JURNAL IPTEK
MEDIA KOMUNIKASI TEKNOLOGI
homepage URL : ejurnal.itats.ac.id/index.php/iptek

Spatial Distribution of Chromium Metal in Water and Sediment in the Berbek Industrial Area, Sidoarjo Regency

Listin Fitrianah[1], Agus Rachmad Purnama[2]

[1]Environmental Engineering Department, Universitas Nahdlatul Ulama Sidoarjo, Indonesia,
[2]Industrial Engineering Department, Universitas Nahdlatul Ulama Sidoarjo, Indonesia

ARTICLE INFORMATION

Jurnal IPTEK – Volume 26
No. 1, May 2022

Page:
33 – 40
Published Date :
31 May 2022

DOI:
10.31284/j.iptek.2022.v26i1.2966

ABSTRACT

Berbek Industrial Estate is the largest industrial area in Sidoarjo Regency. The most dominant concentration of heavy metals in industrial areas is chromium in water and sediments in rivers which have the potential to have a negative impact on humans, this is because rivers are a place for developing aquatic organisms including fish that are consumed by local residents. Parameters include chromium concentration in river water and sediment. Spatial distribution analysis uses the kriging method on laboratory results and overlays to describe the distribution map. The result of the highest concentration in water parameters is the location of Gedongan Village at 0.31 ppm. Based on Peraturan Pemerintah Republik Indonesia Nomor 22 Tahun 2021 about the implementation of environmental protection and management, states that the environmental quality standard for chromium in class III rivers is 0.05 mg/L. The highest concentration in sediment is the Berbek location at 3.24 ppm.

Keywords: *Chromium; Distribution; Kriging; Mapping; River*

EMAIL

[1]listin_fitri.tkl@unusida.ac.id

PUBLISHER

LPPM- Institut Teknologi Adhi Tama Surabaya
Alamat:
Jl. Arief Rachman Hakim No.100,Surabaya 60117,
Telp/Fax: 031-5997244

ABSTRAK

Kawasan Industri Berbek merupakan kawasan industri terbesar di Kabupaten Sidoarjo. Konsentrasi logam berat yang paling dominan di kawasan industri adalah kromium pada air dan sedimen di sungai yang berpotensi dapat memberikan dampak negatif pada manusia, hal ini dikarenakan sungai merupakan tempat berkembangnya organisme air termasuk ikan yang dikonsumsi warga sekitar. Parameter meliputi kandungan kromium pada air sungai dan sedimen. Analisa sebaran spasial menggunakan metode kriging pada hasil laboratorium dan overlay untuk memaparkan berupa peta sebaran. Hasil kandungan tertinggi pada parameter air adalah lokasi Desa Gedongan sebesar 0,31 ppm. Berdasarkan Peraturan Pemerntah Republik Indonesia Nomor 22 Tahun 2021 tentang Penyelengaraan Perlindungan dan Pengelolaan Lingkungan Hidup menyebutkan baku mutu lingkungan untuk kromium pada sungai kelas III sebesar 0,05 mg/L.Kandungan tertinggi pada sedimen adalah lokasi Berbek sebesar 3,24 ppm.

Kata Kunci: Kriging; Kromium; Pemetaan; Sebaran; Sungai

INTRODUCTION

Sidoarjo Regency is an industrial area in East Java, so have positive impact on improving the economy. Sidoarjo is a support area for the economy of the city of Surabaya. Many large industries are established in Sidoarjo Regency and are part of large-scale industries. Based on the Rencana Tata Ruang Wilayah from 2009 to 2029, There is an industrial area divided into two, namely Berbek industrial area in Waru District and Jabon industrial area in Jabon District.

