 1, 2, and 3. The points 1 and 2 of the three rivers are the points before passing through the industrial estates (upstream) and the next points are sampling points after passing through the industrial estate (downstream).

Sampling of Water and Sediment Method

The river water sampling procedure refers to SNI 6989.57-2008 (Indonesian Natioanl Standard) on Water and Wastewater - Section 57: Surface Water Surface Method. Water samples were taken using a water sampler based on grab sampling method. River sediment collection method

refers to Ohio EPA (2012) - Sediment Sampling Guide and Methodologies 3th Edition. Sediment samples were collected using a grab sampler in the form of eckman.

Figure 1 Citarik River sampling points (Source: google earth)

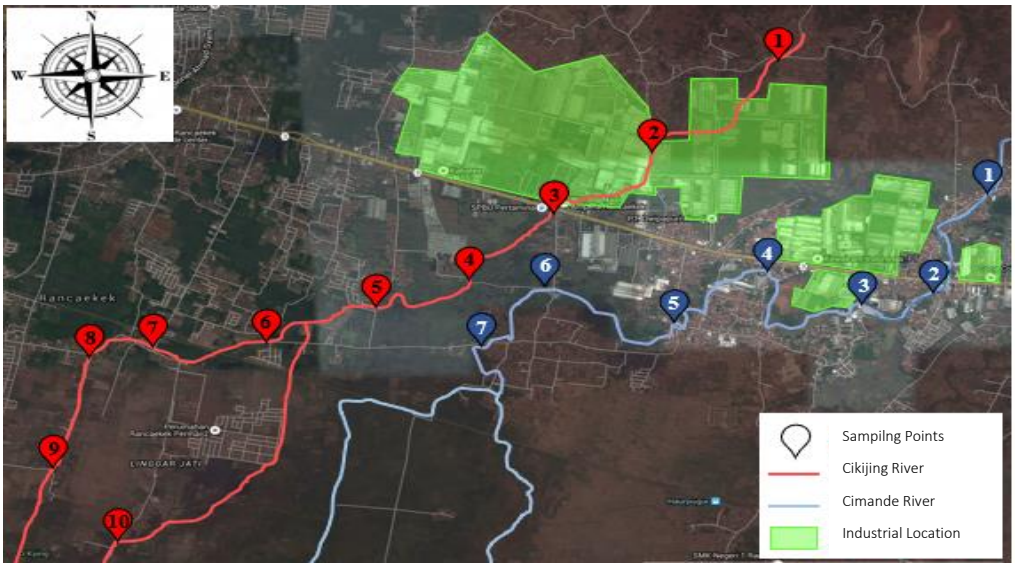

Figure 2 Cimande River and Cikijing River sampling points (source: google earth)

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Water Samples Extraction Method

The water sample extraction method refers to Standard Method for the Examination of Water and Wastewater 21st edition - Section 3030C (2005). Samples of 100 mL are preserve using HNO_3 inserted into beaker glass and added 5 mL of concentrated HCl then it was heated using steam bath for 15 minutes. The heated sample is then fed into a measuring flask and diluted using DI water to a volume of 100 ml.

Sediment Samples Extraction Method

Sediment sample extraction method refers to EPA Method 200.2-1994: Sample Preparation Procedure for Spectrochemical Determination of Total Recoverable Elements. Sediment samples were weighed by wet weight, then heated in an oven at 60 °C and after that weighed dry weight. The temperature is not too high to prevent the evaporation of heavy metals. The oven used is the brand Precision model Economy Oven. Samples that have been heated then crushed until smooth then taken as much as two grams. Two grams of the sample were added aqua regia 10 mL with a ratio of HNO_3 and HCl is 3: 1, then heated to steam bath until the sample dissolves. During the heating process, the glass is covered with a watch glass. This is intended to prevent the evaporation of heavy metal content in the sample since heavy metals are volatile. After that is added H_2O_2 as much as 3 mL then stirred and filtered. The resulting filtrate is fed into a measuring flask and diluted to 50 mL using DI water.

