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Research article

DISTRIBUTION AND CONCENTRATION SEVERAL TYPES OF HEAVY METAL CORRELATED WITH DIVERSITY AND ABUNDANCE OF MICROALGAE AT TALLO RIVER, MAKASSAR, SOUTH SULAWESI, INDONESIA

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ABSTRACT : The main problem of aquatic ecosystem is caused by pollution of heavy metal that comes from industrial disposal and domestic. This pollution is causing loss of biodiversity, also increasing of bioaccumulation and biomagnifications from the poisonous materials at the food web. River ecosystem is the most affected by aquatic pollution due to a major role of the river for community. A study on water quality, heavy metal concentration and microalgae abundance at selected sites of Tallo River was carried out. Eighteen water and sediment samples were collected along the river for heavy metal and water quality analysis and 27 water samples were collected for microalgae analysis. The aims of this research are: 1) Determine distribution and concentration of existing heavy metal Tallo River ecosystem, 2) Identify microalgae dominant from Tallo River ecosystem where have been polluted by several type of heavy metal. The results showed that there were three heavy metals at Tallo River which have a high concentration and above permissible maximum concentration of environment quality standard, such as Lead (Pb), Copper (Cu) and Chromium (Cr). Those heavy metals were distributed patchily between station sampling. The highest concentrations of those heavy metals were found close to the industrial location of the Tallo River. Statistical result showed that there was a significant different of heavy metal concentration between sampling stations and concentration all of heavy metal measured was higher at sediment than in the water column. Only four genera found during sampling. Skeletonema sp and Synedra sp were abundance at all sites of the research location. However, there is a weak regression between abundance of microalgae, species dominant and concentration of heavy metal (Pb, Cu and Cd) in the sediment and water column.

Keywords: Microalgae, heavy metal and Tallo River ecosystem

INTRODUCTION

Nowdays, one of the most important global problem is the pollution of the environment by industrial, economic and social activity. The most affected ecosystem by pollution is river ecosystem due to river play major role to the community, especially in the fishing, industry and a source of water supply for people within the river area [1, 4,8]. Heavy metal pollution in the river has major concern due to they were undegradable element consequently can be either adsorbed onto sediment or accumulated by organisms to toxic level [11, 1, 4]. Heavy metals have been introduced into rivers through land surface run off and rainfall precipitation. Other sources such as mine drainage, off shore oil and gas exploitation, industrial (pesticides, paints, leather, textile, fertilizer, pharmaceutical), domestic effluents and acid rain have all contributed to increase metal load to the river [6, 1]. Heavy metals are considered toxic compounds as their targets are essential metalloenzymes when its present higher than minimum requirement as micronutrient [7]. Accumulating heavy metal in the organism especially plants and microbial can increase in concentration up to 100 to 1000 times those taken up by non accumulator organisms. Previous researchs found that some organisms such as plankton and benthos have a capability to absorb heavy metal in the water and sediment. Those organisms common to be bioindicator and biosorption of heavy metal [2, 3, 10].

A study was conducted to determine distribution and concentration several types of heavy metal (Lead, Pb; Copper, Cu; Cadmium, Cd; Chromium, Cr and Mercury, Hg) in the Tallo River which was known to be in the category of polluted river and to examine whether there is a correlation between the existing type of heavy metal and diversity and abundance of microalgae.

METHODS

Study Site and Sampling Procedure

Tallo River was chosen as representative sites for the polluted river (Fig. 1). Tallo River is the largest river in Makassar City and located in South Sulawesi Province. The river originates from northeast of Makassar Bay and its tributaries rise in the forested mountain which combine of resident, agriculture and industrial activity. The Tallo River drains the province of South Sulawesi and supports a catchment of about 27 km². The river drains through two districts such as Maros and Makassar districts, with the variation of the local monsoon climate. Tallo River receives variable level of rainfall, which is from 75 to 1230 mm in dry and wet season, respectively. Local people use the river for many purposes such as drinking water supply, agriculture and plantation irrigation, pond water supply, daily uses, fishing and industrial waste discharge. A study was conducted from August to October 2009. Sampling was undertaken along Tallo River, which represented and affected area of industrial, agricultural and domestic activity. A number of 3 sampling stations were identified for heavy metal, microalgae analyses and water quality with triplicate sampling each station.

Sample Collection and Storage

The water samples were collected from a depth of 1 meter below the surface using Camerer Water Sampler and kept in polyethylene container (500 mL) with the addition of 2 mL concentrated HNO₃, in order to preserve the metal. Water sample for microalgae analysis added with 2 mL Lugol's solution as a preservation solution. The sediment samples were collected using Eikman Dredge and kept in the plastic container (1 kg) and put into the cool box. Water quality was measured in situ using Water Quality Checkermodel for dissolved oxygen, pH, conductivity, turbidity, temperature and salinity.

