Diversity and abundance of polychaetes in the west coast waters of Batam Island, Kepulauan Riau Province-Indonesia

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Abstract. The existence of benthic organisms describes the environmental conditions of a habitat, and Polychaeta sea worms have widely been used as a representative biomonitor. This study, therefore, aims to see the correlation of environmental parameters, limited to salinity, dissolved oxygen (DO), and the level of heavy metals cadmium (Cd), copper (Cu), and lead (Pb) in both water and sediment, with the presence of Polychaeta in six locations with different potential pollutants along the western waters of Batam Island. The calculation for diversity (H'), dominance (D), and evenness (E') indexes was performed to measure the regularity level of the Polychaeta worm in the ecosystem, while Principal Component Analysis (PCA) was used to examine the relationship between environmental parameters (salinity, DO, and the level of heavy metals and the presence of Polychaeta in each station. A total of twenty-eight species and 147 individuals were dominated by *Nereis* sp, *Arabella protomutans*, *Notomastus hemipodus*, and *Eulalia viridis*, and then all observation stations (except station 5) showed their diversity at the moderate category level, while station 5 exhibited very strong environmental stress, and very low species abundance. Cumulatively, the western waters of Batam Island possess moderate to severe polluted environmental status, and an association was identified between the environmental parameters of Cu, Pb in water, and Cd, Cu, Pb in sediment, as well as salinity towards the presence and abundance of Polychaeta in the waters west of Batam Island. However, there was no correlation with DO, as the six stations studied exhibited a high level of similarity, indicating a connection in the source of contamination.
Key Words: Polychaeta, diversity, abundance, heavy metal.

Introduction. Many researchers have used polychaetes to evaluate the level of marine contaminants. For example, *Tharyx marioni* was previously reported as an extraordinary arsenic accumulator(Gibbs et al 1983), *Nereis diversicolor* binds to cadmium (Cd), zinc (Zn), and copper (Cu) (Bryan & Hummerstone 1971; Nejmeddine et al 1988), while *Australonereis ehlersi* and *Nephtys australiensis* are insensitive to Cu and dissolved Zn, based on the fact that they are sediment-bound (King et al 2004). The response of *Nereis* (Polychaeta, Nereididae) to the effects of pollution in the Authie estuary (uncontaminated sites) and estuary Seine areas (contaminated sites) was reported by Gillet et al (2008), and other studies reveal the metal concentration in *N. diversicolor* worm tissue and sediments from two Atlantic coastal lagoons: Oualidia in the north, located in very industrial urban areas, and characterized by the relatively high level of Zn, Ag, and Cd, while Khnifiss in the south is situated far from anthropogenic influences, with high Ni concentration (Idardare et al 2008). A study aimed at connecting several biomarkers of pollution with chemical sources like metals and organic pollutants, including PCBs, PAHs in *N. diversicolor* (Polychaeta) and *Scrobicularia plana* (Bivalvia) species, showed a different response in two sediment-producing organisms. These include the polychaete sediment eaters and water filtration shells, which are probably the consequence of varying contamination exposures (Solé et al 2009). In addition, *Perinereis gualpensis* (Nereididae) was tested as a parameter of oxidative stress, including antioxidant levels of glutathione (GSH), glutamate cysteine ligase (GCL) and glutathione-S-transferase (GST), and the total capacity, as well as protein oxidation (Díaz-Jaramillo et al 2010).

The existence of benthic organisms describes the environmental habitat conditions, and Polychaeta sea worms are the dominant species in sediments widely used as bio-monitors, which are a better representative of the waters' sedimentary compartments (Dean 2008; Bouraoui et al 2014). This activity has exposed the most endobenthic species to pollutants, characterized by the ability to serve as the main reservoir for some chemicals (Durou et al 2007), hence polychaetes display enormous morphological diversity, where different behaviors produce varying forms (Eklöf 2010). These were also adopted as bioassay organisms, monitors for toxic substances, and as indicators of pollution at various levels, while their use in monitoring the quality of a marine environment has particular value, due to direct contact with the water column and sediment environment. This incidence occurred as a result of the direct contact, and the sensitivity demonstrated towards anthropogenic compounds (Pocklington & Wells 1992). Meanwhile, biological characteristics and geochemistry play an essential role in the incidence of metal and element accumulation in benthic invertebrates, which is affected by the ecological and morphological characteristics (Kalantzi et al 2014). This tends to influence the subsequent transfer of metals to higher trophic levels, due to the varied effectiveness of collecting the benthic metal biota, according to an animals' ecological and metabolic needs, as well as the contamination gradients in water, food, sediments and other factors, including salinity and temperature (Eggleton & Thomas 2004).