Measuring Heavy Metal Concentration Method

Water samples and collected sediments are being extracted first. The water sample extraction method refers to Standard Method for the Examination of Water and Wastewater 21st edition - Section 3030C (2005). Sediment sample extraction method refers to EPA Method 200.2-1994: Sample Preparation Procedure for Spectrochemical Determination of Total Recoverable Elements. The analysis of heavy metals from extracted samples was performed using Inductively Coupled Plasma with Atomic Emission Spectroscopy (ICP-OES).

3. RESULTS AND DISCUSSION

3.1 Preliminary Study

The preliminary test was intended to determine the highest concentration of heavy metal content in the Cikijing River and Cimande River with. The preliminary test has been conducted by Putri (2015) with two sampling points i.e. one sampling point on the Cikijing River and one sampling point on the Cimande River. The location of the sampling point can be seen in Figure 3. Based on the research of Putri (2015), four heavy metals that has the highest concentration are Cadmium (Cd), Chromium (Cr), Copper (Cu), and Zinc (Zn). The concentration values of various metals that have been digested show in Table 1. Based on that preliminary test results, this study will use the four heavy metals as test parameters at various points in the Cikijing River and Cimande River.

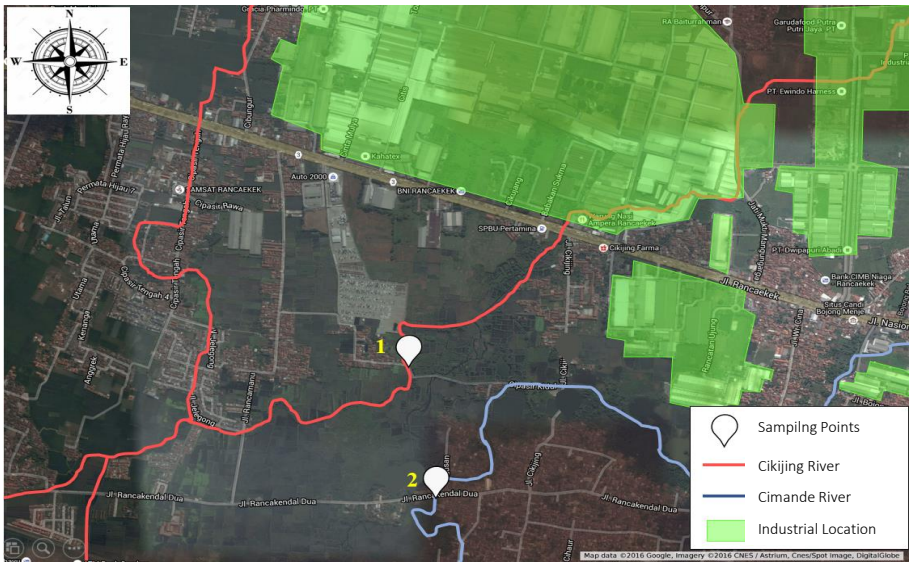

Figure 3 Preliminary study sampling point position (source: Putri, 2015)

Visually, the color of the Cikijing River is dark black while the Citarik and Cimande River water are brownish. Those rivers physical conditions are shown in Figure 2.

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Table 1 Results of preliminary study samples testing (source: Putri, 2015)

Heavy Metals	Concentration (mg/L) Point 1	Concentration (mg/L) Point 2	Standard (mg/L) (West Java Government Regulation No. 39 of 2000
Cd	0.00960	0.00250	0.010
Co	0.01085	0.00145	0.200
Cr	0.01545	0.07080	0.050
Cu	0.05510	0.03340	0.020
Fe	0.99685	1.65225	5
Hg	0.00004	0.00155	0.002
Mn	0.54870	0.31110	2
Ni	0.08585	0.05880	0.500
Pb	0.02750	0.01160	0.030
Zn	0.40540	0.35210	0.020

(a) **(b)** **(c)**

Figure 4 The physical condition of Citarik (a), Cimande (b), and Cikijing (c) Rivers

3.2 Heavy Metal Concentration in Citarik, Cimande and Cikijing Rivers

Table 2 shows the average and range of heavy metal concentrations in water and sediments in Citarik, Cimande, and Cikjing Rivers. The concentrations of the heavy metals measured in the water in each river are shown in Figures 5, 6 and 7. Based on the measurement of the concentration of Cadmium (Cd), Chromium (Cr), Copper (Cu), and Zinc (Zn), it was found that there was an increase in heavy metal concentration at the rivers points after passing through the industrial zone after passing the sampling point 2. This indicates that the wastewater disposal from the industry increases the concentration of heavy metals contained in the three rivers.