Heavy Metal and Microalgae Analysis

A sequential extraction method used to extract heavy metal from the sediment samples. The heavy metal concentration (Pb, Cu, Cd, Cr and Hg) was analysed using Atomic Absorption Spectrophotometry AAS 1100B model Perkin Elmer.

Microalgae samples were identified and counted using Sedwick Rafter Chamber Method and light microscope with maximum 400 times magnification.

Statistical Analysis

All sampling were performed in triplicate. Student t-test were carried out to determine significant differences ($p < 0.01$) of heavy metal concentration in the sediment and water and also between sampling sites. To examine the correlation between heavy metal concentration and abundance and dominant of microalgae, the data were analyzed using regression analysis in the SPSS v. 15 software program.

RESULTS AND DISCUSSION

Water Quality

In general, Tallo River is characterized by good water quality. Water quality data is tabulated in Table 1. Average dissolved oxygen concentration in Tallo River was much higher than minimum requirement for aquatic organism, which is 4 mg/L. Tallo River is the largest river in Makassar. The continuous current created a homogenous condition of DO that was indicated by low standard deviation value. Turbidity of Tallo River was 0.6 m, it was considered normal for Tropical River. Sampling stations are located within order 5, which is normally affected by human activities and make the water color to a brownish color. The pH value also classified Tallo River is a normal pH value for Tropical River.

Most chemical parameter was detected at low concentration except for phosphate which was found slightly high. The quality of river depends on catchment and land activities. It has been reported that more than 60% of water quality at aquatic ecosystem is determined by inland activities. Tallo River is being used by the local community for many purposes such as bathing, cleaning, agriculture, pond, industrial waste discharge. All activities contributed significantly to increase the phosphate input into the river.

Heavy Metal Concentrations

Mean of concentration five types of heavy metal (Pb, Cd, Cu, Cr and Hg) from Tallo River was shown in Fig. 2 and 3. There were 3 types of heavy metal that had a high concentration either on the water or in the sediment, such as Pb, Cu and Cr.

Lead (Pb) was the highest concentration compared to others heavy metal either in the water or in the sediment. In the water, the highest concentration of Pb was found in the agricultural area of the river. This concentration of Pb has been above maximum permissible concentration of environment quality standard (EPA standard). This finding indicated that agricultural activity contributed a significant amount of Pb into the river. This result supported by [4] who found that one of Pb source in the aquatic ecosystem come from fertilizer. Whereas concentration of Pb in the sediment was slightly similar in all station of sampling and still below the maximum permissible concentration.

Table 1. Physical and chemical water quality of Tallo River (the mean in average of 3 replicates)

No.	Water quality variables	Industrial site	Agricultural site	Domestic activity site
1	Turbidity (m)	0.4	0.6	0.9
2	pH	7.66	7.2	7.12
3	DO (mg/l)	11.02	5.63	5

Table 2. T test result of heavy metal concentration between concentration in the water and in the sediment, * = P<0.001; ** = P<0.05**

Heavy metal	Mean of concentration (ppm)		T test value
	Water	Sediment	
Hg	0,0015	0,0688	0.000***
Pb	0,3534	30,7433	0.000***
Cu	0,1095	29,5136	0.000***
Cd	0,0324	1,2947	0.000***
Cr	0,1059	14,3909	0.002**

Tabel 3. T test result of heavy metal concentration between sampling station in the water and sediment. *** = P<0.001; ** = P<0.05

No	Pair Test	Significant value (P value)									
		Hg		Pb		Cu		Cr		Cd	
		Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment
1	Agricultural site vs Resident site	0.635	0.875	0.000***	0.409	0.123	0.124	0.275	0.117	0.038**	0.767
2	Agricultural site vs Industrial site	0.560	0.608	0.049**	0.196	0.441	0.042**	0.224	0.187	0.043**	0.490
3	Resident site vs industrial site	0.336	0.082*	0.535	0.709	0.185	0.001***	0.471	0.998	0.935	0.706

Table 4. Regression analysis result of three types of heavy metal (Pb, Cu and Cr) and abundance and dominant of microalgae. * = significantly strong correlation.

