Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 22 | No. 2 | pp. 835-843 | 2023

Original Research Paper

https://doi.org/10.46488/NEPT.2023.v22i02.025

Open Access Journal

# Types and Distribution of Macroinvertebrates Stressed by Heavy Metals in Mangrove Forests

**W. Budijastuti*†, R. Ambarwati*, N. Ducha*, F. Rachmadiarti*, L. Lisdiana* and K. Sahani***
*Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Ketintang street, Gayungan, Surabaya 60231, East Java, Indonesia
† Corresponding author: Widowati Budijastuti; widowatibudijastuti@unesa.ac.id

**Nat. Env. & Poll. Tech.**
**Website: www.neptjournal.com**

*Received:* 20-09-2022
*Revised:* 03-11-2022
*Accepted:* 11-11-2022

**Key Words:**
Macroinvertebrates
Heavy metals
Principal Component Analysis
Mangrove forests

## ABSTRACT

Heavy metals can decrease the number of species in nature. This research aims to determine the relationship between the type of macroinvertebrates stressed by heavy metals in the Wonorejo Mangrove Area, Surabaya, East Java. This type of research is observational. The determination of stations was done using the purposive random sampling method. Tests for Pb and Cd content were carried out using the AAS method. Nutrient content testing was carried out using the AAS and Kjeldahl methods. Data analysis was presented descriptively, and multivariate analysis was done using Principal Component Analysis (PCA). Based on the present research, it can be concluded that there are variations in the type and distribution of macroinvertebrates stressed by heavy metals in the mangrove area of Surabaya. Station 1 is dominated by *Ocypode ryderi*, Station 2 by *Assiminea* sp., Station 3 by *Scylla paramamosain*, and Station 4 by *Cerithidea* sp. with the high presence of metals (Cd, Pb), and soil and water nutrients (Org-C, N) at Stations 1, 3, and 4. The Station 2 has only Pb. *Assiminea* sp. (Phylum Mollusca) can be the best candidate for metal bioindicators because it appears in all locations where soil and water have been contaminated with Pb and Cd metals without affecting their life.

## INTRODUCTION

A mangrove forest area is an ecosystem located in a transitional area between land and ocean ecosystems that hold various important roles for life (Riry et al. 2020). In Surabaya, namely on the East Coast of Surabaya (Pamurbaya), there is a Wonorejo Mangrove Forest Area located in the eastern part of Surabaya City and directly adjacent to the Madura Strait. This area belongs to the estuary area, the estuary of various rivers in Surabaya, such as the Jagir River (DAS Brantas) and the Avour channel (artificial river), which flows from Rungkut District to the Madura Strait. These rivers are known to pass through industrial areas, so they have the potential to carry heavy metals to the Wonorejo Mangrove Forest Area (Wijaya & Sanjaya 2021).

Heavy metals are metallic elements with a density greater than 5 $g.cm^{-3}$, such as Pb and Cd (Syachroni 2017). Pb has a shiny grayish color, atomic number 82, an atomic weight of 207.20, and a melting point of 1740$^{o}$C (Mauriza et al. 2020). Cd has an atomic number of 48, an atomic weight of 112.40, and a melting point of 321ºC. In seawater, Cd is in the form of $CdCl_2$, while in freshwater $CdCO_3$ and brackish water (river estuaries), the amount of both is balanced (Fatmawati Nur 2013). Based on previous research showed that silvofishery pond water in the Wonorejo Mangrove Area in July 2018 contained Pb of 0.022 ppm and Cd of 0.087 ppm (Wijaya et al. 2019a) than in June 2019 found Pb of 0.304 ppm, and Cd of 0.047 ppm (Wijaya et al. 2019b) and in December 2021, found Pb of 0.045 ppm, and Cd of 0.005 ppm (Wijaya & Sanjaya 2021).

Heavy metal pollution can harm the environment because it is not decomposed, can accumulate in sediments and the water column, and is absorbed in living tissue. High concentrations of heavy metals can interfere with metabolic processes and morphological changes and cause the death of biota (Sari et al. 2017). The research conducted by Budijastuti (2016) shows that the presence of heavy metals Pb and Cr can affect the morphometric structure, including length, weight, body diameter, and the size of the male and female genital holes in earthworms through Principal Component Analysis (PCA) analysis.

Macroinvertebrates are a group of animals without a backbone, with a body size of more than 1 mm (Diantari et al. 2017), equipped with good adaptability in polluted environments. In the mangrove ecosystem, macroinvertebrates are important; they can help reduce water pollutants, become food for other biota, and be a bioindicator of water quality

(Riry et al. 2020). Two phyla belonging to macroinvertebrates, such as Arthropoda and Molluscs, are known to have the ability as metal bioindicators. Phylum Arthropoda can be an environmental cleaner and bioindicator of metal pollution because of its ability to accumulate Pb, Cd, and Zn (Rohyani & Farista 2013). In addition, Mollusc phyla, especially Gastropods, can be used as bioindicators of pollution because they have a wide tolerance level for water and can accumulate heavy metals (Wulansari & Kuntjoro 2018).

Information about the types of macroinvertebrates that are stressed by heavy metals in Indonesia, especially in the Wonorejo Mangrove Area, and their relationship with heavy metals is not yet known, so this study was conducted to analyze the relationship between the types of invertebrates that were stressed by heavy metals in the Wonorejo Mangrove Area.

## MATERIALS AND METHODS

### Study Area and Collection of Samples

This type of research is observational. The research was conducted in August 2021 in the Wonorejo Mangrove Area, Surabaya, at four stations (Fig. 1). determination of stations is done using the purposive random sampling method. Station 1 is located on the riverside jogging track at coordinates 7°18’26.9”S 112°49’31”E, station 2 is located in a riverside mangrove at coordinates 7°18’32”S 112°49’59”E, station 3 is located in the estuary at coordinates 7°18’25”S 112°49’35”E, station 4 is located in the pond at coordinates 7°18’32”S 112°49’42”E.