Table 2 Total metal in surface water (ppm_v) and sediments (ppm_m dry weight) from Citarik, Cimande, Cikijing Rivers

River	Metal	Water (ppm_v)			Sediment (ppm_m)		
		Mean	Range	SD[a]	Mean	Range	SD[a]
Citarik River	Cd	0.012	0.005-0.027	0.007	365.4	288.0-470.4	62.59
	Cr	0.122	0.020-0.218	0.076	2515	2151-3170	380.4
	Cu	0.195	0.054-0.294	0.089	496.1	315.5-620.2	111.4
	Zn	0.349	0.199-0.541	0.113	1057	761.6-1435	248.8
Cimande River	Cd	0.001	0.001-0.002	0.001	2.649	2.293-3.060	0.319
	Cr	0.050	0.009-0.115	0.037	36.00	30.44-40.15	3.344
	Cu	0.026	0.010-0.045	0.011	18.71	10.71-23.23	4.094
	Zn	0.471	0.065-1.461	0.517	106.1	27.27-202.3	58.61
Cikijing River	Cd	0.001	0.001-0.005	0.001	2.255	1.575-3.709	0.679
	Cr	0.440	0.014-0.850	0.280	44.06	25.36-77.52	15.33
	Cu	0.119	0.020-0.268	0.087	24.81	11.91-39.64	8.865
	Zn	0.680	0.054-2.037	0.575	108.98	21.82-175.9	58.64