Batam Island as one of the busiest areas in Indonesia is very sensitive to contamination, which ensues primarily from the mainland and sea. The coasts are known to have received waste discharges from two sources, which include land and sea, as well as anthropogenic and natural sources, as there is an increase in surrounding activities by industry shipyard and transportation, leading to impacts on the level of heavy metals. Also, willful human actions also facilitate the process in the marine environment, and the presence of Cd, Cu, Pb, Ni, and Zn in higher amounts contributes more by anthropogenic factors over the natural sources (Potters 2013). Garno (2001) recorded a rise in the trend level of Cd, Cu, and Pb in the marine environment, as well as in sediment from the western waters of Batam Island. Previous report further confirmed their concentration in water and angel fish (*Chelmon rostratus*) (Ismarti et al 2017a), as well as Cu and Pb in seagrasses *Enhalus acoroides* (Ismarti et al 2017b) on the west coast. In addition, the level of Cu and Pb in the study region exceeded environmental quality standards for biota set by the Indonesian Ministry of Environment.

However, there is limited study on the use of locally sourced polychaetes as a biomonitor for environment quality. This study, therefore, aims to identify their diversity and abundance, and then to observe the linkage between environmental parameters, with restriction to salinity, dissolved oxygen (DO), and the level of heavy metals, encompassing Cd, Cu, and Pb in water and sediment to the presence of Polychaeta biota in six locations with different pollution potentials along the western waters of Batam Island. This is the first study reported for waters at the regional level of the Riau Islands Province, increasing the research value in considerations regarding the management of water pollution related to heavy metals.

Material and Method

Sampling and sampling site. Samples (sediment and seawater) are collected from six locations, including station 1 (S1) - Tanjung Pinggir, S2 - Sekupang, S3 - Tanjung Riau, S4 - Marina Beach, S5 - Tanjung Uncang, and S6 - Sagulung. These are zones that are intertidal and coastal along the waters west of Batam Island in May 2016 (Figure 1), and each is known for high human activity and the potential to contribute towards pollutants from different sources and intensities.