Berbek Industrial Estate is the largest industrial area in Sidoarjo Regency. Some of the large and heavy industries in the Berbek industrial area. In general, the development of the industrial sector cannot be separated from the existence of externalities, namely positive and negative externalities. Positive externalities in the form of increased industrial and economic growth of the surrounding community, while negative externalities such as environmental pollution. The existence of the industry in the end has the potential to be negative for the environment, namely the accumulation of heavy metals in rivers around the industrial area. The presence of heavy metals that are concentrated in industrial areas if not managed properly will eventually cause health problems in humans. Some activities such as industrial activities have the potential to produce waste that can increase levels of harmful heavy metals in waters such as lead and cadmium that can accumulate in the bodies of organisms that live in waters and remain for a long time.

The highest concentration of heavy metal in industrial areas is chromium. Concentrations of Cr in water and sediment in rivers have the potential to have a negative impact on humans, because aquatic organisms live, including fish, which are consumed by local residents. Chromium is a material that can poison the environment and have an impact on all systems in the body. The analyzed is hexavalent chromium (Cr-VI). Heavy metals enter the body through inhalation, food and drink and absorption through the skin. The accumulation of heavy metals that enter the body will affect human health because heavy metals are metallic chemicals that are not needed by the body [5].

The magnitude of the impact that can be caused by the presence of heavy metals in industrial areas, it is necessary to conduct research which is expected to provide information related to the distribution of heavy metals from lead in soil and water in the Sidoarjo Regency. The distribution will later be described by mapping using a Geographic Information System (GIS). GIS is a database system with special capabilities to handle spatially referenced data (spatial) together with a set of work operations. In addition, GIS can also combine data, organize data, and perform data analysis which will ultimately produce output that can be used as a reference in decision making on problems related to geography. Utilization of geographic information system (GIS) technology in the environmental field, one of which is water quality mapping using the Invers Distance Weighting (IDW) interpolation method. One of the studies using this method is the mapping of suspended sediments conducted by Pramono (2008) and the results show that interpolation techniques can be used to map water quality parameters [7]. One of the interpolation methods in GIS is the kriging method. Kriging was chosen in this study because it can assess the attributes taken at the research location by predicting the spatial value at the unsampled location. This is used in research on mapping heavy metals in water using the kriging method. The importance of this research is to obtain information on the distribution of metal concentration along the river in the Berbek industrial area as a basis for information for local residents on the impact of activities there.

LITERATURE REVIEW

Chromium in Water

Residual material is a mixture of fine particles of waste material and fused material. Finely porous with exposed chromite particles on the outer and inner surfaces, which tend to be detached from all exposed surfaces [3]. In addition, the phosphate amendment produced from the ash of sewage sludge or tanning sludge is rich in leaching hexavalent chromium. Its improper use is the main cause of chromium pollution in agricultural areas [4]. The concentration of heavy metal chromium Cr in the waters of Trimulyo is lower than the concentration of heavy metal Cr in the waters of the Morosari River and Gonjol River. This condition is thought to be due to the dynamic movement of seawater [1]. Heavy metals that enter waters will be removed from water bodies through three processes, namely deposition, adsorption and absorption by aquatic organisms. The low levels of Cr in the Trimulyo waters are caused by the dynamic movement of seawater. The tidal cycle causes the number of heavy metals in a certain unit of water mass to decrease. It is also influenced by physical and chemical factors such as temperature, depth, pH, salinity and DO. Chemical factors such as pH can affect the heavy metal concentration of Cr in waters where the pH at each station increases to alkaline from 7.93 to 9.36 so that a high pH will form complex compounds in the form of changes in Cr from carbonate form to form hydroxide that is difficult to dissolve in

water so that it can bind to water particles which then settle to the bottom of the water. According to the quality standard for heavy metal Cr issued by the Decree of the State Minister for the Environment No. 51 of 2004, the Trimulyo waters are classified as not polluted by heavy metal chromium [11].