Macroinvertebrates were collected using the hand-collecting method and by digging to a depth of 5 cm for macroinvertebrates in the substrate. Samples were documented and sorted, and each species was counted at the Taxonomy Laboratory of the Department of Biology, FMIPA, Universitas Negeri Surabaya.

Soil and water samples were taken from each station to analyze the content of heavy metals Pb and Cd, nutrient contents of organic C and N, and some environmental parameters. The heavy metal content of Pb and Cd was analyzed at the Chemistry Laboratory, FMIPA, State University of Surabaya, using the Atomic Absorption Spectrophotometer method. The organic C and N nutrient contents were analyzed at the Faculty of Public Health, Airlangga University. The analysis of the nutrient content of organic C used the Atomic Absorption Spectrophotometer method, while the analysis of the nutrient content of N used the Kjeldahl method. Environmental parameter measurements were carried out in situ, including soil moisture and soil pH using a soil tester, soil temperature using a soil thermometer, air temperature using a thermometer, $CO_2$ using a $CO_2$ meter, light intensity using a lux meter, and salinity using a refractometer.

### Testing of Heavy Metals of Pb and Cd

Testing the content of heavy metals Pb and Cd in soil and water samples in the Wonorejo Mangrove Area, Surabaya was divided into 3 stages: sample preparation, calibration curve making, and sample analysis using Atomic Absorption Spectrophotometer (AAS) at a wavelength of 217.0 nm. The formula used to determine the metal content of Pb is as follows:

a. Soil

Metal levels (mg.kg$^{-1}$) $= \frac{Creg \times P \; x \; V}{G}$

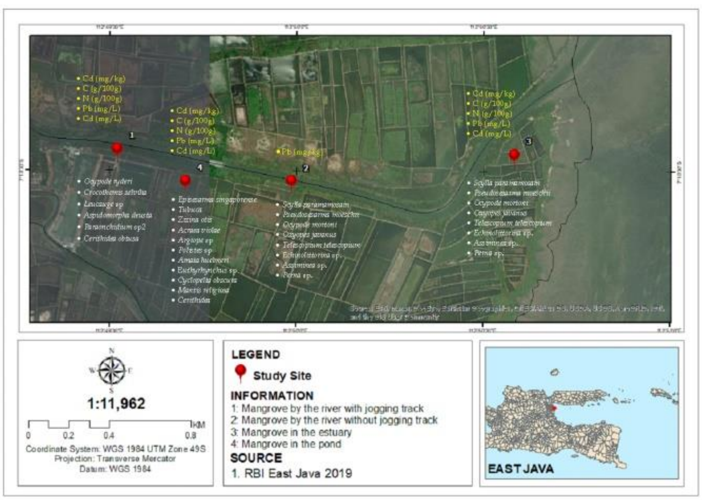



Fig. 1: Sampling location.

b. Sea water

Metal levels $(mg.L^{-1}) = \frac{Creg \times P \times V1}{V2}$

Where:

Creg = Read concentration $(mg.L^{-1})$

P = Dilution factor

G = Sample weight (kg)

V1 = Measured sample volume (L)

V2 = Volume of the dissolved sample (L)

V = Volume of sample solution (L)

## Testing the Nutrient Contents of Organic C and N

### *Testing the Nutrient Contents of Organic C*

Testing the nutrient organic C content in soil samples was divided into 3 stages: sample preparation, calibration curve creation, and sample analysis using the Atomic Absorption Spectrophotometer (AAS) method at a wavelength of 561 nm. The formula for calculating organic C content is as follows:

$$\text{C-organic (\%)} = \frac{(abs\ sample\ value - blanko) \times vol\ sample\ volume}{sample\ weigh} \times 10^{-4}$$

### *Testing the Nutrient Contents of N*

Testing for total nitrogen content was made using the Kjeldahl method. First, sample preparation was carried out, then the solution obtained was titrated until pink. The titration volume of the sample (Vs) and the blank (Vb) was recorded and calculated using the following formula:

$$\text{N-total (\%)} = \frac{(Va - Vb) \times N\ H2SO4 \times atom\ nitrogen\ weigh}{sa\ mple\ weigh\ (mg)} \times 100\%$$

## Data Analysis

Data analysis was presented descriptively and multivariate analysis was done using Principal Component Analysis (PCA).

# RESULTS

## Types of Macroinvertebrates in the Wonorejo Mangrove Area

Based on the results of the research, it was found that 214 macroinvertebrates consisted of 2 Phyla, 6 Classes, 23 Families, and 34 species (Table 1).

Based on the results of PCA analysis related to the correlation of distribution of macroinvertebrates at each station based on Phylum, Class, Family, and species centered on 2 main axes with an eigenvalue of more than 1 with a total variance of 61.698%. At Station 1, macroinvertebrates by phylum were dominated by Arthropods but also small amounts of Mollusca (Fig. 2A); by class (Fig. 2B) dominated by Crustacea, Insecta, Arachnida, Gastropod; by Family (Fig. 2C) dominated by Ocypodidae, Libellulidae, Chrysomelidae, Onchidiidae, and Potamididae; and by species (Fig. 2D) dominated by *Ocypode ryderi, Crocothemis selvilia, Leucauge* sp, *Aspidomorpha deusta, Paraonchidium* sp., and *Cerithidea obtusa* with the largest distribution in *Ocypode ryderi* Species (Table 1).