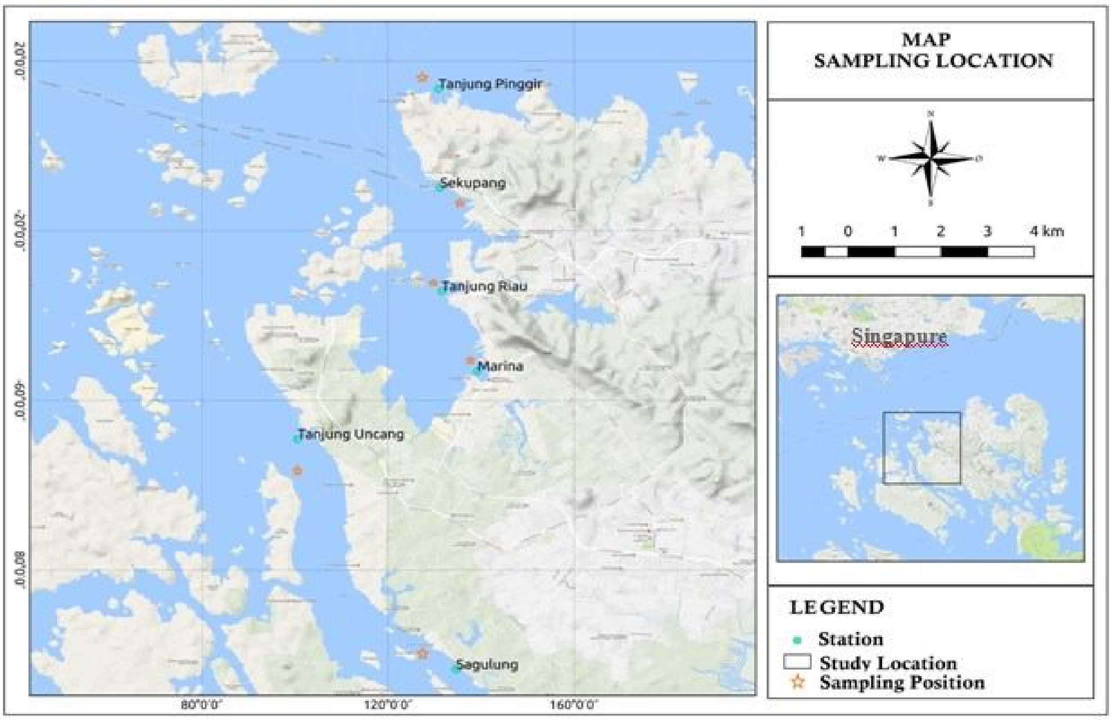

Figure 1. Sampling stations in the western waters of Batam Island, Kepulauan Riau Province, Indonesia.

Location characteristics. Tanjung Pinggir station possesses relatively few human activities because it is quite far from residential areas, as it has mangrove forests on some parts of the coast. Sekupang station is a location characterized by sea transportation activities, being one of the largest domestic ports in Batam, while Tanjung Riau has residential areas, shipyards, and ports. This station is assumed to be the most densely populated area, while Marina is a known tourist site with a number of hotels, ports and recreation spots, and there is also a small amount of mangrove vegetation around the beach that is purposely set for beautification purposes. Furthermore, Tanjung Uncang is used as a shipyard, which is currently the largest in Batam, and this characteristic is also highly expressed in Sagulung, alongside the flow of ships for docking purposes.

Sampling and analysis of sediment and water samples. Water samples were collected at a depth of 2-2.5 m below the surface, using the Van Dorn horizontal water sampler into polyethylene bottles, for further laboratory analysis. These were acidified with nitric acid up to pH 2, and then filtered with Whatman No. 42 filter paper. In addition, the sediment samples were collected at a depth ranging between 2 and 3 m from each location, using a grab sampler, and three replicates were collected and placed in a cooler, which was then transported to the laboratory. During heavy metal analysis, the sediment samples were oven-dried at 80^{o}C and sieved through a 1 mm mesh, and then about 5 g was weighed and mixed with 50 mL of demineralized water in an Erlenmeyer flask, and further decomposed by nitric acid. Sample preparation was based on the Indonesian National Standard (SNI 6989.16: 2009 for Cd, SNI 6989.6:2009 for Cu and SNI 6989.8:2009 for Pb), while the determination was performed using an atomic absorption spectrometer (Shimadzu A7000), as mention in Ismarti et al (2017a).

Sampling analysis of polychaetes samples. The sediment samples were taken three times at each station by purposive sampling, using the Eckman Grab, placed in a plastic bag and labelled. In addition, 10% formaldehyde solution and Rose Bengal dye solution 0.025% were used to preserve the specimen, which was then packed in a cool box and taken to the laboratory for handling, where each is sieved in a stratified filter with 250 mm; 0.500 mm; and 1.00 mm eye. The smaller Polychaeta worm species were sorted under a binocular microscope and collected based on the station of origin in a sample bottle containing 75% ethanol, and identification required the use of a taxonomic key. This was conducted up to the species level, in accordance with the identification books (Fauchald 1977; Knight-Jones & Knight-Jones 1977; Bakken 2004).

Data analysis. The data obtained were examined descriptively to observe the results of parameters measured, and samples tested in the laboratory. This was attained by comparing the quality standards, based on the Ministry of the Environment Decree No. 51 of 2004, on Quality Standard of Sea Water for biota. The content of Cd, Cu, and Pb in sediments makes reference to the USEPA standard (Baharom & Ishak 2015).