Chromium in Sedimentation

Sedimentation is the transfer of material to areas of deposition caused by erosion and weathering by water, wind or glaciers. All rocks that have been deposited over time by erosion and weathering will form sedimentary rocks. The results of the sedimentation process related to the river include narrowing of the trough, erosion, sediment transport, deposition, and compaction of the sediment itself. The process of sediment formation begins with the process of eroding the soil, carried away by currents, leaving some in the soil and partly entering the river and bound by the river [6]. The quality standard for heavy metal chromium in sediments issued by the National Oceanic and Atmospheric Administration (NOAA) in 1999, the concentration of heavy metal Cr in sediments is below the threshold of 52.3 mg/kg including the safe category for life [11].

Spatial Analysis for mapping

Spatial analysis is an analysis and description of geographic data based on environmental factors and the relationship between variables in the environment. To process and analyze the data spatially, an interpolation method from GIS is used.. Kriging is an interpolation with statistical calculations [8]. The kriging method is used to highlight a special method in weighted moving that minimizes the variance of the estimation results, this calculation technique is for the estimation of a regional variable that uses an approach if the analyzed data is considered as a realization of a random variable and all random variables analyzed will form a function. randomized using a structural variogram [9]. The following figure 1 interpolation kriging method.

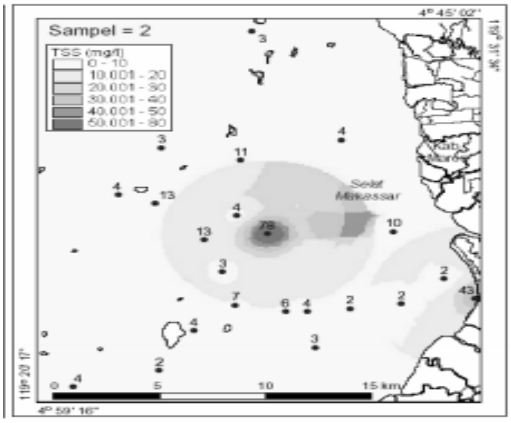

Figure 1. Interpolation results of total suspended solids (TSS) using the Kriging method in Maros, South Sulawesi

METHOD

Location

The location chosen as the research location is along the river in the Berbek industrial area,

Data collection technique

The data used in this study are spatial and non-spatial data (attributes). Spatial data of administrative maps, land use maps, and satellite image data. For non-spatial data will be used in the form of lead concentration data found in soil and water. The lead concentration data were obtained from the results of laboratory tests on water samples taken from the river in the Berbek industrial area. Waru District, Sidoarjo Regency which includes 5 sampling points (Figure 2).

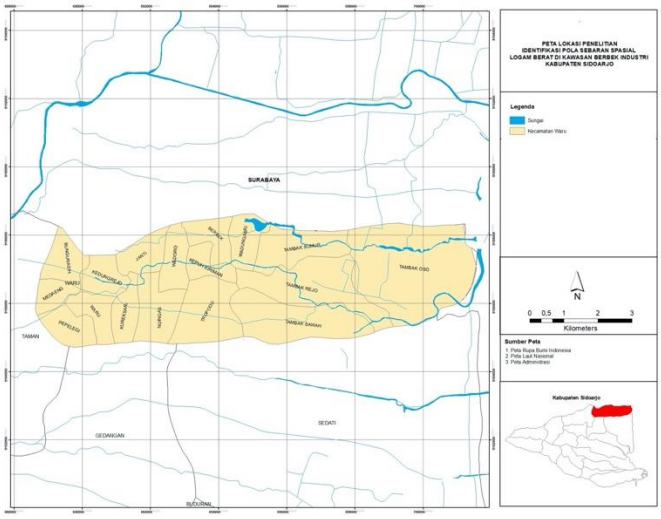

Figure 2. Research Locations

Data Processing Techniques

Data processing is the most important stage of this research, where the results of this activity are the interpretation of the results of the analysis of all research data. In general, the data processing carried out in this study is divided into 2 stages of activity, namely; the data entry and preparation stage, and the data analysis and manipulation stage.

