RESEARCH ARTICLE | APRIL 21 2020

Contamination of shrimp pond waste: The impact on macrozoobenthos diversity FREE

Wahyu Prihanta; Facischa Ayu Irviandari; Elly Purwanti; Abdulkadir Rahardjanto; Fuad Jaya Miharja

AIP Conf. Proc. 2231, 040071 (2020)
https://doi.org/10.1063/5.0002617

Contamination of Shrimp Pond Waste: The Impact on Macrozoobenthos Diversity

Wahyu Prihanta[a], Facischa Ayu Irviandari[b], Elly Purwanti[c], Abdulkadir Rahardjanto[d], Fuad Jaya Miharja[e]

Department of Biology Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Malang, Malang, East Java, Indonesia

[a]wahyuprihanta@gmail.com
[b]facischaayu8@gmail.com
[c]ellypurwanti@ymail.com
[d]rahardjanto@gmail.com
[e]Corresponding author: fuad.jayamiharja@umm.ac.id

Abstract. Shrimp pond waste (*Litopenaeus vannamei*) is a waste metabolite that produces changes in the quality of the aquatic environment and affects the abundance and composition of macrozoobenthos. This study aims to determine the impact of shrimp pond waste inputs on macrozoobenthos diversity. This quantitative descriptive study] uses a purposive sampling technique. Sampling was carried out at five stations along with the Kali Jeruk river flow with three repetitions. Macrozoobenthos identification was carried out at the Fisheries Laboratory and water testing at Perum Jasa Tirta Malang. The diversity of macrozoobenthos was analyzed using PCA tests. The results showed that the parameters that had the most direct correlation with the variety of macrozoobenthos were DO. The results of the macrozoobenthos study found ten species consisting of three classes, seven families, and nine genera. The highest macrozoobenthos diversity value at station 5 was 2.10, and the lowest at station 2 was 0.99. Shrimp pond waste has a different effect on macrozoobenthos diversity in five stations.

INTRODUCTION

Waste management, including shrimp pond waste [1], is an interesting problem that has been widely studied by many researchers [2–4]. Types of contaminant waste and environmental sustainability are often discussed issues [5]. Waste contamination, such as water bodies [2], is indicated as one of the leading causes of changes in the chemical physics of the environment [5,6]. However, changes in chemical physics are very dependent on the characteristics of the waste and environmental carrying capacity so that the effects of pollution caused to differ from one case to another [7,8]. One of the attributes in question is the type of pollutant waste, the amount, and the distance to the river flow.

Shrimp pond in Panggung District – Trenggalek is located near the Kali Jeruk river flow. Observation results indicate that shrimp organic pond waste discharges enter the waters through several points. The site directly connects the shrimp pond area with the Kali Jeruk river. The direct entry of waste into water bodies, without prior treatment [9,10], has the potential to cause problems in aquatic ecosystems [7,11]. The indicated waste content can change the balance of the ecosystem [12–14].

The majority of shrimp farming waste comes from the body's metabolism [15]. The metabolite waste, such as feces or urine, is the result of the decomposition of organic material obtained from feed [16,17]. The nutritional component of feed, according to some researchers, such as protein, is a significant contributor to waste contamination in the aquatic environment [18,19]. Waste contamination that repeatedly occurs and beyond the limit has an impact on changes in the carrying capacity of the environment [20]. Changes in the carrying capacity of the environment are reported to have a significant impact on the life of aquatic organisms [21,22], one of which is macrozoobenthos [5].

International Conference on Life Sciences and Technology (ICoLiST)
AIP Conf. Proc. 2231, 040071-1–040071-6; https://doi.org/10.1063/5.0002617
Published by AIP Publishing. 978-0-7354-1990-2/$30.00

The nature of life that tends to settle at the bottom of waters and low mobility makes this organism vulnerable to environmental changes. Thus, these organisms are often used as bioindicators of water quality. Some researchers report that contamination of waste in aquatic bodies has an impact on the composition and abundance of macrozoobenthos species [23–25]. However, the extent of the correlation between changes in chemical physics and macrozoobenthos diversity has not been revealed. This study aims to show the impact of vanamei shrimp organic pond contamination on differences in chemical physics and macrozoobenthos diversity.