Diversity (H'), dominance (D) and evenness (E') indexes of Polychaeta sea worms were calculated based on the Shannon-Wiener's quantitative ecological values (Ludwig & Reynolds 1988). This analysis aims to measure the level of regularity and not ecosystem regularity (balance and not ecosystem balance), and the diversity index criteria were H' < 1: low diversity, and extreme environmental pressure, 1 < H' ≤3: moderate diversity and moderate environmental pressure, H' > 3: high diversity, ecosystem balance. Conversely the range of E' values between 0 and 1 describes a situation where all Polychaeta worm species are abundant (Odum 1971).

Multivariate analysis was used to analyze the relationship between environmental chemical parameters and species diversity in the western waters of Batam Island. Furthermore, Principal Component Analysis (PCA) method was used to examine the relationship between salinity, DO, and the level of heavy metals (Cd, Cu, and Pb) in water, as well as the Polychaeta content of the sediments at each station. This approach was also adopted by Rozirwan et al (2014) while examining the relationship between the biophysical-chemical parameters of water and the percentage of live coral cover.

Results. The accumulation and toxicity of metals from sediment and water related to organisms are affected by some biological (biotic) and physicochemical parameters, including DO, temperature, pH, hardness, salinity and organic components (Chapman et al 1998). This study illustrates the relationship between the presence of Polychaeta and environmental factors, particularly (1) salinity, with values that tend to increase from station 1 to 6, with a 30-35 ppm gradient, and the highest was identified at station 6, while the lowest was at 1, with 30.3 ppm; (2) DO ranging from 6.47 to 7.26 mg L^{-1}, with 6.47 mg L^{-1}, and 7.26 mg L^{-1} as the highest and lowest, identified at station 6 and 4, respectively; (3) level of heavy metal and sediments (Table 1).

Table 1

Chemical parameters of waters and sediment at each station

Variable	*Unit*	*Station (S)*					
		1	*2*	*3*	*4*	*5*	*6*
Salinity	ppm	30.33±0.577	33.67±0.58	34.33±0.58	34.33±0.58	34.67±0.58	35±0
Dissolved oxygen	mg L^{-1}	6.83±0.461	7.20±0.348	6.99±0.194	7.26±0.687	6.973±0.555	6.47±0.857
Cu in water	mg L^{-1}	0.040±0.005	0.003±0.026	0.045±0.012	0.013±0.022	nd	0.013±0.011
Cd in water	mg L^{-1}	nd	nd	nd	nd	nd	nd
Pb in water	mg L^{-1}	0.030±0.001	0.0363±0.002	0.040±0.001	0.044±0	0.044±0.001	0.043±0.001
Cu in sediment	mg kg^{-1}	0.505±0.219	29.05±6.463	15.775±0.163	13.93±0.580	1.23±0.976	8.775±9.694
Cd in sediment	mg kg^{-1}	0.305±0.191	0.12±0	0.15±0.028	0.195±0.007	0.37±0.156	0.265±0.078
Pb in sediment	mg kg^{-1}	5.385±0.926	15.305±0.049	13.145±0.304	14.24±0.113	9.32±0.579	20.34±1.923

nd = not detected.

Seawater quality standards for marine biota issued by the environmental authorities, based on Indonesia Ministry of Environment Decree No. 51 of 2004 for salinity were not mentioned. In the range of normal environmental conditions, salinity is known to vary at any time (day, night and season), with changes that are often < 5%. Meanwhile the standard quality of DO indicates values that are possibly greater than 5 mg L^{-1}, and based on the Decree, both parameters are within the threshold range.