Pasangan regresi	Sedimen		Kolom Air	
	R ²	F-Sig	R ²	F-Sig
Pb vs Kelimpahan Mikroalga	0.308	0.626	0.905*	0,199
Cu vs Kelimpahan mikroalga	0.278	0.647	0.908*	0,196
Cr vs Kelimpahan mikroalga	0.729*	0.349	0,126	0,769
Pb vs <i>Nitzchia sp</i>	0.995*	0.043	0.548*	0,469
Cu vs <i>Nitzchia sp</i>	0.226	0.685	0,045	0,864
Cr vs <i>Nitzchia sp</i>	0.001	0.982	0.975*	0,100
Pb vs <i>Skeletonema sp</i>	0.309	0.625	0.906*	0,198
Cu vs <i>Skeletonema sp</i>	0.277	0.647	0.908*	0,197
Cr vs <i>Skeletonema sp</i>	0.728*	0.349	0,127	0,768



Figure 1. Location of the sampling station on Tallo River in Makassar

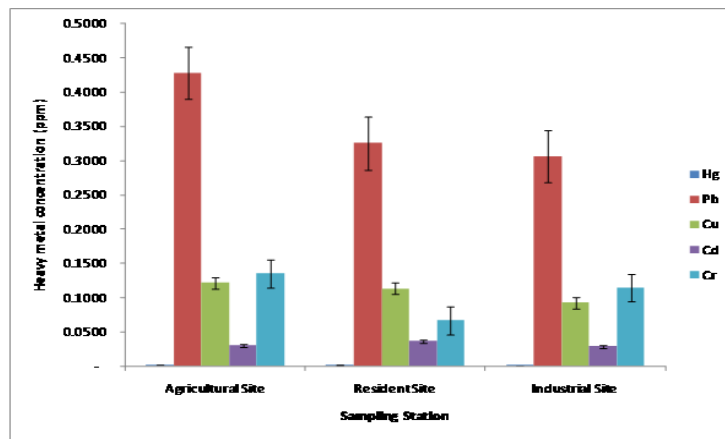


Figure 2. Heavy metal concentration in the water from three sampling stations(\pm SE, N=9)

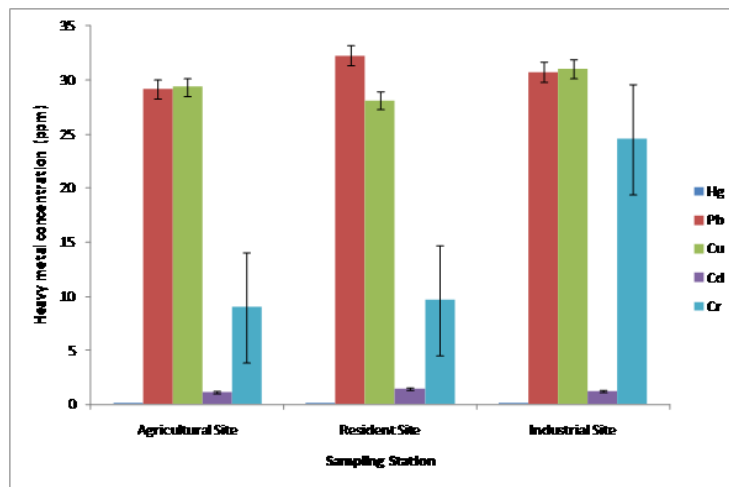


Figure 3. Heavy metal concentration in the sediment from three sampling stations (\pm SE, N=9)

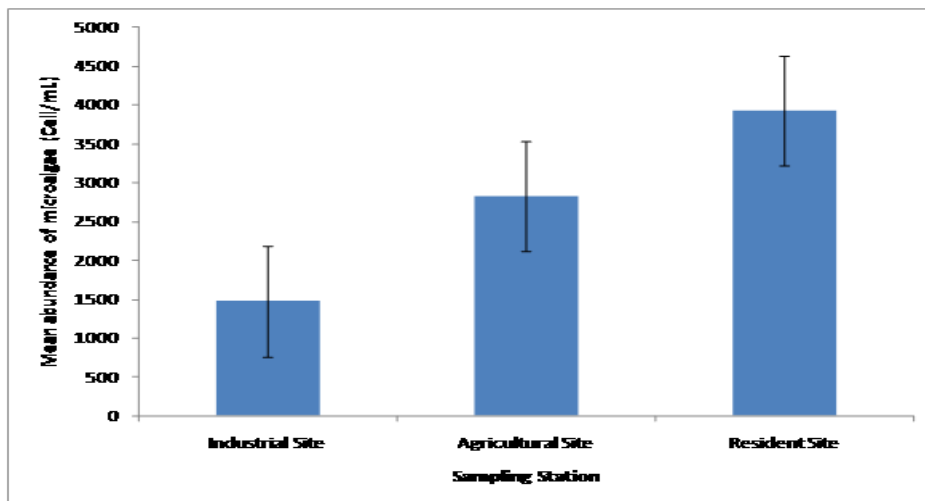


Figure 4. Abundance of microalgae from each sampling station (\pm SE, N=9)