At Station 2 and Station 3, based on the phylum (Fig. 2A), the composition of macroinvertebrates is almost the same between Arthropoda and Mollusca; based on class (Fig. 2B), dominated by Crustacea, Arachnida, Gastropod, and Bivalves; by Family (Fig. 2C) dominated by Portunidae, Sesarmidae, Ocypodidae, Oxyopidae, Potamididae, Littorinidae, Assimineidae, and Mytilidae; and by species (Fig. 2D) dominated by *Scylla paramamosain, Pseudosesarma moeschii, Ocypode mortoni, Oxyopes javanus, Telescopium telescopium, Echinolittorina* sp., *Assiminea* sp., and *Perna* sp. At Station 2, the distribution of *Assiminea* sp. was found the most, while at Station 3, *Scylla paramamosain* species were found the most (Table 1).

At Station 4, based on the species (Fig. 2A), the macroinvertebrates were dominated by Arthropods; based on class (Fig. 2B), dominated by Crustacea, Arachnida, Insecta, and Gastropod; by Family (Fig. 2C) dominated by Sesarmidae, Ocypodidae, Lycanidae, Nymphalidae, Araneidae, Vespidae, Erebidae, Pentatomoidae, Dinidoridae, Mantidae, Potamididae, and by species (Fig. 2D) dominated by *Episesarma singaporense, Tubuca, Zizina otis, Acraea violae, Argiope* sp, *Polistes* sp, *Amata huebneri, Euthyrhynchus* sp, *Cyclopelta obscura, Mantis religiosa,* and *Cerithidea.* At this station, the distribution of *Cerithidea* sp. was found the most (Table 1).

## Measurement of Metals and Nutrient in Water and Soil of Wonorejo Mangrove Area

Based on the results of PCA analysis (Fig. 3), it can be seen that there is a negative correlation between levels of organic $C(g.100g^{-1})$ and $Cd(mg.kg^{-1})$, $N(g.100g^{-1})$ and $Cd(mg.kg^{-1})$, $Cd(mg.L^{-1})$ and $Pb(mg.kg^{-1})$ and positive correlation between organic $C(g.100g^{-1})$ and $N(g.100g^{-1})$

In Fig. 3C, it can be seen that Stations 1, 3, and 4 have strong characteristics of mangrove soil and water metals and nutrients, namely Cd $(mg.kg^{-1})$, organic C $(g.100g^{-1})$, N $(g.100g^{-1})$, Pb $(mg.L^{-1})$, Cd $(m.L^{-1})$ while at Station 2 the prominent feature of metal and nutrients in mangrove soil and water is Pb $(mg.kg^{-1})$.

## Measurement of Ecological Environment in Wonorejo Mangrove Area

Based on the results of PCA analysis (Fig. 4), it can be seen that there is a negative correlation between ecological parameters, namely soil pH and soil moisture, air temperature and air humidity, $CO_2$ and air humidity, light intensity and air humidity, soil salinity and pH, and salinity and air humidity. While the correlation is positive between air temperature and soil temperature, $CO_2$ and air temperature, light intensity and soil pH, light intensity and soil temperature, light intensity and air temperature, light intensity and $CO_2$, and salinity and air temperature.

In Fig. 4C, Station 1 has strong environmental ecology characteristics, including soil pH and salinity. Station 2 has prominent environmental and ecological characteristics: soil temperature, air humidity, air temperature, $CO_2$, light

Table 1: Types of Macroinvertebrates in the Wonorejo Mangrove Area.

| Phylum | Class | Family | Species | Station | | | | Σ |
|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | |
| Arthropoda | Crustacea | Grapsidae | *Metopograpsus frontalis* | 1 | 1 | | | 2 |
| | | Portunidae | *Scylla paramamosain* | | 2 | 3 | | 5 |
| | | Sesarmidae | *Pseudosesarma moeschii* | | 1 | 1 | 2 | 4 |
| | | | *Episesarma singaporense* | 5 | 2 | 5 | | 12 |
| | | Camptandriidae | *Ilyogynnis microcherium* | 1 | 1 | | | 2 |
| | | Ocypodidae | *Tubuca Bellator* | 6 | 8 | 2 | | 16 |
| | | | *Ocypode mortoni* | | | 2 | | 2 |
| | | | *Tubuca rosea* | 5 | 7 | 1 | | 13 |
| | | | *Tubuca coarctata* | 3 | 3 | 1 | | 7 |
| | | | *Ocypode ryderi* | 12 | 1 | | | 13 |
| | | | *Austruca triangularis* | 3 | 3 | | | 6 |
| | Arachnida | Araneidae | *Argiope sp* | 1 | 2 | | 2 | 5 |
| | | | *Leucauge sp* | | 2 | | 1 | 3 |
| | | Oxyopidae | *Oxyopes javanus* | | | 2 | | 2 |
| | Insecta | Lycaenidae | *Zizina Otis* | 4 | | | 5 | 9 |
| | | Nymphalidae | *Acraea violae* | 2 | | | 6 | 8 |
| | | Libellulidae | *Crocothemis selvilia* | 5 | | | 4 | 9 |
| | | Chrysomelidae | *Aspidomorpha deusta* | | 2 | | 1 | 3 |
| | | Apidae | *Apis sp* | 1 | 2 | | 1 | 4 |
| | | Vespidae | *Polistes sp* | | 1 | | 1 | 2 |
| | | Erebidae | *Amata huebneri* | | | | 1 | 1 |
| | | Pentatomoidae | *Euthyrhynchus sp* | | 1 | | 2 | 3 |
| | | Dinidoridae | *Cyclopelta obscura* | | 1 | | 2 | 3 |
| | | Mantidae | *Mantis religiosa* | 2 | 2 | | 2 | 6 |
| Mollusca | Gastropoda | Ellobiidae | *Ellobium sp1* | 4 | | | | 4 |
| | | | *Ellobium sp2* | 4 | | | | 4 |
| | | Onchidiidae | *Paraonchidium sp1* | 1 | | | | 1 |
| | | | *Paraonchidium sp2* | 5 | | | | 5 |
| | | Potamididae | *Telescopium* | 4 | 3 | | | 7 |
| | | | *Cerithidea obtuse* | | 5 | | | 5 |
| | | | *Cerithidea sp* | | | | 10 | 10 |
| | | Littorinidae | *Echinolittorina sp.* | | | 1 | | 1 |
| | | Assimineidae | *Assiminea sp.* | 3 | 32 | | | 35 |
| | Bivalvia | Mytilidae | *Perna sp* | | | 2 | | 2 |
| | | | Σ | 72 | 82 | 20 | 40 | 214 |