Previous researchers in experimental studies reported on the influence of salinity on Polychaeta, while the long-term effects of Cd at different concentrations (0.2 and 0.4 ppm) and the level of salinity (30, 25, and 20 ‰) on egg growth and production from *Ophryotrocha labronica* have been observed for three generations. In addition, low salinity and the presence of Cd produces moderate growth rate, lengthened time to reach sexual maturity, and a reduced size at maturity (Roed 1980). Subsequent studies reported on the effect of salinity and temperature on the growth and survival of *Marenzelleria viridis* (Polychaeta, Spionidae) planktonic larvae, and the results showed the ability for all stages of development to tolerate salinity < 1 ‰ (Bochert et al 1996). Next, the effect of salinity on fertilization and development of *Nereis virens* (Polychaeta, Nereidae) larvae obtained from the White Sea showed successful development in the range of trochophore and nectochaete, reaching 14-45x. This elevation in limits of tolerance may be due to the formation of a protonephridium system (Ushakova & Sarantchova 2004).

This study revealed the inability to detect Cu in seawater from station 5, which was present in sediments from all sampling locations, with the highest level in station 2. In addition, Cd was not detected in seawater, but present in all sampling location sediments, where the highest was obtained in station 5, while the Pb element was identified in water and sediment from all locations. The highest level of Pb in sediment obtained for station 6 while for water the highest level obtained for station 4 and 5, with the value of 0.044 mg L^{-1}. With reference to the Ministry of Environment regulation of the Republic of Indonesia No. 51, 2004 concerning Water Quality Standards, the level of Cu in seawater in this study shows that Tanjung Pinggir, Sekupang, Tanjung Riau, and Marina stations have exceeded the standard limit (0.008 mg L^{-1}). Similarly, the Cu and Pb levels in seawater from all sampling locations have also surpassed the specification (0.008 mg L^{-1}).

In this study, a total of 147 individual polychaetes, encompassing 28 species and 22 families were collected in six sediment stations along the western waters of Batam Island. Furthermore, their presence illustrates different environmental conditions (Table 2), as the abundance level in each location respectively include 14 species and 28 individuals in S1, 10 species and 37 individuals in S2, 14 species and 37 individuals in S3, 13 species and 32 individuals in S4, 2 species and 5 individuals in S5, 6 species and 8 individuals in S6.

The dominance of species in the calculation of the biotic index possibly explains the differences that occur as a result of variation in sensitivity levels (Labrune et al 2006). In addition, the most significant amount of *Nereis* species was characterized by 34 individuals, followed by *Arabella protomutans* species with 19, *Notomastus hemipodus* at 16, *Eulalia viridis* encompassing 14, and others present in small quantities (Table 2). These dominant species were identified in at least four stations, with *N. hemipodus* present in all, while *Nereis* and *A. protomutans* were in five locations except stations 6 and 4, respectively, and *E. viridis* was present in four, except stations 5 and 6.

The diversity index (H') at all observation stations (except station 5) was in the range of 1 < H' ≤3, which classifies the Polychaeta worms in the medium category, as well as the display of medium pressure. In contrast to station 5 of the H' diversity index < 1 (0.5), the presence of a very strong environment with the value of evenness (E') approaching 0, at 0.311 (where H_{max} = 1.609). This indicates a very low abundance of the studied species in the location. Therefore, it is realized that the western region of Batam Island has a diversity index (H') 2.710, dominance (D) 0.903, and evenness (E') 0.543, placing the environment in the category of moderate to severe contamination (Figure 2), depicting abundance in Polychaeta use down at the end station (S6).

Table 2

Diversity and abundance of Polychaeta sea worms from the western waters of Batam Island