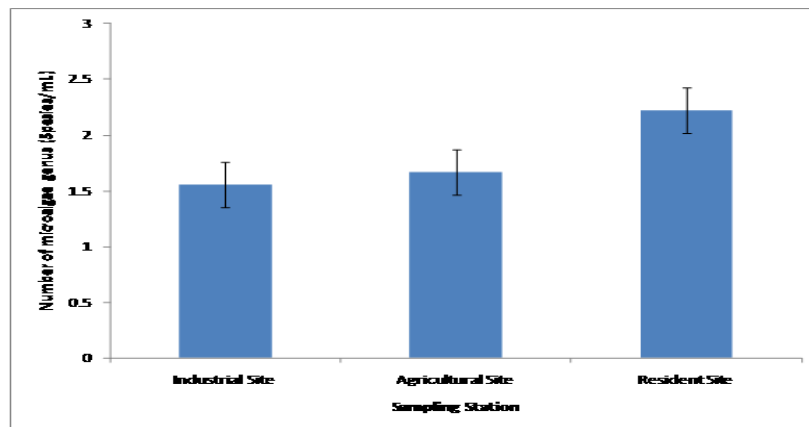


Figure 5. Number of microalgae species from each sampling station (\pm SE, N=9)

The average concentration of Copper (Cu) and Chromium (Cr) was relatively similar in each station either in the water or in the sediment. The highest concentration of Cu and Cr at the sediment found in the industrial area of the river, with the average of concentration account for 31.05 kg/L and 24.55 kg/L, respectively. Statistical analysis indicated that there was a significant difference of all type of heavy metal between concentrations in the water and in the sediment and concentration of heavy metal was higher in the sediment than in the water (Table 2). This result supported by Sekhar et al (2003) who found that sediment functioned as a sink for heavy metal that was enter to the water either from natural or from anthropogenic source. The distribution five types of heavy metal in the water and in the sediment in all sampling stations were relatively even. Only concentration of Pb and Cr in the sediment showed a significant difference between sampling stations. Whereas for others heavy metal were not differ significantly (Table 3). Concentration of heavy metal in the water that has been above maximum permissible concentration of environment quality standard which were Cr, Pb and Cd, whereas concentration of heavy metal in the sediment that has exceed maximum concentration of environment quality standard was Cd.

Abundant and dominant of microalgae

Microalgae abundant from Tallo River varied in every station. The highest microalgae abundance found in the resident area of the river, with the average of abundance was 3928 cell/L. Whereas the lowest abundance of microalgae was found in the industrial area of the river (Figure 4). Statistically, the result indicated that there was a significant difference ($P < 0.01$) microalgae number of genus between sampling stations (Table 3). Microalgae number of genus in the Tallo River was very low, there was only 4 genus of microalgae that was found from all stations (Figure 5). Low number of microalgae genus indicated that condition of the river was less support to growth of microalgae due to the pollution.

The correlation between type of heavy metal concentration and the dominant of microalgae

Regression an analysis indicated that between three types of heavy metal (Pb, Cu and Cr) and abundance and dominant of micro algae has strong correlation for several pairs of regression with the value of $R^2 > 0.5$. Others pair of regression have R^2 value < 0.5 (Table 5). This result indicated that the correlation between concentration three types of heavy metals in the sediment and water and abundance and dominant of micro algae were slightly weak and statistically was not differ significantly. The research found that heavy metal concentration of Pb and Cr in the water have strong correlation with Nitzschia sp with the R^2 value were 0.548 and 0.975, respectively. Skeletonema sp have a strong correlation with Pb and Cu with the value of R^2 was 0.906 and 0.908 respectively. This finding indicated that this species the most affected and responded by three type of heavy metal mentioned above. This condition could be explained possibly due to Skeletonema costatum has a great tolerant to the condition of the water which have been polluted by heavy metal. This finding supported by previous research which was found that Skeletonema costatum was very abundance at Jakarta Bay when the water had high concentration of heavy metal.

Strong correlation between particular species of microalgae showed that some of microalgae (eg. *Skeletonema costatum* and *Nitzschia* sp) have a capability to bind with heavy metal. Our finding supported by Chojnacka (2007) who found that heavy metal was effectively fasten metal ions in the water. They also found that blue green algae *Spirulina* sp was a microalgae that was a good as biosorbent from some metal ions like Cr (III), Cd (II) and Cu (II) from solution media.

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