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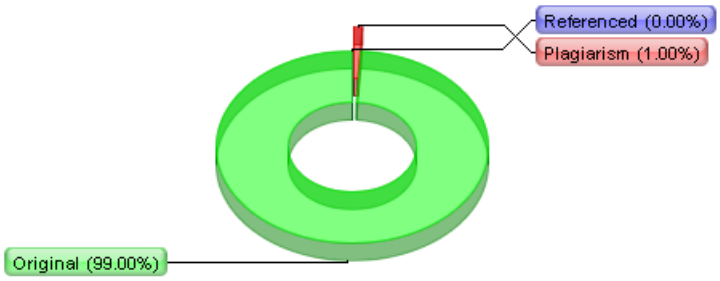

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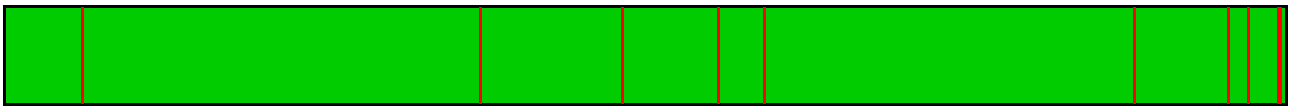

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The evaluation of water quality at Prafi River, Manokwari, West Papua
using macrozoobenthos biotics index and chemical physics of water parameters

Abstract

This study aims to determine the water quality along the Prafi River at Manokwari, West Papua, using some

macrozoobenthic biotic index and chemical physics of water parameters. The location grouping was done using cluster and biplot analysis based on a macrozoobenthic biotic index with several factors of water chemical physics, as well as different values of each chemical physics parameter using the Anova or Brown-Forsythe test. Sampling was done based on the Purposive Random Sampling method at the beginning of summer. The macrozoobenthos collected by using Surber and hand nets at eight locations (repeated 3x). The results showed that the pH and BOD5 values in all locations met the quality standard based on PP 82/2001 class I for pH and class III for BOD5. Turbidity values at locations 5 and 6 had met WHO quality standards for drinking water (5 NTU). As for locations 1, 2, 3, 5 and 6 can also be categorized as fish-farming activities with a turbidity requirement of between 2 and 30 NTU, except for locations 4, 7, and 8. FBI values at all locations show excellent water quality, while HBI values at all locations show good, moderate or moderately poor water quality. Furthermore, the ASPT values in all locations indicate clean and lightly polluted water quality. The cluster and biplot analysis was based on the macrozoobenthic biotic index, and the chemical physics parameters grouped the Prafi River water quality into three categories: locations 1, 5, and 6 were categorized as having unpolluted water conditions, location 2 was categorized as mildly contaminated water, and the remaining locations 3, 4, 7 and 8 were categorized as moderately pollute,d water.
Keyword: Macrozoobenthos, water quality, biotic index, Prafi River, chemical physics

INTRODUCTION

Prafi River is located in one region of Manokwari regency, namely Prafi district. The Prafi River is 65 km long, and

Pacific Ocean (BPS, 2013). The Prafi River is utilized by communities along the river to meet the needs of life such as bathing, washing, latrines, agriculture/plantation, fisheries, tourist attractions, reservoirs for hydropower, irrigation reservoirs, livestock and oil palm plantations. All the human activity along the Prafi River ultimately discharges its waste into aquatic bodies. This can negatively affect the river ecosystem, i.e., causing changes in the water quality and the structure of the aquatic biota community (Singh et al., 2013).

Changes in the structure of the Prafi River community indicates in the downstream areas due to the use of teodan and electric socker in free fishing. The use of theodans resulted in a very disturbed ecosystem balance, decreased fish catch, which had an impact on the economic decline of the community (Fadli, 2015). Based on research conducted by Dwiranti et al. (2014) it is noted that high cases of diarrhea and skin diseases in the community happen because the source of water used does not meet health standards. A preliminary study of the area found out a fact that the existence of oil palm and dam plantation activities has resulted on silting and decreasing the quality of water which gives a severe impact on river water that can not be utilized for bathing water for the community. Meanwhile, during the dry season, the river becomes dry, and it becomes a puddle of green river. In both locations, there found out the dominance of diatom type Fragillaria (Sinuraya, 2016). Onyema (2013) stated that diatom organism Fragillaria has high enrichment of nutrients and organic compounds in the water.