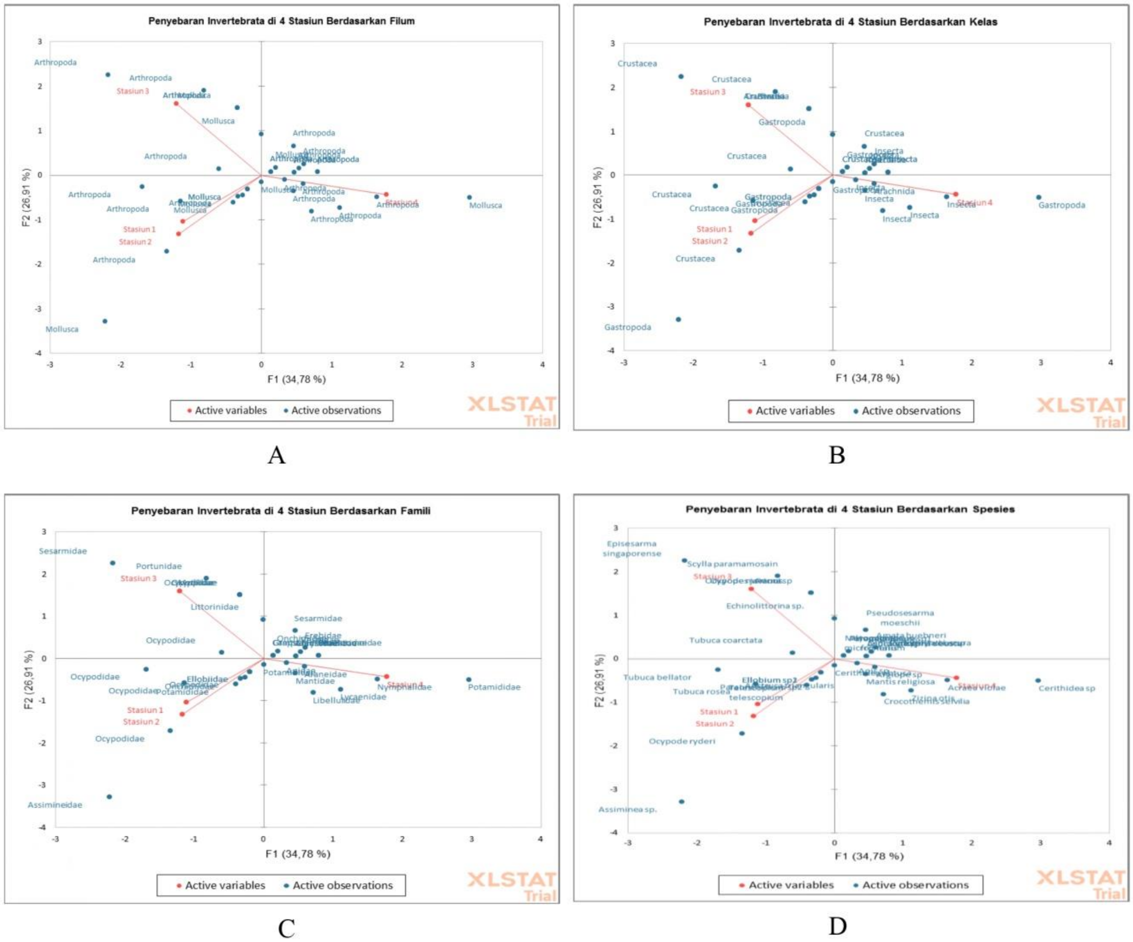



Fig. 2: Distribution of macroinvertebrates at 4 stations in the Wonorejo Mangrove Area based on: A. Phylum, B. Class, C. Family, D. Species.

Table 2: Average Metal and Nutrient Test Results in Water and Soil of Wonorejo Mangrove Area.