Species	*Family*	*Station*						*Ind. (ni)*
		1	*2*	*3*	*4*	*5*	*6*	
		Number of species (ind.)						
Nereis sp.	Nereidae	9	10	2	9	4	-	34
Dendronereis pinnaticirris	Nereidae	-	-	-	4		1	5
Nereiphylla pusilla	Nereidae	-	1	-	-	-	1	2
Eulalia viridis	Phylodocidae	2	7	4	1	-	-	14
Typosyllis armillaris	Syllidae	-	-	6	2	-	-	8
Syllis gracillis	Syllidae	-	3	-	-	-	-	3
Goniada gigante	Goniadidae	-	1	1	1	-	-	3
Sphaerodoridium fauchaldi	Sphaerodoridae	-	1	1	-	-	-	2
Nephty shombergii	Nephtyidae	-	-	-	1	-	-	1
Paralacydonia sp.	Lacydoniidae	1	-	-	-	-	-	1
Glycera lapidum	Glyceridae	1	-	-	-	-	-	1
Glycera tesselata	Glyceridae	-	-	1	-	-	-	1
Chrysopetalum occidentale	Chrysopetilidae	2	-	-	2	-	-	4
Notomastus hemipodus	Capitellidae	2	5	5	1	1	2	16
Heteromastus filiformis	Capitellidae	2	-	2	-	-	-	4
Heteroclymene robusta	Maldanidae	1	-	4	-	-	-	5
Owenia collaris	Oweniidae	2	1	-	-	-	-	3
Arabella protomutans	Arabelidae	1	7	5	4	-	2	19
Ctenodrilus serratus	Ctenodrilidae	2	1	1	2	-	1	7
Archinome rosacea	Euphrosinidae	-	-	-	1	-	-	1
Boguella ornate	Bogueidae	-	-	-	-	-	1	1
Terebellides stroemi	Tricobranchidae	-	-	2	-	-	-	2
Ophelia rathkei	Opheliidae	1	-	2	-	-	-	3
Ophelia borealis	Opheliidae	-	-	-	1	-	-	1
Pherusa inflate	Flabelligeridae	-	-	-	3	-	-	3
Poecilochaetus johnsoni	Poecilodhaetidae	-	-	1	-	-	-	1
Laonice bahusiensis	Spionidae	1	-	-	-	-	-	1
Scoloplos armiger	Orbiniidae	1	-	-	-	-	-	1
Number (N)		28	37	37	32	5	8	147
Diversity (H')		2.329	1.946	2.436	2.268	0.500	1.733	2.710
Dominance (D)		0.997	0.850	0.923	0.891	0.400	0.929	0.903
Evenness (E')		0.699	0.539	0.675	0.654	0.311	0.833	0.543

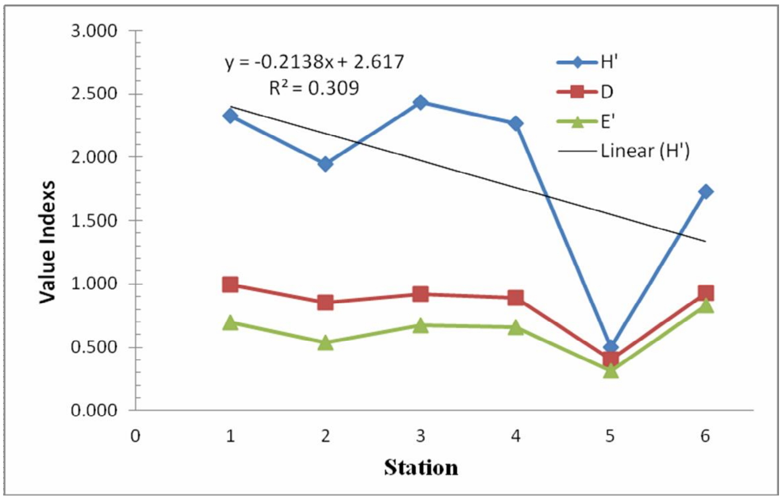

Figure 2. Diversity (H'), dominance (D), and evenness (E') indexes.

The limitations of using polychaetes as an environmentally friendly quality monitor are basically information on the natural feedback on other environmental parameters (Pocklington & Wells 1992). In addition, the result of Principal Component Analysis (PCA) shows the relationship between chemical parameters on diversity and the abundance of Polychaeta, which is explained from the main money (F1 and F2), with the cumulative characteristic root of 81.26%. A total of three groups are formed in the biplot, where F1 are positive and negative, and the third is seen on the positive F2 axis (Figure 3a).