Changes in the structure of the diatom community in several locations of Prafi River indicate that there has been a decrease in water quality. In the context of proper management, a more thorough evaluation of water quality is required. Water quality monitoring can be done in various ways namely by physics, chemical, and biological analysis. One of the best water biota used as bioindicator is benthic macroinvertebrate (Hakwes, 1979). Some of the benefits of monitoring using macrozoobenthos as bioindicators are easy to do, fast and relatively low cost and can provide a clear picture of water because the nature of these macrozoobenthic organisms can rapidly respond to pollutants and environmental changes (Singh et al., 2013).

The determination of the water quality category through the macrozoobenthos as a bioindicator can be based on biotic indexes. Some macrozoobenthic indexes are used as bioindicators to determine the organic material contamination called FBI (Family Biotic Index) and HBI (Hilsenhoff Biotic Index). Moreover, the ASPT (Average Score Per Taxa) index is used to identify the level of contamination with toxic substances (Retnaningdyah & Arisoesilaningsih, 2014). Also, the presence of several species of insects of the Ephemeroptera, Plecoptera and Trichoptera orders can be indications of water quality which is still good (Rini, 2007). Based on the explanation above, the purpose of this research is to evaluate the water quality along Prafi River at Manokwari, West Papua, using a macrozoobenthic biotic index and the chemical physics of the water parameters.

MATERIALS AND METHODS

Study Area

The sampling locations were determined using purposive random sampling i. Thus, location 1 is in the upper (where there is no human activity), location 2 is a plantation area, location 3 is a dam, location 4 is an irrigation reservoir for agriculture and a fishery activities, location 5 is an oil palm plantation, location 6 is domestic area, location 7 is agricultural and livestock area, and location 8 fishing area. The treatment done at each location

was repeated 3 times (Webster & Lark, 2013) (Figure 1).

Taking samples of macrozoobenthos, identification, and analysis

Taking samples of the macrozoobenthos was done using a Surber net if the habitat was surrounded by rock and gravel, and using a hand net if it was on riparian vegetation. Samples obtained were then collected and separated from garbage or dirt using plastic plates. Sampling was done until at least 100 individual macrozoobenthos organisms were obtained for each location to calculate the biotic index value (Mandaville, 2002). The resulting macrozoobenthic organism was inserted into a flacon bottle containing 70% alcohol which served to preserve the sample. The obtained macrozoobenthic sample was identified using a stereo microscope in an environmental laboratory and animal diversity. The identification was carried out using the Jutting & Benthem identification key (1956); Edmonson (1963); and Quigley (1977). The measurements of the chemistry physics indicators of water quality in the field included: pH with a pH meter, turbidity with a turbidimeter, and BOD5 using titration (Clesceri, 1992). Differences in the value of each chemical physics parameter were measured by using the PAST 3.19 program. The location groupings were based on the macrozoobenthic biotic index, and the chemical physics parameters were analyzed by cluster and biplot analysis using the PAST 3.19 program.

FINDINGS AND DISCUSSION

Profile of water quality using chemical physics parameters at Prafi River

The degree of acidity or pH at the eight sites ranged from 7.80 to 8.36 (Figure 2). This value meets the standard for a class I water quality based on PP 82/2001 which set a pH value ranging from 6 to 9. The highest pH value was 8.36 at location 4, and the lowest was 7.80 at location 1. Different test results using Analysis of Variance show that locations 2, 3, 5, 6, 7 and 8 have relatively similar pH values, indicated by the same notation (Figure 2). The increase of pH may be caused by various activities that take place at this location, such as bathing, washing, extracting stone or sand, or as a place of recreation for people either from Prafi or from outside Prafi. Increased levels of detergent in aquatic bodies can increase the pH value to the alkaline range from pH 10 to 11 (Sastrawijaya, 2000). The pH value of water is determined by the water's ability to bind and release some hydrogen ions, and the ionized ammonium content can cause the pH in the water to be lower (Effendi, 2003).

