

INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ENVIRONMENT & GEOGRAPHY



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To Link this Article: <http://dx.doi.org/10.46886/IJAREG/v5-i1/4497>

DOI: 10.46886/IJAREG/v5-i1/4497

Received: 20 July 2018, **Revised:** 10 August 2018, **Accepted:** 17 September 2018

Published Online: 12 September 2018

In-Text Citation: (Anita, Faisal, & Meilina, 2018)

To Cite this Article: Anita, R., Faisal, & Meilina, H. (2018). The Quality and Distribution of Water at Krueng Geukueh Waters in North Aceh Regency - Indonesia. *International Journal of Academic Research in Environment and Geopgraphy*, 5(1), 82–98.

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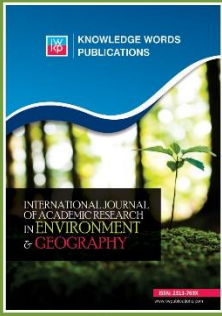
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Vol. 5, No. 1 (2018) Pg. 82 - 98

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The Quality and Distribution of Water at Krueng Geukueh Waters in North Aceh Regency - Indonesia

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Abstract

This research conducted to understand the quality of water at Krueng Geukueh Waters in North Aceh Regency – Indonesia reviewed by parameters such as chemical, physical, biological condition and distribution as well as the quality standard status for the area of the harbour, marine tourism and marine biota. The study covers 7 research points with 10 chemicals, physical and biological parameters and distance of sea depth taken were 5 meters. The in situ testing process involves temperature, brightness, pH and DO while the laboratory testing includes COD, BOD₅, TSS, salinity, mercury, and total coliform. Test result indicates several values such as temperature 28.0 – 28.5 °C, DO 4.90 – 5.93 mg/L, pH 7.6 – 8.1, brightness 1.5 – 2.5 m, TSS 10.4 – 38.0 mg/L, COD 17.78 – 27.94 mg/L, BOD₅ 0.39 – 0.59 mg/L, coliform 14 – 1600 APM/100 ml, salinity 31.4 – 32.4‰ and mercury 0.001 – 0.006 mg/L. The quality standard for the harbour in Krueng Geukueh Waters North Aceh Regency is considered good, as the marine tourism is lightly polluted and marine biota is slightly contaminated.

Keywords: Water Quality, Distribution, Quality Standard, Krueng Geukueh Waters.

Introduction

The characteristic of water quality in the aquatic environment was originated from physical, chemical and biological factors (Ullah, 2011). Influx of contaminant could be identified from the activity of organism and environmental change that happened (Hendrawan, 2005). Water contamination will decrease nature's ability to provide human needs so the sustainability and quality of human life will also decline (Wardhana, 2004). When the quality of human life is declining, it will affect the continuity of another organism.

Krueng Geukueh waters located in the Strait of Malacca, one of the busiest shipping lines in the world. The Krueng Geukueh waters are greatly affected by the activity of people in surrounding coastal area of the waters. The activities in Krueng Geukueh waters are including an industry

which producing urea fertilizer granules (prill), harbour, cement packaging, beach tourism, residential areas, and fish auction. These human activities that occurred around the waters could have an important impact on the environment.

At the east area of Krueng Geukueh waters, the Krueng Geukueh Rivers is located. Specifically, in Krueng Geukueh waters, the interaction between fresh water and salt water takes place. This interaction will affect the distribution of TSS, COD, BOD5, salinity, total coliform, temperature, DO, pH, mercury and brightness.

The quality of salt water and groundwater relies on several chemical parameters such as pH, chloride, TDS, electrical conductivity, DO, COD, BOD, and alkalinity (Stylus and Ramesh, 2015). The decline of water quality is because of overwhelming waste disposal triggered by the disposal activity in the waters which does not fit with the environmental carrying capacity (Prihartanto and Budiman, 2007). Krueng Geukueh waters as the estuary of Krueng Geukueh River was estimated to decrease in the quality of water. For Krueng Geukueh waters to be sustainably useful according to its allocation, a water quality identification would be needed especially in Krueng Geukueh waters.

The spreading or spatial and temporal distributions of water quality parameters including physical, chemical and biological parameters are an important part to indicate the oceanography of waters. It is because of various distribution aspect parameters such as chemical and biological reactions are directly related to the parameters existing.

This research aims to understand water quality in the Krueng Geukueh waters in terms of chemical, physical and biological parameters and the distribution as well as the quality standard status for the area of harbour, marine tourism and marine biota, so it can be used as information for anyone who wants to know more about dynamic pattern of Krueng Geukueh waters and as the basic consideration in developing the surrounding of Krueng Geukueh waters.