EXPERIMENTAL DETAILS

Macrozoobenthos and water samples were taken in the Kali Jeruk river – Trenggalek in April 2018 that shows in Fig. 1. Identification of macrozoobenthos in the Fisheries Laboratory of the Universitas Muhammadiyah Malang and water samples were tested at the laboratory of Perum Jasa Tirta – Malang. A sampling of macrozoobenthos was carried out at five different stations. The first station is located before shrimp pond waste disposal, the second station is situated in the shrimp pond waste disposal site, and the other stations (three) are located after shrimp pond waste disposal. Distance between sampling stations 500 m. Each research station consisted of three sampling points, which were carried out three times. Sampling was carried out 45 times in all observation stations. Sampling macrozoobenthos using a plot measuring 1×1 m^2, where the distance between plots is 1 m.

FIGURE 1. Research location in the Kali Jeruk River - Trenggalek

The data collection used in this study uses the method of observation. Data obtained by directly reviewing the location of research and using the assessment instrument sheet. The data collected in the form of macrozoobenthos types. Supporting data in the form of chemical physics parameters are total dissolved solids (TDS), total suspended solid (TSS), color, temperature, turbidity, salinity, pH, DO, and ammonia. The data obtained is processed by calculating the diversity index, evenness index, and dominance index. Diversity index/H' (Eq. 1) [26], evenness index/E (Eq. 2) [27], and dominance/C (Eq. 3) [27] are index studies that are often used to estimate the condition of an aquatic environment and community stability based on biological components.

$$H' = -\sum_{i=1}^{s} pi \ln pi \tag{1}$$

Description: H' (Shannon-wiener diversity index), Ni (number of individual species i), N = total importance value/total number of all individuals), Pi (chance for each type (ni/N)), S (number of species). Diversity index criteria, according to [28] consist of: high (H'>3), moderate (1<H'<3), and low (H'<1).

$$E = \frac{H'}{H_{\max}} = \frac{H'}{\ln S} \tag{2}$$

Description: E (evenness index), S (total number of species), H' (Shannon-Wiener diversity index), H' max = ln S (maximum diversity index of species s). The assumption evenness index consists of depressed (0<E<0.5), unstable (0.5<E<0.75), stable (0.75<E<1) [29].

$$C = \sum \left(Pi \right)^2 \tag{3}$$

Description: C (dominance index), Pi (n/N): n (number of individuals throughout the species), N (the number of individuals of each species).

All data collected were analyzed by principal component analysis (PCA) using SPSS software for windows. This analysis is used to determine the correlation between physical factors and watersports with the diversity of macrozoobenthos, which are found in addition to decide what parameters most contribute to the level of diversity.

RESULT AND DISCUSSION

The respond ability to environmental changes is one of the determinants of whether macrozoobenthos can survive or not. The ecological changes consist of several interrelated indicators. The physical and chemical parameters measured in this study are described in Table 1.

TABLE 1. Results of chemical physics parameter analysis

Parameter	Station 1	Station 2	Station 3	Station 4	Station 5
TDS (mg/L)	101,200	20,100	29,180	14,200	7,680
TSS (mg/L)	34.7	36.7	27.1	24.6	15.1
DO (mg/L)	9.9	4.8	20.1	18.4	17.8
Turbidity (cm)	40	20	40	35	35
Color (Pt.co)	0.55	0.34	0.45	<0.30	<0.30
Temperature (°C)	29.2	29.3	28.5	28.3	26.2
Salinity (‰)	10	10	7	6	4
pH	7.5	6.8	7.4	7.2	7.3
Ammonia (mg/L)	0.42	0.50	0.52	0.06	0.03