The Biochemical Oxygen Demand (BOD5) value in all locations ranged from 0.53 mg/L to 5.51 mg/L (Figure 2). That value complied with the class III water quality standard based on PP 82/2001, which set the value of BOD5 6 mg/L. The highest BOD5 value was 5.51 mg/L at location 3, and the lowest was 0.53 mg/L at location 1. Different Tukey test results show that locations 3, 6, and 7 have a relatively high degree of similarity, indicated by the same notation (Figure 2). The BOD5 value of the research results is farther from the upstream so the higher the BOD5 value, the lower the water quality. This may be due to the existence of a variety of higher level of activities along the waters of the Prafi such as dam construction, toilets, recreation, sand and stone retrieval, agriculture, and animal husbandry so that aerobic microorganisms need more oxygen to decompose the organic compounds resulting from these activities. The BOD5 value of water indicates the amount of oxygen present in that water that can be utilized by aerobic microorganisms to oxidize organic matter from the environment caused by the various activities around the river (Effendi, 2003).

Turbidity values in all locations ranged from 1.93 NTU to 66.36 NTU (Figure 2). Turbidity values at location 5 and 6 still meet the maximum water turbidity standards of water based on WHO for drinking water (5 NTU), and for location 1, 2,3,5 and 6 were categorized into fish farming activities with turbidity value requirements between 2 to 30 NTU (Figure 2) (Wakman et al., 2015), except the turbidity values at location 4,7, and 8 consecutive values of 53.23 NTU; 66,36NTU and 38.72 NTU. Different test results with Brown-Forsythe show that location5 and 6 have similar relative similarity, indicated by the same notation. Meanwhile, for location s 1, 2 and 3 also have similarity levels, but they are significantly different from those of locations 4, 7 and 7 (Figure 2). This indicates a difference in activity at location 1,2,3,5, and 6 with those happens at locations 4,7 and 8. Thus, it affects different turbidity values. Differences in turbidity can be attributed to the activities at locations 4,7 and 8 in the form of sand and stone taking, agriculture, livestock, using electric socker and various river systems, which can lead to high turbidity (Meutter, 2005). Water turbidity is caused by suspended particle particles such as dust, clay, mud, dissolved organic materials, bacteria, plankton and other organisms in water (Koswara et al., 2015). Turbidity (turbidity) is a water abiotic factor associated with sedimentation of water, and it can affect the life of an organism in water(Meutter, 2005)

Macrozoobenthos biotic index as a bioindicator of water quality at Prafi River

The ASPT value of the macrozoobenthos is an index that can show the quality of the water. The calculated ASPT values of the eight locations ranged from 5.857-7.417 (Table 1). The water quality at the selected locations is classified into two categories, namely clean water (6) and slightly contaminated water (5-6) (Mandaville, 2002). Locations 1, 2, 5, 6 and 8 are in areas having clean water quality. This might be because in these locations a Plecoptera order is found, which is not the case at locations 3, 4 and 7. Plecoptera is an order that can be used as a bioindicator of good quality water with a high oxygen content and low nutrient concentration (nitrogen and phosphorus). This order typically lives in strong water (Tyufekchieva et al., 2013). On the other hand, locations 3, 4 and 7 are classified as having slightly contaminated water quality. This may be caused by the activities of people using fertilizer for gardens on the bank of the river, and there is also the activity of rock and sand dumping. Furthermore, there is still much garbage scattered by the river from recreational activities, and other activities of the people around these locations.
The FBI value of the macrozoobenthos is an index that can show the level of pollution of water due to organic matter. The FBI values across all locations ranged from 3.852 to 4.978 (Table 1). The water quality at the eight locations is classified into the two categories 'very good' and 'good'. Locations 1 and 2 have excellent water quality, while locations 3, 4, 5, 6 and 8 are considered to have