Methodology

Sampling Process

This research was conducted at the Krueng Geukueh waters, North Aceh Regency, Province of Aceh as shown in the location map (Figure 1) on February 20, 2016. The sampling process was implementing Vandorn sampler vertical done for 7 sampling points. point 1 at coordinate N 05°14'31.1" E 97°03'0.20", point 2 at coordinate N 05°14'38.0" E 97°02'57.4", point 3 at coordinate 05°14'43.4" E 97°02'36.2", point 4 at coordinate N 05°14'47.9" E 97°02'34.7", point 5 at coordinate N 05°45'43.1" E 97°45'19.6", point 6 at coordinate N 05°14'47.3" E 97°02'42.0" and point 7 at coordinate N 05°14'52.0" E 97°02'39.2". The decision mechanism of choosing sampling coordinate points was using a GPS (Geographical Positioning System). Sampling process in Krueng Geukueh waters was done at 10.30 - 12.30 IWST. Solar radiation was classified as morning a slightly cloudy, at 5 meters in depth. Sampling method adopted is to grab sampling. Grab sample is the sample that directly collected from a water body that currently monitored. This kind of sample is only illustrating the characteristic of water at the time of samples taken (Effendi, 2003). Water quality parameters that measured by in situ are temperature, brightness,

DO and pH. In the other hand, other water quality parameters including TSS, COD, Hg (mercury), BOD5, salinity and total coliform are analysed at research and industry standardization centres BARISTAND industry testing laboratory Banda Aceh.

Determining the Distribution

Testing result of both in situ and ex situ testing then presented in a form of transverse spread using software called Surfer. From the result, distribution condition of the parameters could be analysed horizontally at the research location (Patty, 2013).

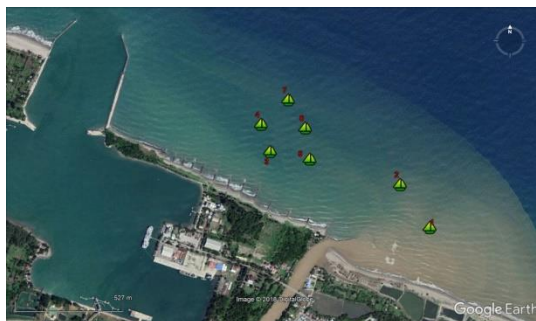


Figure 1. Sampling location (Source: Google Map)

Result and Discussion

Temperature

The temperature of the measurement result is ranged at 28.0 - 28.5°C. The lowest temperature was at point 2 with coordinate N 05°14'38.0" E 97°02'57.4" and temperature 28.0°C. The highest temperature was found at point 7 with coordinate N 05°14'52.0" E 97°02'39.2" and temperature 28.5°C. According to Idris (2009), seawater temperature especially at the surface layer is determined by the solar heating and the intensity could change anytime. The solar heating condition when sampling process conducted at point 7 was greater than the condition at the other sampling points, which leads to evaporation that increases the surface temperature caused by heat flow from the air to the surface layer of the waters. As stated by Tubalawony (2008), the evaporation could raise the temperature for about 0.1°C at surface level to the 10 meters in depth. The deepness of water at the sampling process was 5 meters from the water surface and at point 7 N 05°14'52.0" E 97°02'39.2" the temperature was rising or higher than at the other sampling points. The average temperature of sampling results is 28.2°C. Sampling was done at 10.30 – 12.30 IWST so the overall temperature of the waters was about the same and did not indicate any significant difference. This condition was because of the weather affecting at the time of sampling, where the weather was slightly cloudy and causing the same temperature. One of the important factors in controlling life processes and organism distribution and managing waters ecosystem is the temperature. According to the decree of the ministry of environment No. 51 the Year 2004 regarding quality standard of seawater for marine biota, the temperature need to be around 28 – 32°C so the temperature at Krueng Geukueh waters is still considered to be appropriate for supporting biota's life.

As shown in the (Figure 2) which illustrated the distribution of temperature transversely, the temperature is the same as point 1, 4 and 5 because of the altering temperature and the highest

temperature 28.5°C at point 7. The temperature concentration at each point inspected is not significantly different from each to another.