Total dissolved solid (TDS) at the five stations shows vast range differences. The difference between the highest TDS at station 1 and the lowest at station 5 was 93,520 mg/L. High TDS at station 1 is indicated not to have been contaminated with vaname shrimp organic pond material because station 1 was before the entry point of waste. However, TSS at station 2, which is at the entry point of shrimp pond waste, is 36.7 mg/L. These results indicate the presence of liquid organic material input into the waters. Some researchers [5,30] said that the inclusion of waste increase the suspension dissolved in the waters. Progressively, within a certain threshold, the suspension will break down along the river flow. The total content of solids in water can reduce the penetration of light (20 cm at station 2) into the water so that the impact on the rate of photosynthesis and oxygen content in the water decreases [2,31]. Decreasing oxygen levels in the water will directly disrupt the life of aquatic organisms, such as macrozoobenthos because dissolved oxygen is needed in the metabolic process [4,32].

When compared with the results of the analysis of dissolved oxygen content (DO) at station 2, there is a high correlation of TSS analysis results on DO content (4.8 mg/L). Moreover, the difference between the results of the analysis with the station that is post-inlet waste shows a large difference (15.3 mg/L). These results correspond with some researchers who claim that polluted waters have shallow oxygen content due to the decomposition and oxidation of organic waste [29]. However, [33] states that the life of aquatic organisms can survive if the minimum dissolved oxygen is 5 mg/L, the rest depends on the organism's resistance, degree of activity, presence of pollution and temperature. Oxygen plays a vital role in the life of aquatic organisms, such as macrozoobenthos. Oxygen is essential for breathing and metabolic processes. However, macrozoobenthos oxygen requirements differ depending on the species characteristics [34].

The results of macrozoobenthos types identification found at five stations consist of two phyla, namely molluscs and arthropods. A total of ten species are found, eight of which are members of the phylum molluscs while the other two species are from the arthropod phylum — the classification of species found in this study, as described in Table 2.

TABLE 2. Macrozoobenthos classification found in Kali Jeruk

Class	Family	Genus	Species
Gastropods	Neritidae	*Neritina*	*Neritina natalensis*
			Neritina pulligeria
		Clithon	*Clithon diadema*
		Vittina	*Vittina semiconica*
	Potamididae	*Cerithiopsis*	*Cerithiopsis malayensis*
	Pachychilidae	*Faunus*	*Faunus ater*
Bivalves	Corbiculidae	*Polymesoda*	*Polymesoda bengalensis*
	Ampullariidae	*Pomaceae*	*Pomaceae canaliculata*
Malacostraca	Sesarmidae	*Episesarma*	*Episesarma versicolor*
	Ocypodidae	*Uca*	*Uca dussumieri*

Diversity index analysis (Table 3) shows that the three stations (2, 3, and 4) have low diversity (H'<2). High or low diversity index values caused by the spread of the number of individuals. At stations 1 and 5, it is observed that the distribution of the number of individuals is moderate, and the aquatic ecosystem is still balanced with medium ecological pressure. Besides, at stations 2, 3, and 4, it shows that there are indications of environmental stress caused by the entry of shrimp waste, creating an unstable ecosystem. The higher diversity indicates better environmental conditions and vice versa.

A relatively similar pattern is shown for the analysis of evenness (0.62) and dominance (0.52) at station 2, which is different from the other four stations. This indicates that the condition of the community is relatively stable. According to [29], a stable community suggests that the ecosystem has a high evenness. There is no dominant type and dominant individual division. Station 2 is the station that has the lowest evenness index, 0.62. This value indicates that the condition of the community is unstable. The smaller the index of evenness, the smaller the uniformity of the types of communities. It means that there are certain types that dominate an uneven distribution of individuals and tendencies. The dominance test results show that the high dominance value indicates unstable waters. This condition then causes an imbalance of ecosystems so that only certain species can survive in an unbalanced ecosystem condition [35].