Locations 1 and 2 are in the area of the mountains with an altitude of 293-1435 mdpl, so there are still many trees along the water's edge. The population is therefore still sparse, although the community carries out gardening activities. At downstream locations, the altitude ranges from 14-296 mdpl. Thus, there are more and varied activities taking place along the water with a denser population. Hence, it can be said that the condition has decreased from very good to excellent.
The HBI value of the macrozoobenthos is an index that can show the level of pollution of water from organic matter to species level. The calculation of HBI values from the eight locations ranged from 4.765 to 6.60 (Table 1). The water quality across locations is classified into three categories: 'good,' 'moderate' and 'fairly poor' (Mandaville, 2002). Locations 1, 2, 4, 5 and 7 (Table 1) are classified as having fair water quality which indicates significant and organic significant pollution. Location 6 (Table 1) is classified as good water quality showing little organic pollution. Locations 3 and 8 (Table 1) are relatively weak, indicating significant organic pollution (Mandaville, 2002). The quality of water that is classified as moderate and severe is caused by the various activities being carried out along the river that affect it, such as community gardening activities, dam-making, bathing and fishing using thiodan and electric shockers by both the local community and people from beyond Prafi River. The location is easy to reach for recreation purposes and is not yet managed by local government or private companies. Furthermore, there is still much garbage scattered on the riverside by recreational users, as well as sand and stone collecting activity, agricultural activity and farming. Thus, the result of the evaluation is based on the HBI and the results of an evaluation based on the FBI.
The% EPT value of macrozoobenthos based on calculations from all locations is more than 50%, except for location 2 with 41.864% (Table 1). EPT taxa can be considered to have good water quality (NRCS, 2001). However, Chironomidae is found to be more than% EPT in location 2. Therefore, this location can be categorized in medium quality. Chironomidae is a tolerant pollution-tolerant taxa, the presence of these taxa may indicate the quality of moderately to severe polluted water. The high value of %EPT can be caused along the river there is still abundant riparian vegetation. More nutrients are needed to be able to support the viability of macrozoobenthos, and this can be supplied from riparian vegetation along the water (Lestari & Trihardiningrum, 2011).

Table 1. The average value of ASPT, FBI, HBI indexes, % EPT and % Chironomidae.
Location ASPT FBI HBI % EPT % chironomidae
1 7,4/E 3,852/VG 5,726/F 62,845 31,277 2 7,417/E 4,121/VG 5,901/F 41,864 50,441 3 6/F 4,949/G 6,613/FP 60,632 33,768 4 6/F 4,674/G 6,173/F 70,361 23,375 5 6,875/E 4,705/G 6,04/F 77,539 14,760 6 7/E 4,264/G 4,765/G 59,350 14,064 7 5,857/F 4,974/G 5,648/F 89,140 10,169 8 6,25/E 4,978/G 6,6/FP 63,594 14,289
Water quality category: Excellent (E); Very Good (VG); Good (G); Fair (F); Fairly Poor (FP); H '= Index of Shannon- wiener Diversity; ASPT = Average Score Force; TR = Richness Tax, FBI = Family Biotic Index, HBI = Hilsenhoff Biotic Index; EPT = Ephemeroptera, Plecoptera, Trichoptera.

Water quality in research locations based on chemical physics parameters and biotic index from macrozoobenthos using cluster and biplot analysis
The water quality at all the observation locations, based on the chemical physics and biotic indices of the macrozoobenthos as bio-indicators of water quality,