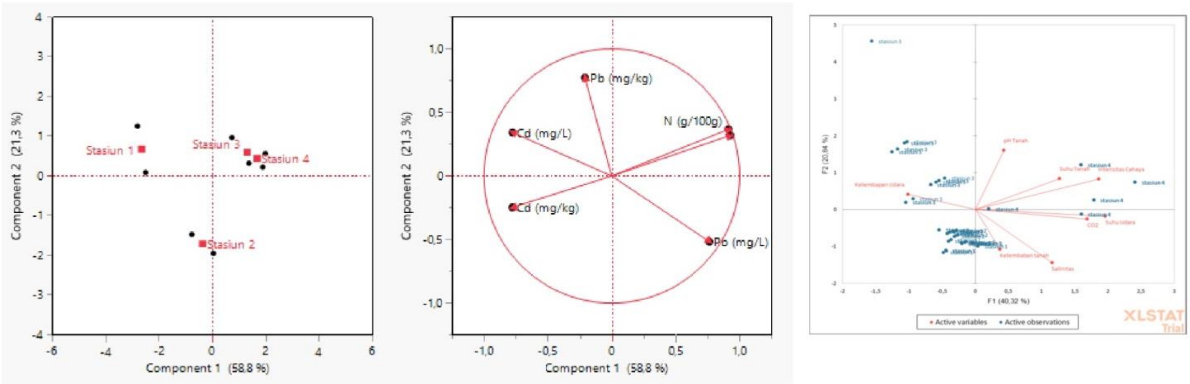
| Station | Test Result of Soil Metal | | Test Result of Nutrient | | Test Result of Water Metal | |
|---|---|---|---|---|---|---|
| | Pb [mg.kg$^{-1}$] | Cd [mg.kg$^{-1}$] | Org-C [g.100g$^{-1}$] | N [g.100g$^{-1}$] | Pb [mg.L$^{-1}$] | Cd [mg.L$^{-1}$] |
| 1 | 0.402±0.0169 | 0.220±0.0045 | 0.942±0.0979 | 0.071±0.0046 | 0.028±0.0056 | 0.008±0.0010 |
| 2 | 0.288±0.0298 | 0.194±0.0057 | 1,243±0.0766 | 0.080±0.0025 | 0.055±0.0133 | 0.005±0.0012 |
| 3 | 0.333±0.0059 | 0.109±0.0043 | 2,045±0.0787 | 0.116±0.0053 | 0.048±0,0137 | 0.006±0,0006 |
| 4 | 0.387±0.0129 | 0.170±0.0022 | 2.002±0.0299 | 0.129±0.0089 | 0.058±0.0025 | 0.003±0.0013 |

Note: Station 1 jogging track by the river; Station 2 riverside macroves; Station 3 estuary; Station 4 pond

Table 3: Average Ecological Data on Wonorejo Mangrove Area.

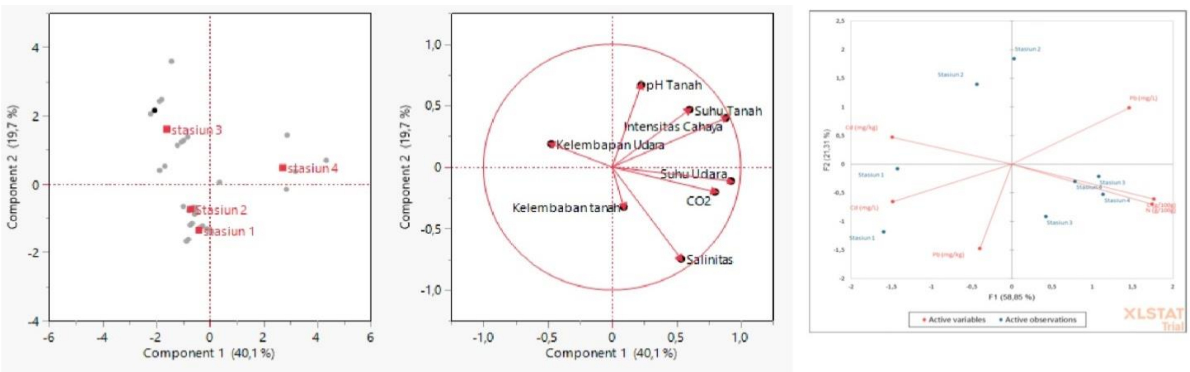
| Station | Soil Moisture [%RH] | Soil pH | Soil Temperature [°C] | Air Humidity [%] | Air Temperature [°C] | $CO_2$ [ppm] | Light Intensity (Lux) | Salinity [‰] |
|---|---|---|---|---|---|---|---|---|
| 1 | 10 | 7 | 27,8 | 82% | 31.15 | 472,2 | 310 | 10 |
| 2 | 10 | 7 | 29 | 75% | 30 | 414 | 345 | 10 |
| 3 | 10 | 7,2 | 29 | 83% | 29.6 | 413 | 617 | 27 |
| 4 | 10 | 7,2 | 30,2 | 78% | 33 | 494 | 1800 | 10 |

Note: Station 1 jogging track by the river; Station 2 riverside macroves; Station 3 estuary; Station 4 pond




A B C

Fig. 3: PCA Graph of distribution of research station points based on metal and nutrient properties of soil and water mangrove: A. Projection of observation station points on the main component; B. Distribution of metal and nutrient soil and water mangrove properties in the main components; C. Classification of observation stations based on metal and nutrient properties of mangrove soil and water.




A B C

Fig. 4: PCA Graph distribution of research station points based on environmental ecological characteristics: A. Projection of observation station points on the main component; B. Distribution of environmental ecological characteristics in the main components; C. Observation station point classification based on environmental ecological characteristics.

intensity, soil pH, and salinity. Station 3 has environmental ecological characteristics such as soil pH, temperature, air temperature, $CO_2$, light intensity, and salinity. Meanwhile, Station 4 has environmental and ecological characteristics of soil temperature, air temperature, $CO_2$, light intensity, and air humidity.

## DISCUSSION

The Wonorejo mangrove forest area in Surabaya is a wetland area dominated by mangrove forests and traditional ponds with high diversity potential (Akhadah et al. 2019). This area is not only managed for Mangrove Ecotourism, silvofishery ponds, and traditional ponds (Wijaya & Sanjaya 2021) but is also a spawning location, nursery, and a place for foraging, spawning, rearing, and sheltering for several species of macroinvertebrates.