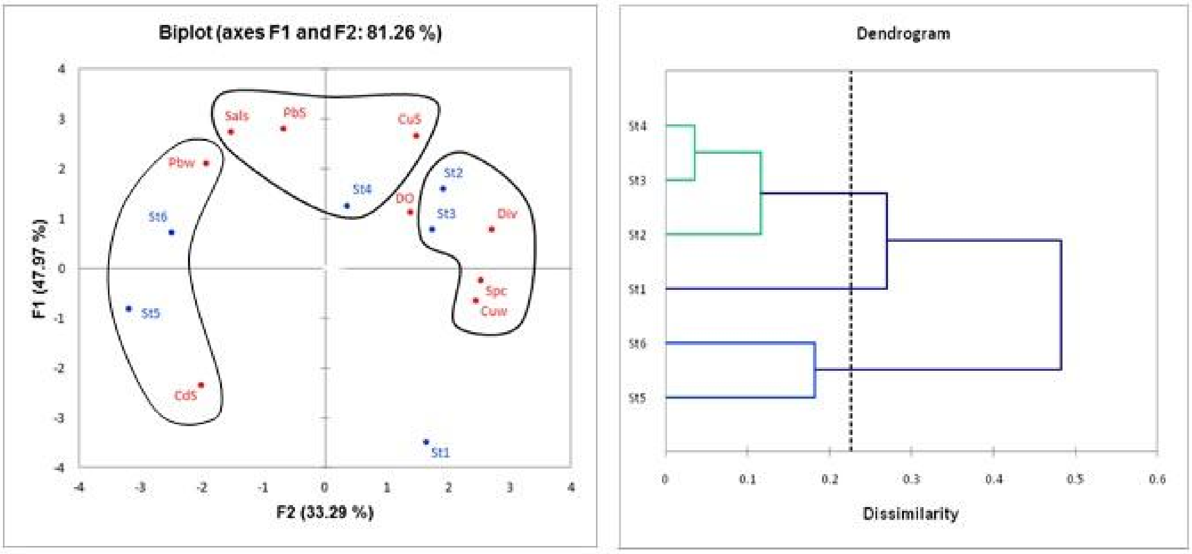

Figure 3. (a.) The Principal Component Analysis (PCA) analysis of water's chemical parameters on the diversity and abundance of Polychaeta. (b.) Dendrogram of dissimilarity between stations based on the type and abundance of Polychaeta

The first group formed on the positive F1 axis provides an overview at stations 2 and 3, with the identifiers of Cu concentration in water (S2 = 0.003 mg L^{-1} and S3 = 0.45 mg L^{-1}), where the type and abundance of Polychaeta is higher (N = 37), with diversity index of 1.946, and 2.436. The second group formed on the negative F1 axis indicates the characterization of stations 5 and 6 with Pb in water (S5 = 0.044 mg L^{-1} and S6 = 0.043 mg L^{-1}) and Cd in sediments (S5 = 0.37 mg L^{-1} and S6 = 0.265 mg L^{-1}), with low types and abundance of Polychaeta (N = 5 and 8) and a diversity index of 0.500 and 1.733. In addition, the third group was formed on the positive F2 axis, which showed the features of station 4, based on salinity (34.33 ppm), Cu (13.93 mg L^{-1}) and Pb (14.24 mg L^{-1}) in the sediment. The types of medium and abundance of Polychaeta were demonstrated with 2.268 of diversity index.

Fluctuations in heavy metal concentration measured in each location did not accurately describe the high and low abundance of Polychaeta worms. This phenomenon is assumed to have occurred because each specimen possesses different adaptability to type, concentration and length of time exposed to pollutants in the environment, which is in line with results of previous studies. In addition, high amount of Cd and Ag were identified in several species obtained from the Severn estuary, although there is no definite evidence confirming the incidence of deadly effects on the benthic populations. Conversely, experimental studies with Ag, Cd, Cr, Cu, Hg, and Zn demonstrated the toxicity of heavy metals to some species, which was at realistic levels in the environment. Based on the fact that pollutants rarely occur singly, as most estuaries contaminated with metals contribute to the pressure on organisms caused by substances that require detoxification (Bryan & Langston 1992). Furthermore, similar findings were also reported by Saha et al (2006) on four types of Polychaeta against heavy metals (Zn, Mn, Cu, Cr, Se, and Hg), demonstrating the variability as a reflection of different absorption levels, physiology and the impact of environmental factors.