based on cluster and biplot analysis, as can be seen in Figures 3 and 4. Based on cluster analysis (Figure 3) at a 73% equivalence level, Group I consists of locations 4, 7 and 8, forming one group at an 87% equality level. Group II is a different location to another location and has a similarity within the group of about 78.449%. Group III consists of location 3, and group IV consists of location 1, which has a similarity rate of about 93%. Groups III and IV have a similarity with group II for about 73%. Group V consists of locations 5 and 6, which have a similarity rate of about 89% and similarity with the other groups of about 80%. This grouping is also supported by a biplot analysis that obtains similar results (Figure 4). Based on the cluster and biplot analysis of Figures 3 and 4, it can be seen that locations 4, 7 and 8 are one group characterized by EPT%, BOD5, HBI, FBI, turbidity and high pH, and moderate Chironomidae, but low ASPT. The EPT% value indicates clean water quality, the high HBI and FBI values characterize the water quality in terms of organic material contamination, the low ASPT values indicate pollution from toxic compounds, BOD5 is still below 5.1, indicating unfrewed waters, high turbidity indicates suspended particles such as dust, clay, mud, and dissolved organic materials from agricultural activities, bacteria, plankton and other organisms in the water, while a high pH is a sign of increased detergent or household waste. The two sites based on biplot analysis (Figure 4) were characterized by high Chironomidae and ASPT, moderate HBI and FBI, while they are slightly wet and have high turbidity and pH values, and these result in low EPT and BOD5 values . The high percentage of Chironomidae indicates contaminated water. However, the high ASPT showed there was no contamination by toxic or inorganic substances. The HBI values, moderate FBI and low EPT indicate the presence of organic material contamination, while the slightly alkaline pH indicates an increase in detergent or household effluent, whereas high turbidity indicates suspended particles of organic compounds. Next, the low BOD5 values show that few organic compounds are described. Thus, it can be said that this location has water that is contaminated with organic matter at a reasonable or light level. This may be due to a small amount of plantation activity around the river and bathing and washing activities done by the community. Thus, this location can be said to have water quality contaminated with

moderate level. This can be due to sand, rock, washing, bathing, recreation, fishing with explosives activities and agricultural activities with chemical fertilizers and pesticides applications. At this location found% EPT in the high category, but also found% Chironomidae being. Chironomidae found at this location of its existence comes from adjustments to environmental conditions (Noortiningsih et al., 2008). Chironomidae is a pollution tolerant taxa, and the presence of these taxa may indicate moderate to severe water quality (Mandaville, 2002). The three sites based on biplot analysis (Fig. 4) are characterized by HBI, FBI,% EPT, pH, BOD5 and high turbidity, together with moderate Chironomidae and ASPT. The high HBI and FBI values indicate slight contamination with organic matter to slightly worse. Next, the high EPT values indicate moderate water quality, with chironomid and ASPT values indicating mild contamination with inorganic compounds. Then, the pH, BOD5, and high turbidity indicate the presence of medium-level pollution from human activities consisting of both organic and inorganic compounds. Thus, it can be said that this location has water contaminated with

moderate level. This can be due to plantation activities, river widening, dam-making activities, and bathing and washing activities. At this location there found high percentage of EPT and Chironomidae was also found at the same time. Chironomidae found at this location of its existence comes from adjustments to environmental conditions (Noortiningsih et al., 2008). Chironomidae is a pollution tolerant taxa, and the presence of these taxa may indicate moderate to severe water quality (Mandaville, 2002).

The one location based on biplot analysis (Figure 4) is characterized by high ASPT values, while the Chironomidae, HBI, FBI, turbidity, and pH are moderate, with low EPT and BOD5 levels. The high ASPT value shows that there is no contamination with toxic or inorganic materials, given the value of the Chironomidae percentage of the HBI. Then, the FBI shows the presence of pollution from organic compounds, while the EPT percentage shows clean water quality, and the turbidity shows that there were fewer suspended particles of organic compounds. In this case, the pH is seen to be not too far from normal pH, while the BOD5 value indicates that there is little or a low level of organic compounds. Thus, it can be said that this location has clean water quality. This may be due to the location, where there is a lack of human activity and still many trees along the river so that BOD5 is low. The primary source of DO comes from the atmosphere and oxygen from the air that is absorbed by direct diffusion on the water surface due to the wind and current movement (Firdaus et al., 2013).The percentage of EPT values indicate clean water quality, so this is related to EPT organisms in a group of benthic sensitive benthic macroinvertebrates (Badawy et al., 2013).