Data Analysis Stage

Data entry and entry in this study were carried out using ArcGIS 10.1 software. This software is useful in carrying out the analysis process and the interpretation of the results. The process of entering data based on spatial data is carried out using the on-screen digitization method. Meanwhile, for non-spatial data (attributes) using a database facility, then proceed with the database management process in order to obtain an attribute database and a spatial database [8]. The attribute database and spatial database generated in the next stage are then further analyzed in the following stages. Analysis of chromium concentration based on the results of laboratory tests using the kriging method. The analysis was carried out by interpolating the test results on water and sediment parameters. Analysis of chromium distribution The analysis carried out at this stage was to determine the distribution pattern of chromium concentration in the river waters of the Berbek industrial area, Sidoarjo Regency. The analysis was carried out by overlay the chromium concentration data with administrative data, so that information on the distribution and concentration at each sampling point would be obtained.

RESULTS AND DISCUSSION

Distribution of Chromium Heavy Metal Levels in Water in the Berbek Industrial Area River

Based on the testing of river water samples, chromium concentration was obtained at each location. The chromium concentration in the river water of the Berbek industrial area at several locations is shown in Table 2.

The results of laboratory testing showed that the chromium concentration of the seven locations included location A at 0.23 ppm, location B at 0.25 ppm, location C at 28 ppm, location D at 0.31 ppm, at location E at 0.28 ppm. , location F is 0.26 ppm and location G is 0.25 ppm. Based on the Peraturan Pemerintah Republik Indonesia Nomor 22 Tahun 2021 about the implementation of environmental protection and management, it is stated that the environmental quality standard for Cr-IV in class III rivers is 0.05 mg/L. The results showed that the chromium concentration in the seven locations exceeded the environmental quality standards set by the government. This is due to location C, which is the location prior to the disposal of industrial liquid waste, containing chromium metal which has exceeded the quality standard due to several factors, including the presence of

industrial activities. At a distance of about 300 meters before location A, there are densely populated houses, sandal craftsmen and a market. According to information from the local community, the waste generated from domestic household and market activities is directly dumped into the river. This reason is supported by previous research which states that liquid waste in domestic activities has the effect of increasing the chromium VI concentration in Berbek River water. Location D contains higher chromium concentration than other locations. This is because apart from the already high chromium concentration at location D, it is also caused by the entry of pollutants containing high chromium from the industry. This reason is supported by the theory which states that after entering the waters the nature of the pollutant is determined by several factors, including the spread of the pollutant by turbulence and water currents. Location D had the highest chromium concentration compared to the other three locations. The high chromium at this location is because location D is the shallowest location compared to other locations so the sampling is carried out closer to the bottom of the water. The chromium concentration in river water close to the bottom of the water is higher because the chromium accumulated in sedimentation is lifted into river waters by river currents and water turbulence. Heavy metals that enter waters will be removed from water bodies through three processes, namely precipitation, adsorption and absorption by aquatic organisms. The high and low concentration of metal Cr in the waters is caused by the amount of chromium heavy metal waste input into the waters. The low levels of Cr in the Trimulyo waters are caused by the dynamic movement of seawater [11].

Table 2 The chromium concentration in water

No.	Sample	Location	Coordinate	Concentration (ppm)
1.	A	Wedoro	S 7º 20’ 59,5” - E 112º 44’ 52,5”	0,23
2.	B	Kepuh Kiriman	S 7º 21’ 4,1” - E 112º 45’ 20,4”	0,25
3	C	Berbek	S 7º 20’ 58,4” -E 112º 45’ 46,8”	0,28
4.	D	Gedongan	S 7º 21’ 2,3” - E 112º 46’ 1,8”	0,31
5.	E	Tambak Rejo	S 7º 21’ 8,6” - E 112º 46’ 32,4”	0,28
6.	F	Tambak Sari	S 7º 21’ 12,6” - E 112º 46’ 42,3”	0,26
7.	G	Tambak Oso	S 7º 21’ 55,8” - E 112º 46’ 27”	0,25