Idardare et al (2008) reported the absence of significant correlation between total metal concentration in sediment and in the *N. diversicolor* worm. This low bioaccumulation is possibly associated with the organisms' capacity to control the incorporation of metals from contaminated deposits. Moreover, Cu and Zn have been identified as essential cofactors in some biochemical processes, while Cd, Hg, and Pb have no known biological function in animals, all of which are toxic at high concentrations (Ivanina & Sokolova 2015). Pesch & Hoffman (1982) reported the increased tolerance of *Nereis* (*Neanthes*) *arenaceodentata* to Cu prior to being exposed to sub lethal concentrations, although no elevation in tolerance was obtained at the initial treatment threshold. In addition, the net absorption rate was lower in worms with increased tolerance than otherwise. Said et al (2017) reported on the potential for polychaete worms (family Nereidae) to pile up and endure in the presence of some heavy metals, including Mn, Pb, Cd, and Cu. This concentration determined for individuals inhabited by the two study sites confirmed the accumulating potential of *Nereis succinea* in the surrounding habitats.

Conversely, histopathological investigations clarified the relationship between the granular depositions of heavy metals in tissues of *N. succinea* to the level of heavy metal load from one place to another. Also, it is important to not ignore the influence of natural factors, comprising of food availability on the worm conditions (Durou et al 2007). Recent research reveals the ability for other factors, including variations in pH, redox potential, ageing, nutrition and behavior of benthic organisms in the sediments to greatly alter mobility and metal distribution (Zhang et al 2014).

The results of dissimilarity analysis were calculated based on the Bray-Curti dissimilarity index, obtained between the characteristics of aquatic chemical parameters and the type as well as the percentage of Polychaeta abundance in the western waters of Batam Island, showing significant similarity with the very strong category. Based on the dendrogram (Figure 3b) of the six observation stations, the three classes obtained showed similarity levels reaching 84.86%. In addition, the highest values are shown in stations 4, 3 and 2, which form the first class at 88%, followed by 6 and 5, at about 82%, and then station 1 demonstrated the closest similarity to class 1 at 74%.

These results show the existence of a high level of similarity across all research stations, which indicate similarity in the source of contaminants. In real terms, the western waters of Batam Island are generally dominated by shipyards and groove of ships activities, despite the existence of other activities, including harbors, hotels and coastal communities, assumed to contribute more organic materials than heavy metals. This is due to the fact that an elevation in the biological components increases the dominance of certain Polychaeta types.

Dean (2008) stated the propensity for some polychaetes species to live in sediments with very high metal content, with presence that is often not a reflection of the sediments concentration, due to the regulation by species. In addition, numerous species appear relatively resistant to organic contaminants and pesticides, as well as the collective effects. Samuelson (2001) associated environmental disturbances resulting from human activities with polychaete communities, marked by their absence in zones that are closer to polluters. In addition, the disturbed zone is identified by an elevation in species diversity, which is due to organic enrichment, low diversity, and the increasing density of some opportunistic species. Cabrini et al (2017) reported on the importance of high spatial variations in metal concentrations measured during contamination assessment for better understanding, due to the established fact that the contamination source spreads along the coast. This study, therefore, strengthens the research by Idardare et al (2008), which stated the necessity to present a better characterization of the environment, with respect to the presence of metals.

Conclusions. A total of twenty-eight species and 147 individual Polychaeta were dominated by *Nereis* sp., *Arabella protomutans*, *Notomastus hemipodus*, and *Eulalia viridis*, and all observation stations showed diversity at the moderate category, except station 5, which demonstrated the presence of very strong environmental stress, and also significantly low abundance of species. In summary, the western waters of Batam Island possess moderate to severe environmental pollution status, and a linkage was observed between the parameters of Cu, Pb in water, as well as Cd, Cu, Pb in sediment, with salinity. This was further affiliated with the presence and abundance of Polychaeta, while dissolved oxygen showed no correlation. Furthermore, the six study stations demonstrated a high level of similarity, which indicates the same source of contamination.

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