Locations 5 and 6 become one group based on cluster analysis and the biplot Figures 3 and 4, characterized by high EPT and ASPT values. For moderate FBI and HBI values, it was found that there are low chironomid values followed by high BOD5, and this will result in slightly wet pH and low turbidity. The high values of EPT and ASPT show that there was no pollution. Next, the FBI and HBI values show a slight and reasonable

organic matter contamination, while the BOD values are still below 5.1 mg/L, showing that they are not in a medium contaminated state. On the other hand, the pH and turbidity values reflected a lack of pollution. The turbidity values still meet the maximum water turbidity standard for water based on the WHO standard for drinking water (5 NTU), and the pH value still meets the quality standard of class I water quality based on PP 82/2001, which sets the pH value range from 6 to 9. Thus, it can be said that this location has a clean water quality. This may be due to the small amount of community plantation activities.

Figure 3. Cluster Analysis based on physics and chemistry parameters and Macrozoobenthos Biotics Index at Prafi river

FIGURE 4. the biplot analysis based on physical and chemical parameters using Macrozoobenthos biotic index at Prafi river.

CONCLUSION

The quality of the physical chemistry of the Prafi River based on the pH values at eight sites still meets the quality standards of first-class water quality (raw materials of drinking water, fishery, recreation, livestock, and irrigation) based on PP 82/2001, which specifies pH values ranging from 6 to 9. Of the turbidity values at the eight sites, locations 5 and 6 still meet the maximum water turbidity standard of water based on the WHO standard for drinking water (5 NTU). Locations 1, 2, 3, 5 and 6 can also be classified as having fish cultivation activity with the requirement for turbidity values between 2 and 30 NTU. However, locations 4, 7 and 8 have already exceeded the standard according to WHO and the requirements for aquaculture. The BOD5 values at the eight locations still fulfill the class III water quality standard (for fishery, livestock and irrigation) based on PP 82/2001, which sets the value of BOD5 6 mg/L. Based on the ASPT values, the water quality in all locations is classified into two categories: the water at locations 1, 2, 5, 6 and 8 is assessed as clean, while the water at locations 3, 4 and 7 is classified as light water quality. Based on the FBI values, the water quality in all locations is classified into two groups: locations 1 and 2 have an excellent standard while the remaining locations 3, 4, 5, 6, 7 and 8 are considered as good. Based on the HBI values, the water quality in all locations is classified into three groups: location 6 is classed as good, followed by locations 1, 2, 4, 5 and 7 which are considered as having medium water quality, and lastly locations 3 and 8, which are slightly worse. Based on the water quality category using cluster and biplot analysis, the locations are grouped in three categories: locations 1, 5 and 6 show clean water conditions; locations 5 and 6 are categorized as uncontaminated water, and location 2 is categorized as mildly polluted water, while locations 3, 4, 7 and 8 are considered to have medium levels of polluted water.

This was not clear so I looked at your conclusions and have revised the wording accordingly, but please check.
In general, I find it rather hard to reconcile these statements about the various locations with those in the conclusion - it might help if you used exactly the same terminology (polluted/contaminated, medium/moderate.), including in relation to the tables given in Mandaville (2002) and the other standards that you cite e.g. WHO.
For the locations, you use Arabic numerals everywhere else, and have Roman numerals only for the groups below.
Please check your wording here.
Please check the revised wording
Please check this slightly unclear statement.
It was not clear what 'higher activities' meant here so please check my suggested revision.
It is not clear what exactly 'strong water' means here. Please check.
What about location 7, which you do not mention?
I have had a quick look at Mandaville (2002). The categories he uses are excellent//very good// good// fair// fairly poor// poor//very poor. I think that it is important that you should use exactly these same terms to make the classification clear. Therefore I asssume that 'slightly bad' should in fact be 'fairly poor'. And please check all the other terms you use.
How does 'fair' relate to the three criteria you have just given? Is this 'moderate' or 'slightly bad'?
Please check this wording, which is not clear.
?'fair and poor' rather than 'moderate and bad'?
Please check my revisions here. Could you alternatively say 'electrofishing'?
?equivalence level
This wording is not at all clear - please check.
This is not clear.
? I do not know this word and think it is a mistake - please check
?Which two sites?
'wet' is not correct her (all the water samples are surely wet)! Do you mean acid or alkaline?
Which site?