This reason is supported by previous research which states that heavy metals that are transferred to the waters, either in rivers or the sea will be removed from the water body through several processes, one of which is deposition. The results of the study also provide a geographical description which provides information related to the distribution map. The distribution of the mapping on the chromium concentration in the waters is shown in Figure 2. The distribution of maps in the processing of geographic data modelling has several concentration ranges consisting of 9 concentration ranges of cadmium. The first range shows a cadmium concentration of 0.23 ppm – 0.24 ppm, the second range is 0.24 ppm – 0.25 ppm, the third range is 0.25 ppm – 0.26 ppm, the fourth range is 0.26 ppm – 0.26 ppm, the fifth range is 0.26 ppm – 0.27 ppm, the sixth range is 0.27 ppm – 0.28 ppm, the seventh range is 0.28 ppm – 0.29 ppm, the eighth range is 0.29 ppm – 0.30 ppm and the ninth range is 0.30 ppm – 0.31 ppm. The distribution of chromium was lowest in river waters in parts of Kepuh Kiriman Village and part of Wedoro Village. The distribution of cadmium concentration in the second and third ranges in river waters is also in some parts of Kepuh Samudra Village. The distribution of cadmium concentration in the fourth and fifth ranges in river waters in some Wadungasri Villages. The distribution of cadmium concentration ranges from the sixth to the eighth in Berbek and Wadungasri villages. The distribution of the highest cadmium concentration is in the ninth range in Tambak Sumur Village. The geographical location of Tambak Sumur Village is close to Berbek Village and the Surabaya border and the location of industrial activities in Surabaya City.

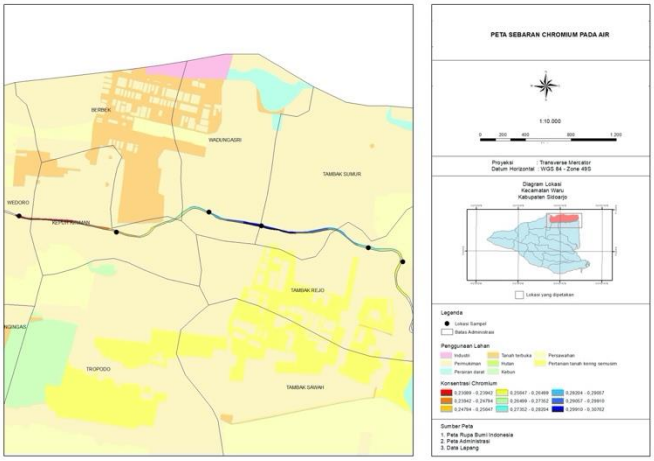

Figure 2. The Map of the distribution of chromium concentration in river water

Distribution of Chromium Heavy Metal Levels in Sediments in the Berbek Industrial Estate River

Based on the testing of river sediment samples, chromium concentration was obtained at each location. The chromium concentration in the river water of the Berbek industrial area at several locations is shown in Table 3.

Table 3. The chromium concentration in sediment

No.	Sample	Location	Coordinate	Concentration (ppm)
1.	A	Wedoro	S 7º 20’ 59,5” - E 112º 44’ 52,5”	2,11
2.	B	Kepuh Kiriman	S 7º 21’ 4,1” - E 112º 45’ 20,4”	2,19
3	C	Berbek	S 7º 20’ 58,4” -E 112º 45’ 46,8”	3,24
4.	D	Gedongan	S 7º 21’ 2,3” - E 112º 46’ 1,8”	2,95

The results of laboratory tests showed that the chromium concentration in the sediments from the four locations included location A at 2.11 ppm, location B at 2.19 ppm, location C at 3.24 ppm, at location D at 2.95 ppm. The highest heavy metal concentration was found at location C at 3.24 ppm. The lowest heavy metal concentration of Cr was found at location A, which was 2.11 ppm. This is because the heavy metal concentration of Cr is stirred in the sediment caused by the current factor. This is directly proportional to the relationship between pollutants and their sources, where the level of pollutants in a place is directly proportional to the distance from the pollutant source [10]. This is in line with the results of Sudarwin's research [13]. who found that there was an effect of the distance between the heavy metal concentration in the Kreo River sediment and the distance of the pollutant source. The heavy metal concentration of Cr at the research site shows that the heavy metal concentration in the sediment is much higher than the heavy metal concentration in the water. This is because the heavy metal Cr has properties that easily bind organic matter and tends to settle to the bottom of the water and then merge with the sediment so that the heavy metal concentration in sediment is higher than in water [12]. The quality standard for chromium heavy metal in sediments is that the concentration of heavy metal Cr in sediments is below the threshold of 52.3 ppm including the safe category for life.