Based on the study results, Station 1 was dominated by macroinvertebrates of the species *Ocypode ryderi, Crocothemis selvilia, Leucauge* sp, *Aspidomorpha deusta, Paraonchidium* sp2, and *Cerithidea obtuse* with the largest distribution in the species *Ocypode ryderi*. *Ocypode ryderi,* or Ghost Crab, is a nocturnal biota commonly found in tropical and subtropical regions. It has a carapace size ranging from 2.375-2.4 cm and lives by making burrows in the sand. These ghost crabs live in the highest tide areas, and when the sea water is high, they can control the water that enters their burrows (Elfandi et al. 2018).

The existence of this crab population is strongly influenced by the condition of the beach, which is its habitat. Unspoiled beaches usually have ghost crabs because the food chain process is still maintained. Polluted beaches will rarely find ghost crabs (Elfandi et al. 2018). The negative effects caused by exposure to heavy metals in animals are in the form of: disturbances in the rate of feeding, respiration, reproduction processes, morphological abnormalities, behavior, and functions of body organs, which will ultimately have an impact on the distribution of a species (Marbun et al. 2013).

Based on the results of the study, at the location where this species was found (Station 1), it has strong characteristics of Metals and Soil Nutrients and Mangrove Water, namely Cd ($mg.kg^{-1}$), organic C ($g.100g^{-1}$), N ($g.100g^{-1}$), Pb ($mg.L^{-1}$), Cd ($mg.L^{-1}$). However, the presence of these heavy metals did not affect the distribution of Ghost Crab (*Ocypode ryderi*) because the number was still abundant at this station, so it can be seen that this species can adapt to heavy metal stress and can be a bioindicator. This aligns with Stelling Wood's (2016) statement that Ghost Crab is widely used as an ecological indicator for the environment.

Based on the results of PCA analysis, Station 1 has strong environmental ecology characteristics, including soil pH and salinity, which are negatively correlated. This means that the higher the soil pH, the lower the salinity. The degree of acidity (pH) is a limiting factor that can affect the survival of macroinvertebrates if it is too acidic or alkaline. At this station, the soil pH value is 7 and is classified as a neutral pH suitable for macroinvertebrate life, including mollusks and arthropods. This is in accordance with Fatmala et al. (2017) statement that ground surface arthropods can live well and must be in a neutral pH range between 6-8 (Fatmala et al. 2017). In addition, this station has a salinity value of 10‰ which is considered good and in line with the statement of Riry et al. (2020) that the salinity level of mangrove waters is (0.5-35 ppt) so that it can support the survival of macroinvertebrates.

Stations 2 and 3 are dominated by the same species, namely *Scylla paramamosain, Pseudosesarma moeschii, Ocypode mortoni, Oxyopes javanus, Telescopium telescopium, Echinolittorina* sp., *Assiminea* sp., and *Perna* sp. However, Station 2 has the largest distribution of *Assiminea* sp. while Station 3 is *Scylla paramamosain. Assiminea* sp has the characteristics of a short upper shell with a blunt end of the shell, a round bottom, reddish body color, with a body size ranging from 0.5 cm (Achsan 2019). This species belongs to the mollusk phylum, which can be used as a bioindicator of the condition of the mangrove ecosystem (Sani et al. 2020). This is in accordance with the results of the study that the distribution of *Assiminea* sp was not affected by the presence of heavy metals in station 2, which was known at this station to have strong Metal and Nutrient characteristics of Soil and Mangrove Water, namely Pb ($mg.kg^{-1}$).

*Scylla paramamosain,* or the mud crab, has a brown carapace characteristic. The outer chela is orange. There are six sharp spines on the frontal margin, one spine is not sharp on the carpus and two blunt spines on the right side of the chela. Mangrove crabs have a wide distribution area and can tolerate and adapt strongly to mangrove forests (Gita,2016). Mangrove crabs can be a bioindicator because mangrove crabs have habitats in shallow coastal areas with mud substrate (Susilo et al. 2017). Based on research conducted by Noviani et al. (2020), mangrove crabs can accumulate Pb metal of m 0-0.053 $mg.kg^{-1}$, so they have the potential to become metal pollution bioindicators. This is in accordance with the results of the study that the distribution of Scylla paramamosain at station 3 has the highest value even though, based on heavy metal testing, this station has strong Metal and Nutrient characteristics of Soil and Mangrove Water, including Cd ($mg.kg^{-1}$), organic C ($g.100g^{-1}$), N ($g.100g^{-1}$), Pb ($mg.L^{-1}$), Cd ($mg.L^{-1}$) but the presence of these metals did not affect the population of *Scylla paramamosain*.

Based on PCA analysis, it is known that stations 2 and 3 almost have similarities in the dominant environmental and ecological characteristics, including soil temperature, air humidity, air temperature, $CO_2$, light intensity, soil pH, and salinity. However, the characteristic of air humidity is only at station 2. This station's air humidity value is quite high, namely 75%RH. Fatmala et al. (2017) state that high humidity is better for soil animals than low humidity. However, ground surface arthropods may die or migrate to other places in very high humidity conditions. Low humidity will stimulate soil surface arthropods to move to a place with optimum humidity, thus allowing the formation of groups. In addition, air humidity has a negative correlation with air temperature and $CO_2$. The lower the temperature and $CO_2$, the higher the humidity, and vice versa. This is because low temperatures result in higher water activity in the air, so air humidity becomes high.