Note: a: standard deviation

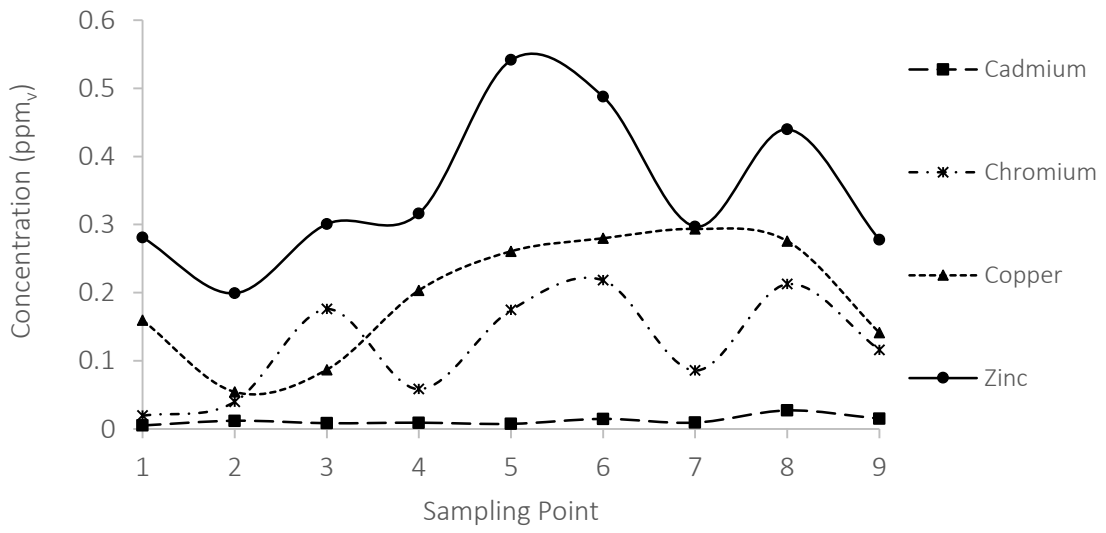

Figure 5 Profile of heavy metal pollution distribution on Citarik River water

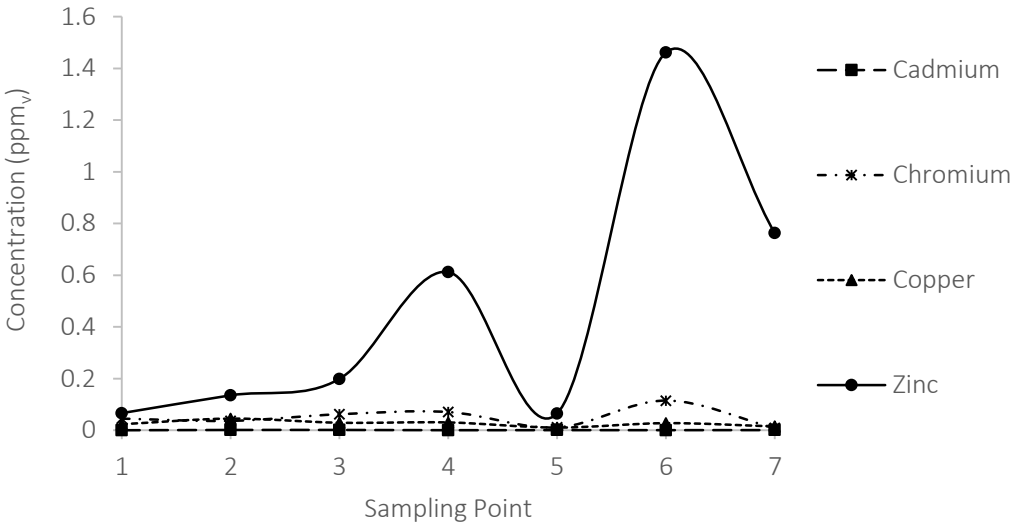

Figure 6 Profile of heavy metal pollution distribution on Cimande River water

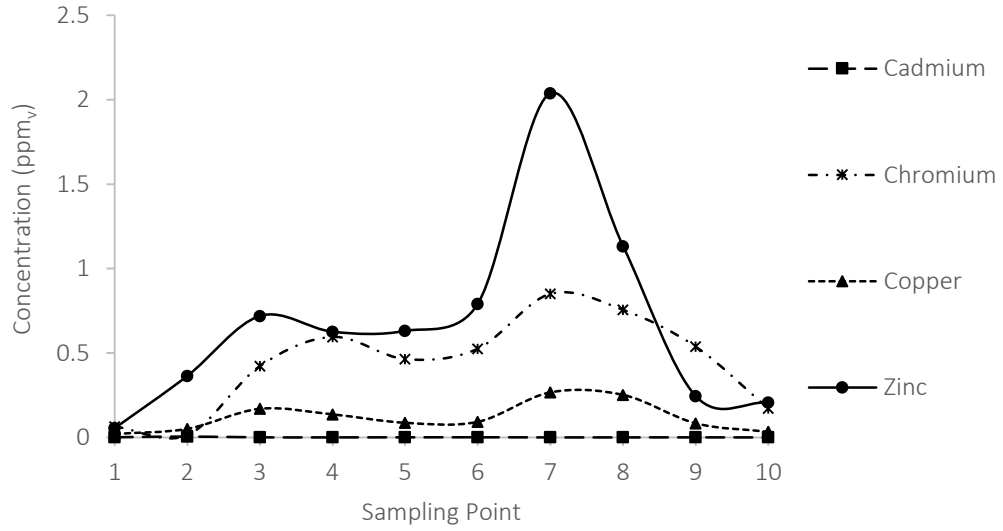

Figure 7 Profile of heavy metal pollution distribution on Cikijing River Water

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Based on Indonesian Government Regulation No. 82 of 2001 on the Management of Water Quality and Control of Water Pollution, the standard of heavy metal content for class III - class water sources is: Cadmium (Cd) of 0.01 ppm, Chromium (Cr) of 0.05 ppm, Copper (Cu) of 0.02 ppm, and Zinc (Zn) of 0.05 ppm. When the concentration of heavy metals compared to the quality standard, it shown that at the sampling point before passing the industrial estate, the heavy metals concentration is still below the standard while the concentration of all heavy metals at the sampling point after passing the industrial estate exceeds the quality standard. This indicates that the wastewater disposal from the industry pollutes Citarik, Cimande, and Cikijing Rivers.