TABLE 3. Index of diversity, evenness, and dominance of macrozoobenthos

No	Stations	Diversity index (H')	Evenness index (E')	Dominance (C)
1.	Station 1	2.046637	0.888843	0.153646
2.	Station 2	0.992773	0.616844	0.517778
3.	Station 3	1.758381	0.800274	0.203326
4.	Station 4	1.826134	0.878185	0.181163
5.	Station 5	2.100751	0.912344	0.142229
	Average	1.7449352	0.819298	0.239628

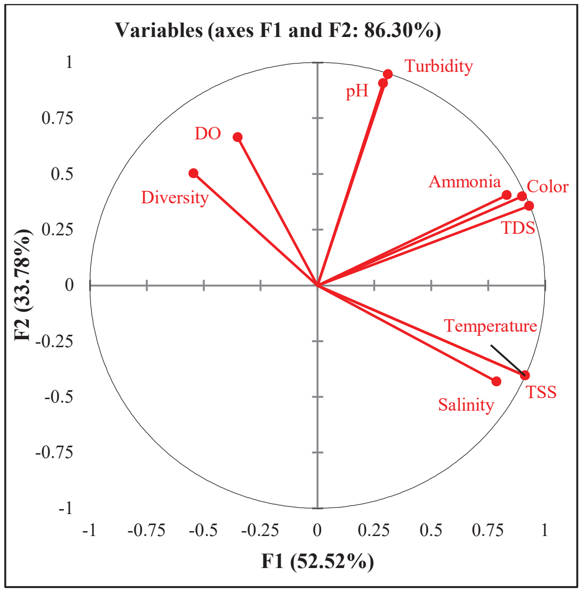

FIGURE 2. Principal component analysis results

Principal component analysis (PCA), as in Figure 2 shows that several variables are positively correlated with macrozoobenthos diversity. The parameters indicated positively correlated with variety are DO, pH, brightness, TDS, color, and ammonia. The test results show that the value of the six parameters is directly proportional to the level of macrozoobenthos diversity. However, the metric most correlated with macrozoobenthos diversity is DO. These results are based on the magnitude of the angles that show the proximity of DO points to differences.

SUMMARY

The results of this study indicate that the inclusion of shrimp waste in Kali Jeruk river waters has an impact on ecological indicators such as DO, pH, turbidity, and macrozoobenthos diversity, while the environmental chemical physics parameters indicated to have the highest correlation are DO levels.

ACKNOWLEDGMENTS

This article is the thesis selected in the publication-based acceleration program at the Biology Education Department, the University of Muhammadiyah Malang, with number E.2.3/408/Bio-FKIP/UMM/VII/2018. The authors would like to give a big appreciation to the Biology Education Department for facilitating the research and publication process related to this article.

REFERENCES

1. Salahuddin, C. Fandeli, and E. Sugiharto, Jurnal Tekno Sains **2**, 32 (2012).
2. R. Pangestu, E. Riani, and H. Effendi, Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan **7**, 219 (2017).
3. S. Tyagi, N. Garg, and R. Paudel, European Researcher **81**, 1491 (2014).
4. F. Mialhe, Y. Gunnell, C. Mering, J.C. Gaillard, J.G. Coloma, and L. Dabbadie, Journal of Land Use Science **11**, 236 (2016).
5. B.N. Lohani and N.L. Santos, International Journal of Water Resources Development **2**, 61 (1984).
6. S.A. Oke, Journal of Environmental Engineering and Landscape Management **12**, 108 (2004).
7. D. DEFRA, *Environmental Key Performance Indicators* (London, 2006).
8. H.A. Arafat, K. Jijakli, and A. Ahsan, Journal of Cleaner Production 1 (2013).
9. Fuad Jaya Miharja, Husamah, and Tatag Muttaqin, Jurnal Pengelolaan Lingkungan Berkelanjutan **2**, 165 (2018).