Which sites?
Is it just the turbidity that is high, or also the pH and BOD5? Check the position of the word 'high'.
Which one?
Please check this phrase - it was not clear.
Check 'wet' again.
Please check 'reasonable', which looks incorrect/unclear. Do you mean 'moderate'?
Please check the wording here. If they were 'not in a medium contaminated state', exactly what state were they in?
Please check 'light' as you have not used this term before and its meaning is not clear.
Does 'slightly worse' mean 'fairly poor'?
For locations 5 and 6, is it clear what the distinction is between the two descriptions of 'clean water' and 'uncontaminated water'?

Figure 2. the variation of pH, BOD5 and turbidity values at Prafi river

Games howell
Tukey
Chart1
Descriptives
Mean
Std. Deviation
Suhu_air
SPI
Aimasi
SP3
Muara Prafi
Kedalaman
Kecepatan_arus
NO3
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Sinay
Sinamboy
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Anova dilanjutkan Tukey HSD
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54,79
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102,27
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106,79
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Lokasi
Turbiditas (NTU)
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abc
Mean
Lokasi
Suhu Udara (oC)
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Lokasi
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0,58
0,11
0,69
0,17
0,96
0,13
1,25
0,18
1,00
0,17
1,02
0,15
0,71
0,09
0,06
0,02
0,07
0,02
0,07
0,01
0,11

5,77E-03
0,06
0,01
0,10
0,02
0,05
0,03
0,06
0,01
1,00
0,53
0,16
2,00
1,23
0,62
3,00
5,52
0,94
4,00
4,03
0,46
5,00
2,56
0,19
6,00
5,05
0,32
7,00
4,64
1,05
8,00
2,19
0,35
Mean
Lokasi
Suhu Air (oC)
a
b
b
b
cd
b
c
d
Mean
Lokasi
Kedalaman (cm)

a
a
a
a
a
a
a

a
Lokasi
Kecepatan Arus (m/detik)
bc

a
ab
abc
c
abc
abc
ab
Mean
Lokasi
Nitrat (mg/L)
ab
abc
abc
c
ab
bc
a
abc
Mean
Lokasi
BOD5 (mg/L)
a
ab
d
cd
bc
d
d
ab
Mean
Lokasi
Turbiditas (NTU)
ab
ab
bc
cd
b
b
d
acd
17,91
22,96
9,57
5,88
27,28
2,82
53,23
0,04
1,93
0,56
3,38
0,61
66,36
24,36
38,72
7,82
Games howell
Tukey
Chart1
Descriptives
Mean

Std. Deviation
Suhu_air
SPI
Aimasi
SP3
Muara Prafi
Kedalaman
Kecepatan_arus
NO3
Indabri
Sinay
Sinamboy
Sidomuncul
Anova dilanjutkan Tukey HSD
DO
BOD5
Konduktivitas
Turbiditas
Suhu_udara
Orthofosfat
1
2
3
4

BOD
Lokasi
Standart deviasi
8,48
0,37
9,40
0,58
7,68
0,23
8,07
0,14
6,58
0,19
8,67
0,17
8,21
0,60
7,21
0,53
3,43
0,40
7,60
0,10
4,57
0,25
4,30
0,20
4,10
0,20
3,87
0,06
3,70
0,95
5,23
0,15
48,15

4,07
83,66
8,15
79,53
5,77
83,74
3,36
94,75
7,67
54,79
1,67
102,27
12,33
106,79
2,60
17,91
22,96
83,63
7,65
27,28
2,82
53,23
0,04
5,00
1,93
0,56
6,00
3,38
0,61
7,00
66,36
24,36
8,00
38,72
7,82
22,21
2,30
26,51
1,68
26,18
0,17
33,36
1,22
33,09
0,87
29,63
0,58
30,87
0,49
31,58
0,98
0,10
0,01
0,05
0,01
0,11
0,02
0,14
0,02
0,20
0,06