Comparing between heavy metal concentrations in the Citarik River, the order of concentrations from highest to smallest is Zn> Cu> Cr> Cd. As for the Cimande and Cikijing Rivers is Zn> Cr> Cu> Cd. It is known that the industries that dispose of wastewater into the Citarik, Cimande and Cikijing Rivers are dominated by industrial waste. The high concentration of Zinc in these rivers is due to the use of zinc-containing materials in organo-metallic chemicals in the finishing process, such as water repellent, flame retardant, anti-fungal and anti-odor.

While the use of chromium in the textile industry is for the oxidizing agent of vat dyes. This affects the high content of chromium in the effluent being discharged into the body of water. Another use of chromium as an oxidizing agent is as a cleaning solution in the laboratory. This solution has the characteristics of a strong oxidizing agent to be a useful solution in the laboratory, but its use may cause some problems, for example chromium is not flushed from laboratory equipment so as to compromise microbiological work. Chromium is toxic in aquatic environments, and chromium is toxic in biological waste treatment facilities. In addition to chromium, copper is also contained in textile industry dyes. As for cadmium can come from the fertilizer used by farmers in the rice fields.

The concentrations of heavy metals measured in the sediments in each river are shown in Figure 8, 9, and 10. The concentrations of heavy metals in sediments were much higher than the concentrations of heavy metals contained in water, since heavy metals are accumulation occurring continuously in the sediment. Degree of acidity or pH is a major factor affecting the presence of metals in aquatic systems. While the pH increases, the metal will settle and reduce the concentration of dissolved metals in water. Water that has a pH range between 6-9 will increase the metal adsorption capability by sediment (Azhari *et al*, 2016). Samples of river water Citarik, Cimande and Cikijing have pH in the range 6-9. Therefore, the high concentrations of

heavy metals contained in sediments can be caused by a water pH with a range of 6-9.

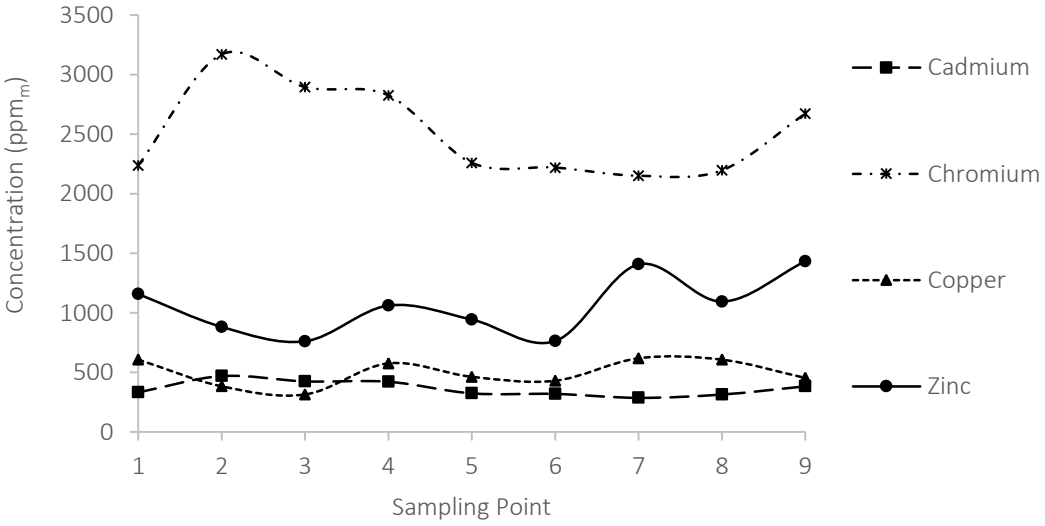

Figure 8 Distribution profile of heavy metal pollution in sediment of Citarik River