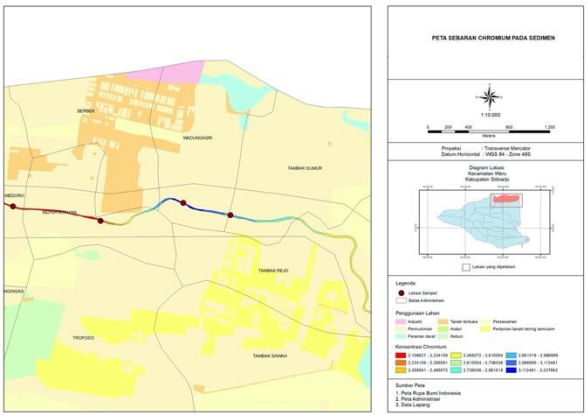

Figure 3. The map of chromium distribution in sediment

The distribution of maps in the processing of geographic data modelling has several concentration ranges consisting of 9 concentration ranges of cadmium in sediments. The first range shows the chromium concentration of 0.23 ppm – 0.24 ppm, the second range 0.24 ppm – 0.25 ppm, the third range 0.25 ppm – 0.26 ppm, the fourth range 0.26 ppm – 0.26 ppm, the fifth range 0.26 ppm – 0.27 ppm, the sixth range 0.27 ppm – 0.28 ppm, the seventh range is 0.28 ppm – 0.29 ppm, the eighth range is 0.29 ppm – 0.29 ppm and the ninth range is 0.30 ppm – 0.31 ppm. The distribution of chromium was lowest in river waters in parts of Kepuh Sendan Village and part of Wedoro Village. The distribution of chromium concentration in the second and third ranges in river waters is also in some parts of Kepuh Samudra Village. The distribution of chromium concentration in the fourth and fifth ranges in river waters in some parts of Tambak Sumur Village. The distribution of chromium concentration ranges from the sixth to the eighth in Wadungasri Village. The distribution of the highest chromium concentration was in the ninth range in Tambak Sumur Village. The geographical location of Wadungasri Village is next to Berbek Village, where most of the activities are industrial and densely populated housing.

There is a difference in concentration between water and sediment parameters. The chromium concentration in the sediment is much higher than the chromium concentration in the water. This is in line with the research of the sample of D. Rahardjo and the sample of A. Prasetyaningsih (2021) that the allowable level of chromium metal in sediment is 52.30 mg/kg so that the chromium concentration found in sediment from all location points is still in the safe category [2]. This is if the heavy metal deposition process occurs continuously, it will not rule out the possibility that the accumulation of chromium in the sediment will be higher and result in a decrease in environmental quality. The presence of chromium in the water and sediments indicates that the biota living in the waters are also contaminated with chromium metal with varying results at each sampling location. This is because it is suspected that the concentration of heavy metal chromium (Cr) experienced turbulence in the sediment caused by the current factor. This is directly proportional to the relationship between pollutants and their sources, where the level of pollutants in a place is directly proportional to the distance from the pollutant source [11]

CONCLUSION

From the results of the research that has been carried out, it can be concluded that the highest concentration in the water parameter is the location of Gedongan Village at 0.31 ppm. Based on the Peraturan Pemerintah Republik Indonesia Nomor 22 of 2021 about the implementation of environmental protection and management, it is stated that the environmental quality standard for chromium in class III rivers is 0.05 mg/L. The distribution of the highest cadmium concentration is in the ninth range in Tambak Sumur Village. The geographical location of Tambak Sumur Village is close to Berbek Village and the Surabaya border and the location of industrial activities in Surabaya City. The highest concentration in the sediment is the Berbek location at 3.24 ppm. There is a difference in concentration between water and sediment parameters. The chromium concentration in the sediment is much higher than the chromium concentration in the water. The distribution of the

highest chromium concentration was in the ninth range in Tambak Sumur Village. The geographical location of Wadungasri Village is next to Berbek Village, where most of the activities are industrial and densely populated housing.