10. R.U.A. Fauzi and E.R.N. Sari, Industria: Jurnal Teknologi Dan Manajemen Agroindustri **7**, 39 (2018).
11. P. Li and J. Wu, Human and Ecological Risk Assessment: An International Journal **0**, 1 (2019).
12. C. Brachet, J. Magnier, D. Valensuela, K. Petit, B. Fribourg-Blanc, N. Bernex, M. Scoullos, and D. Tarlock, *The Handbook for Management and Restoration of Aquatic Ecosystems* (Anne-Marie Harper, 2015).
13. S. Irfan and A.M.M. Alatawi, Open Journal of Ecology **09**, 1 (2019).
14. A. Forslund, *Securing Water for Ecosystems and Human Well-Being: The Importance of Environmental Flows* (2009).
15. S. Goddard, *Feed Management in Intensive Aquaculture* (Chapman & Hall, 1996).
16. E. Yuwono, P. Sukardi, and I. Sulistyo, Berkala Penelitian Hayati **10**, 129 (2005).
17. M. Gariglio, S. Dabbou, M. Crispo, I. Biasato, F. Gai, L. Gasco, F. Piacente, P. Odetti, S. Bergagna, I. Plachà, E. Valle, E. Colombino, M.T. Capucchio, and A. Schiavone, Animals **9**, (2019).
18. S. Banun, W. Arthana, and W. Suarn, Ecotrophic **3**, 10 (2007).
19. A.J. Charlton, M. Dickinson, M.E. Wakefield, E. Fitches, M. Kenis, R. Han, F. Zhu, N. Kone, M. Grant, E. Devic, G. Bruggeman, R. Prior, and R. Smith, Journal of Insects as Food and Feed **1**, 7 (2015).
20. C. Emeh and O. Igwe, Geology, Ecology, and Landscapes **9508**, 1 (2018).
21. S.D. Sadhu, M. Garg, and A. Kumar, in *New Polymer Nanocomposites for Environmental Remediation* (Elsevier, 2018), pp. 77–97.
22. N. Voulvoulis and M.A. Burgman, Critical Reviews in Environmental Science and Technology **0**, 1 (2019).
23. E.D. Fisesa, I. Setyobudiandi, and M. Krisanti, Jurnal Depik **3**, 1 (2014).
24. G.A. Skilleter and S. Warren, Journal of Experimental Marine Biology and Ecology **244**, 107 (2000).
25. C.R. Beasley, C.M. Fernandes, C.P. Gomes, B.A. Brito, S.M. Lima, and C.H. Tagliaro, Ecotropica **11**, 9 (2005).
26. S. Puryono and S. Suryanti, Journal of Ecological Engineering **20**, 165 (2019).
27. E.P. Odum and G.W. Barrett, *Fundamental of Ecology*, Fifth (Cengage Learning, 1953).
28. F. He and X.S. Hu, Ecology Letters **8**, 386 (2005).
29. E. Odum, *The Basics of Ecology* (Universitas Gajah Mada, Yogyakarta, 1993).
30. A. Wiessner, J.A. Müller, P. Kuschk, U. Kappelmeyer, M. Kästner, Y.-J. Liu, and U. Stottmeister, Journal of Environmental Engineering and Landscape Management **22**, 71 (2014).
31. V. Pramaningsih, S. Suprayogi, and Ig.L.S. Purnama, Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan **7**, 211 (2017).
32. Y.-F. Li, R.-L. Xu, and C.-F. Wang, Zoological Studies **51**, 745 (2012).
33. D.R. Simamora, Macrozoobenthos Diversity Study in Padang River Stream, Tebing Tinggi, Universitas Sumatera Utara, 2009.
34. Ahmadin, Identification of Plankton and Macrozoobenthos Types in Traditional Tiger Shrimp Ponds in Bangil Pasuruan, Universitas Muhammadiyah Malang, 2007.
35. Riswan, The Structure of the Macrozoobenthos Community Is Related to the Diversity of Mangroves in the Munte Village, Bone-Bone, North Luwu, Universitas Hasanudin Makasar, 2016.