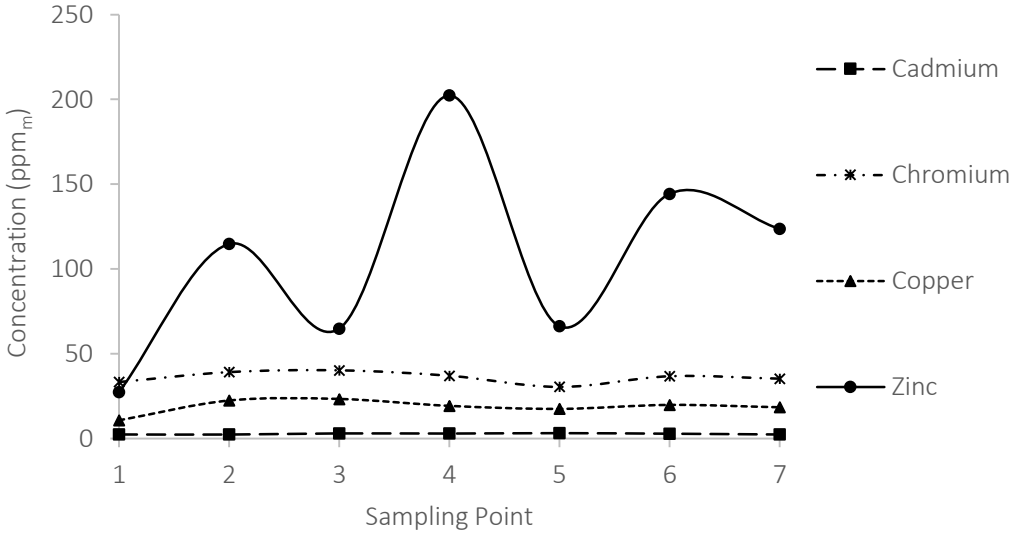

Figure 9 Distribution profile of heavy metal pollution in sediment of Cimande River

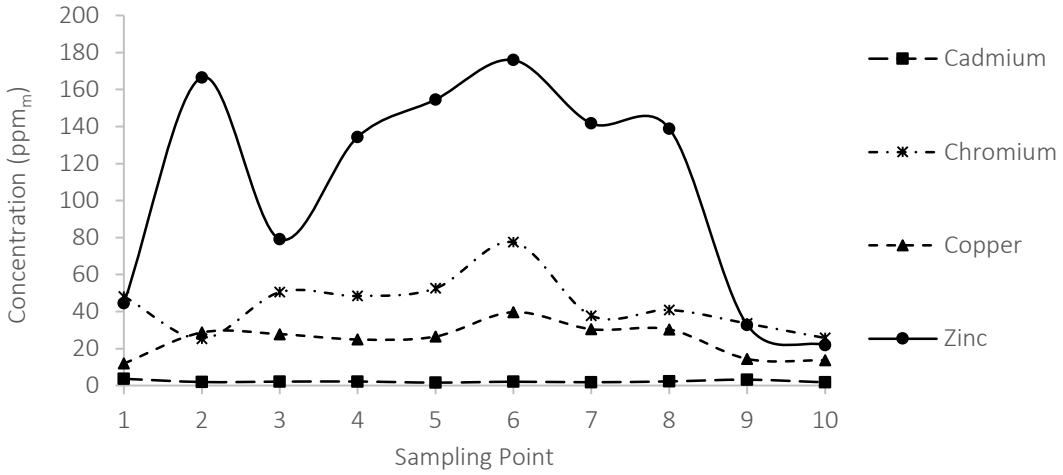

Figure 10 Distribution profile of heavy metal pollution in sediment of Cikijing River

4. CONCLUSION

Citarik, Cimande, and Cikijing Rivers in Rancaekek District are the important rivers in West Java, Indonesia. The probable source of the pollutants is anthropogenic, arising from agricultural activities and textile industry near the rivers. Based on the present study, it can be concluded that the degree of contamination and seasonal variation of heavy metals were high in water and sediment. Based on the result of research, it is concluded that the existence of industry in Rancaekek District resulted in heavy metal contamination to rivers. This is evidenced by the high concentrations of heavy metals in rivers in the downstream area of the river after the disposal of industrial waste compared to the upstream areas prior to the disposal of industrial waste. Efforts should be needed to protect these Rivers from pollution and also to reduce environmental risks. This study and the valuable data will pave the way for the future.

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