BIBLIOGRAPHY

[1] Azhar, H., Widowati, I. dan Suprijanto, J. 2012. Studi Kandungan Logam Berat Pb, Cu, Cd, Cr Pada Kerang Simping (Amusium Pleuronectes), Air Dan Sedimen Di Perairan Wedung, Demak Serta Analisis Maximum Tolerable Intake Pada Manusia. J. Mar. Res.,1,35-44.

[2] D. Rahardjo dan A. Prasetyaningsih Pengaruh Aktivitas Pembuangan Limbah Cair Industri Kulit Terhadap Profil Pencemar Kromium di Lingkungan serta Moluska, Ikan dan Padi Di Sepanjang Aliran Sungai Opak Bagian Hilir.

[3] Mcleod N. Chemical Immobilisation of Chromium Wastes using Modified Smectite Clays (E-clays) *Environ. Geochem. Health.* 2001;23:273–279. doi: 10.1023/A:1012401332610

[4] M. Tumolo *et al*. 2020. Chromium Pollution in European Water, Sources, Health Risk, and Remediation Strategies: An Overview.International Journal of Environmental Research and Public Health. , vol. 17, no. 15, p=5438.

[5] Palar H. 1994. Pencemaran dan Toksikologi logam berat. Jakarta: Rineka Cipta.

[6] Pangestu, H., dan Haki, H. 2013. Analisis Angkutan Sedimen Total pada Sungai Dawas Kabupaten Musi Banyuasin. Jurnal Teknik Sipil dan Lingkunan. 1(1): 103-109.

[7] Pramono, H P. 2008. Akurasi Metode IDW dan Kriging untuk Interpolasi Sebaran Sedimen Tersuspensi di Maros, Sulawesi Selatan. Forum Geografi, Badan Koordinasi Survei dan Pemetaan Nasional (Bakosurtanal). Vol. 22(1):145- 158

[8] Prahasta E. 2005. Sistem Informasi Geografis Konsep Dasar Perspektif Geodesi dan Geomatika. Bandung (ID): Informatika .

[9] Puspita W, 2013. Analisis Data Geostatistik Menggunakan Metode Ordinary Kriging. Bandung: Universitas Pendidikan Indonesia

[10] R Nuraini. Analisis Kandungan Logam Berat Kromium (Cr) Pada Air, Sedimen Dan Kerang Hijau (Perna viridis) Di Perairan Trimulyo Semarang. Jurnal Kelautan Tropis.,Maret 2017. vol 20, no.1, 48-55

[11] Ria Azizah Tri Nuraini, Hadi Endrawati dan Ivan Riza Maulana. 2017. Analisis Kandungan Logam Berat Kromium (Cr) Pada Air, Sedimen Dan Kerang Hijau (Perna viridis) Di Perairan Trimulyo Semarang. Jurnal Kelautan Tropis 20 (1): 48-56

[12] S. Harahap. (2014). Pencemaran Logam Berat di Perairan Pesisir Kota Makassar dan Upaya Penanggulangannya. Jurnal Info Teknis EBONI, 11, (1), 1-13.

[13] Sudarwin. "Analisis Spasial Pencemaran Logam Berat (Pb dan Cd) pada Sedimen Aliran Sungai dari Tempat Pembuangan Akhir (TPA) Sampah Jatibarang Semarang". Tesis. Semarang: Program Pascasarjana Universitas Diponegoro, 2008.