0,03
0,01
0,03
0,03
0,01
5,77E-03
1,00
17,91
22,96
2,00
9,57
5,88
3,00
27,28
2,82
4,00
53,23
0,04
5,00
1,93
0,56
6,00
3,38
0,61
7,00
66,36
24,36
8,00
38,72
7,82
Mean
Lokasi
DO (mg/L)
bc
bc
b
bc
a
c
abc
abc
Mean
Lokasi
BOD (mg/L)
a
c
ab
a
a
a
abc
b
Lokasi
Konduktivitas (µS/cm)
a
bcd
bc
c
cd
ab
abcd

d
Mean
Lokasi
Turbiditas (NTU)
abcd
d
b
cd
a
a
abcd
abc
Mean
Lokasi
Suhu Udara (oC)
ab
abc
a
de
ce
bd
bcd
bcd
Mean
Lokasi
Ortofosfat (mg/L)
b
a
b
b
ab
a
ab
a
Mean
Lokasi
Turbiditas (NTU)
ab
ab
bc
cd
b
b
d
acd
19,13
1,30
23,67
0,72
22,07
0,38
24,73
0,89
31,48
0,69
24,63
0,09
28,80
1,39
31,66
1,40

19,22
1,35
19,75
8,45
48,78
17,17
40,31
15,30
39,22
13,17
49,33
7,55
33,55
15,85
18,67
1,53
1,05
0,26
0,58
0,11
0,69
0,17
0,96
0,13
1,25
0,18
1,00
0,17
1,02
0,15
0,71
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5,77E-03
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0,01
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0,01
1,00
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0,16
2,00
1,23
0,62
3,00
5,52
0,94
4,00
4,03
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5,00

2,56
0,19
6,00
5,05
0,32
7,00
4,64
1,05
8,00
2,19
0,35
Mean
Lokasi
Suhu Air (oC)
a
b
b
b
cd
b
c
d
Mean
Lokasi
Kedalaman (cm)

a
a
a
a
a
a
a

a
Lokasi
Kecepatan Arus (m/detik)
bc
a
ab
abc
c
abc
abc
ab
Mean
Lokasi
Nitrat (mg/L)
ab
abc
abc
c
ab
bc
a
abc
Mean
Lokasi
BOD5 (mg/L)
a

ab
d
cd
bc
d
d
ab
Mean
Lokasi
BOD5 (mg/L)
a
ab
d
cd
bc
d
d
ab
1,00
2,00
3,00
4,00
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6,00
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1,23
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5,52
0,94
4,03
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2,56
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5,05
0,32
4,64
1,05
2,19
0,35
Sheet1
Chart1
Mean
Std. Deviation
Suhu_air
Indabri
Sinay
Sinamboy
SPI
Aimasi
SP3
Sidomuncul
Muara Prafi
Kedalaman
Kec_arus
pH
NO3

1

2
3
4
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6
7

8
2
2Page
19,13
1,30
23,67
0,72
22,07
0,38
24,73
0,89
31,48
0,69
24,63
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28,80
1,39
31,66
1,40
1,05
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7,80
0,13
7,90
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8,36
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7,93
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5,77E-03
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19,22
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19,75
8,45
48,78
17,17
40,31
15,30
39,22
13,17
49,33
7,55
33,55
15,85
18,67
1,53
Mean
Lokasi
Suhu Air (o C)
a
b
b
b
cd
b
c
d
Mean
Lokasi
Kecepatan Arus (m/det)
bc
a
ab
abc
c
abc
abc
ab
Mean
Lokasi
pH
a
ab
ab
b
ab
ab
ab

ab
Mean
Lokasi
NO3
ab
abc
abc
c
ab
bc
a
abc
Mean
Lokasi
Kedalaman (m)

a
a
a
a
a
a
a

a
Mean
Lokasi
pH
a
ab
ab
b
ab
ab
ab
ab

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2
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7,80
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7,93
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8,31
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