Station 4 is dominated by macroinvertebrates from *Episesarma singaporense, Tubuca, Zizina otis, Acraea violae, Argiope* sp, *Polistes* sp, *Amata huebneri, Euthyrhynchus* sp, *Cyclopelta obscura*, *Mantis religiosa*, and *Cerithidea* with the distribution of species *Cerithidea* sp. found to be more abundant than other species. *Cerithidea* sp. has a habitat in the tropics with moderately warm temperatures (28-30 ºC), in shallow waters, and lives on the bottom of muddy substrates and estuarine environments. Based on research by Wahyudi et al. (2015), *Cerithidea* sp. can accumulate Pb of 1,900 ± 0.393 ppm and has the potential as a bioaccumulator and bioindicator. This is in accordance with the results of the study at the location where this species was found (Station 4) has strong characteristics of Metals and Soil Nutrients and Mangrove Water, namely Cd ($mg.kg^{-1}$), organic C ($g.100g^{-1}$), N ($g.100g^{-1}$), Pb ($mg.L^{-1}$), Cd ($mg.L^{-1}$). *Cerithidea* sp. will accumulate these metals along with the entry of food;

however, the presence of these heavy metals does not affect the distribution of *Cerithidea* sp. because their numbers are still abundant at this station and other stations; it can be seen that these species can adapt to heavy metal stress and can be a bioindicator of metal pollution.

Based on the research results, Station 4 has dominant environmental and ecological characteristics: soil temperature, air temperature, $CO_2$, light intensity, and humidity. All these characteristics, except humidity, are positively correlated with each other. This means that the higher the soil temperature, the higher the air temperature, and vice versa. The higher the $CO_2$, the higher the air temperature, and vice versa. The higher the light intensity, the higher the soil temperature, and vice versa. The higher the light intensity, the higher the air temperature, and vice versa., the higher the light intensity, the higher the $CO_2$, and vice versa.

Soil temperature can affect the sustainability of ecosystems. Soil animal life is also determined by soil temperature. Extremely high or low temperatures can kill ground animals. Soil temperature generally also affects soil animals' growth, reproduction, and metabolism. Each type of soil animal has an optimum temperature range. This activity is very limited at temperatures below 10ºC. The optimum beneficial soil biota activity rate occurs at 18-30ºC (Husamah et al. 2017). In addition, according to Burhanuddin et al. (2019), the temperature range of 26-31 ºC is still within the tolerance limit of macroinvertebrate life. This is in accordance with the study's results that the average values of soil and air temperatures at the location were 29 ºC and 30.9 ºC, which is still quite good for biota.

This study's average carbon dioxide or $CO_2$ value was 448.3 ppm, which is still considered good and permissible. This is in accordance with the statement of Kurniawan (2019) the permissible $CO_2$ threshold value according to OSHA is 500 ppm. $CO_2$ does not cause harmful health effects if it is at a concentration above 550 ppm but if it is above 800 ppm, $CO_2$ can indicate a lack of fresh air.

The population of soil macrofauna will decrease with the increasing intensity of incoming light. The intensity of sunlight the ecosystem receives is a critical determinant of primary productivity, which can affect species diversity and nutrient cycles. The high and low intensity of sunlight is influenced by the density of the canopy and the location of the angle of incidence of sunlight. The higher the canopy density of a protective plant and the denser (density and large/wide) canopy, the lower the intensity of sunlight that can enter the soil surface (Qomariyah et al. 2021). This study's average light intensity value is 768Lux which is still classified as a good light intensity.

Based on this research, it can be seen that from all stations, *Assiminea* sp. (phylum mollusca) can be the best candidate for metal bioindicator because of its appearance in all locations where soil and water have been contaminated with Pb and Cd metals without affecting their life. This is in accordance with Maretta et al. (2019) that mollusks can be used as bioindicators of heavy metals because of their slow mobility, the tendency to settle, and feeding methods that filter suspensions, making them easy to adapt and accept any environmental changes that occur.

## CONCLUSION

Based on this research, it can conclude that there are variations in the type and distribution of macroinvertebrates stressed by Pb and Cd in the Mangrove Area of Surabaya. Station 1 is dominated by *Ocypode ryderi*, station 2 *Assiminea* sp., station 3 *Scylla paramamosain*, and Station 4 *Cerithidea* sp. with the characteristics of Metals and Soil and Water Nutrients at stations 1, 3, and 4, namely Cd ($mg.kg^{-1}$), organic C ($g.100g^{-1}$), N ($g.100g^{-1}$), Pb ($mg.L^{-1}$), Cd ($mg.L^{-1}$) while Station 2 only Pb ($mg.kg^{-1}$). *Assiminea* sp. (phylum Mollusca) can be the best metal bioindicator candidate because of its appearance in all locations where soil and water have been contaminated with Pb and Cd metals without affecting their life.

## ACKNOWLEDGEMENT

Thank you to the head of the university and faculty from Universitas Negeri Surabaya for the financial support.

## REFERENCES

Achsan, N. 2019. Study of Macrobenthos Community Structure and Environmental Quality in the Mangrove Ecosystems of Sidoarjo Mud Island, East Java. Dissertation. Universitas Islam Negeri Sunan Ampel Surabaya

Akhadah, N., Sanora, G.D., Nurlaili, R.A. and Ambarwati, R. 2019. Diversity and abundance of birds in the mangrove area of Wonorejo Surabaya. Biol. Nat. Sem., 9: 237-242.

Budijastuti, W. 2016. Candidate Types of Earthworms Potentially as Bioindicators of Heavy Metals Pb and Cr Based on Abundance, Morphometric Structure, and Cysteine Content. Retrieved from http://lib.unair.ac.id (Accessed on 23 July 2022).

Burhanuddin, I.I., Setyobudiarso, H and Sudiro. 2019. Study of Macroinvertebrate Biomonitors and Lake Sentani Water Quality Status, Jayapura Regency. Proceedings of the National Seminar on Sustainable Infrastructure in the Industrial Revolution Era 4.0, Malang. 55-64. [Indonesian]

Diantari, N.P.R., Ahyadi, H., Rohyani, I.S. and Suana, I.W. 2017. Diversity of Ephemeroptera, Plecoptera, and Trichoptera insects as bioindicators of water quality in the Jangkok River, West Nusa Tenggara. J. Entomol., Indo., 14(3): 135-142.

Elfandi, T., Adi, W. and Syari, I.A. 2018. The density of ghost crabs (Ocypode) at Batu Bedaun Beach and Air Anyir Beach of Bangka. Akuatik J. Sumb. Pera., 12(1): 10-17.

Fatmala, L., Kamal, S. and Agustina, E. 2017. Diversity of soil surface arthropods under pine (*Pinus merkusii*) vegetation stands Tahura Pocut Meurah Intan. Proceed. Nat. Bio. Sem., 63: 2115

Gita, R.S.D. 2016. Mangrove crab diversity (*Scylla* spp.) in Alas Purwo national park. J. Biol. Pemb. Biol., 1(2): 146-161.

Husamah, R., Sisti, A. and Hudha, A.M. 2017. Soil Animal Ecology (Theory and Practice). Penerbit Universitas Muhammadiyah, Malang.

Kurniawan, A. 2019. Basics of Environmental Quality Analysis. Wineka Media, Malang.

Marbun, L.R. and Widyorini, N. 2013. Diversity and abundance of macrozoobenthos substrates in based metal lead (Pb) in the coast of Jakarta bay. Journal of Management of Aquatic Resources. 2(2): 54-59.

Maretta, L., Widiani, G.N. and Septiana, N.I. 2019. Mollusc diversity on the White Sand Beach, South Lampung. Biotropika: J. Trop. Biol., 7(3): 87-94.

Mauriza, R., Ashari, M. and Yahya, H. 2020. Test the effectiveness of the shells of gold conch (*Pomacea canaliculata* L.) as a biosorbent in absorbing metal lead (Pb). J. Phi Pend. Fisik. Terap., 1(3): 25-32.

Noviani, E., Sulistiono, K. and Samosir, A.M. 2020. Heavy metal (Pb, Hg) extent in mud crab (*Scylla serrata*) in Cengkok Coastal Waters, Banten Bay, Indonesia. Omni-Akuatika, 16(2): 108-115.

Nur, Fatmawati 2013. Cadmium (Cd) heavy metal phytoremediation. Biogenesis, 1(1): 74-83.

Qomariyah, N., Nugroho, A.S. and Hayat, M.S. 2021. Soil macrofauna in horticultural land, Losari Village, Sumowono District, Semarang Regency. Quagga: J. Pend. Biol., 13(1): 68-73.

Riry, K.Z, Prihatmo, G. and Kisworo, M. 2020 Macroinvertebrate Diversity in the Mangrove Ecosystem in Lempong Pucung Hamlet, Kampung Laut District, Cilacap Regency. Proceedings of the National Biology Seminar in the Gowa COVID-19 Pandemic Era, 19 September 2020. [Indonesian]

Rohyani, I.S and Farista, B. 2013. The diversity of soil arthropods at Kerandangan protected forest and natural park in West Lombok. J. Biol. Trop., 13(1): 39-44.

Sani, L.H., Candri, D.A., Ahyadi, H. and Farista, B. 2020. Mollusk community structure in natural mangrove areas and south coastal rehabilitation of Lombok Island. J. Trop. Biol., 20(1): 139-147.

Sari, S.H.J., Kirana, J.F.A. and Guntur. 2017. Analysis of dissolved heavy metals Hg and Cu in Wonorejo Coastal Waters, East Coast of Surabaya. J. Pend. Geogr., 22(1): 1-9.

Stelling Wood T. 2016. Responses of Ghost Crabs and Other Scavengers to Habitat Modification Of Urban Sandy Beaches. Thesis. Master of Philosophy at The University of New South Wales School of Biological, Earth and Environmental Sciences. Sydney.

Susilo, A., Setyawati, T.R. and Yanti, A.H. 2017. Morphometry of mangrove crab (*Scylla* spp.) in the Mutusan River Estuary mangrove forest area, Sambas Regency. Protobiont, 6(1): 53-58.

Syachroni, S.H. 2017. Analysis of cadmium (Cd) heavy metal content in rice fields in Palembang City. SYLVA, 6(1): 23-29

Wahyudi, R.A., Purnomo, T. and Ambarwati. R. 2015. The level of leads (Pb) and population density of *Cerithidea* sp. on the southern shores of Bangkalan Madura, East Java. LenteraBio, 4(3): 174-179.

Wijaya, N.I, Sanjaya, R. and Nuhman. 2019a. Influence of Waters in Silvofishery Ponds on Wonorejo Mangroves That Contaminated by Heavy Metals Pb, Cd, and Cu toward Aquaculture Animals. Proceedings of the 7th– International Seminar on Ocean and Coastal Engineering, Environmental and Natural Disaster Management (ISOCEEN). December 2019, pp. 207-211.

Wijaya, N.I. and Sanjaya, R.F. 2021. Mangrove density on Pb, Cu, and Cd metal content in milkfish meat (*Chanos chanos*) at Mangrove Wonorejo, Surabaya. J. Pert.Terp., 9(2): 150-161.

Wijaya, N.I., Trisyani, N. and Sulestiani, A. 2019b. Potential development of mangrove crab silvofishery cultivation (*Scylla serrata*) in the Wonorejo Mangrove Area, Surabaya. J. Forest Res. Nature Conserv., 16(2): 173-189.

Wulansari, D.F. and Kuntjoro, S. 2018. Gastropod diversity and its role as bioindicator of heavy metal lead (Pb) at Kenjeran Beach, Bulak District, Surabaya City. LenteraBio, 7(3): 241-247.