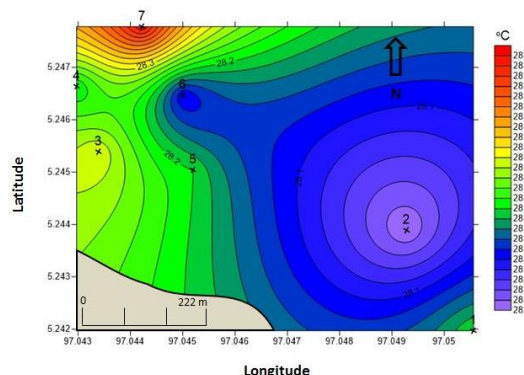


Figure 2. Temperature distribution at Krueng Geukueh waters, North Aceh Regency

Dissolved Oxygen (DO)

The measurement result of Dissolved Oxygen (DO) using in situ method in the research is ranged between 4.90 – 5.93 mg/L. The average of dissolved oxygen at all research point is 5.34 mg/L. The highest number of dissolved oxygen is at point 4 which is 5.93 mg/L, since the temperature and salinity found in this point are fit for photosynthesis process. Contrarily, the lowest oxygen level is at point 7 which is 4.90 mg/L. The temperature at this point is 28.5°C that considered as the highest temperature in this research, which is corresponding with a statement by Salmin (2005) that oxygen level at seawater will increase by the decrease of temperature. At surface level, the oxygen level will be higher, since there is a diffusion process between water and free air and a photosynthesis process. As the deepness of sea is increasing, level of oxygen dissolved is declining since the photosynthesis process is reduced and the oxygen levels available is used for respiratory and oxidation of organic and inorganic matters. According to decree of ministry of environment No. 51 Year 2004 regarding quality standard of seawater for marine biota and marine tourism, it is appointed that dissolved oxygen level ought to be > 5. Therefore, the DO result in this research is still considered as normal. This statement also correspond to the one stated by Verawati (2016) that dissolved oxygen is the main necessity for healthy waters ecosystem and shows the capability of waters to support a balanced ecosystem.

Dissolved oxygen distribution (Figure 3) is evenly distributed, the dissolved oxygen (DO) from point 7 is moving towards the land (water is high tide heading from north to southeast). Direction and speed of tidal current are moving to the land, while receding current is moving in a reverse direction (to the sea). Dissolved oxygen (DO) is the total number of oxygen that dissolved in the water. According to Effendi (2003), DO concentrations in the waters fluctuate daily and seasonally which makes it rely on the mixing of water masses, photosynthesis activity, respiration and waste input. Oxygen diffusion from the air depends on several factors such as turbidity of water, temperature, salinity, movement of water and air masses like the stream, wave and tidal. At the time research was conducted, waters condition was receding towards the tide so the

stream was powerful and under certain condition will be turbid caused by the number of domestic waste disposal.

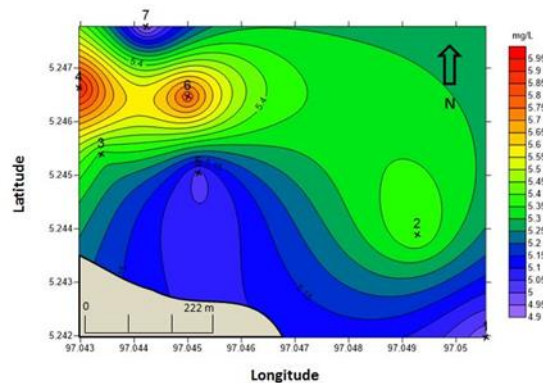


Figure 3. DO distribution at Krueng Geukueh waters, North Aceh Regency

pH

Measurement result of seawater pH at Krueng Geukueh waters is around 7.6 – 8.1. Average number of all research point is 7.9. The highest pH level is at point 3 which is 8.1 where the lowest is at point 4. The high and low pH level in this research is affected by the number of organic matters that brought through the river stream or the reaction of waste from the land. According to decree of ministry of environment No. 51 Year 2004 regarding quality standard of seawater for marine biota and marine tourism, the pH level appointed is from 7 – 8.5. This number indicates that the research result is still in the range of normal condition. As said by Simanjuntak (2009), acidity of waters is one of the important chemical parameters in monitoring waters stability. In general, sea water has pH level more than 7 which tend to be alkaline.

pH distribution (Figure 4) at north, south, southeast, east, northeast, and west of research points have a high level of pH and declining at the northwest ranged 8.0 – 8.1 and with the average of 7.9. The increase in temperature or pressure generates a slight decrease in pH level (Machdar, 2010). In this research, the highest temperature is at 28.5oC and pH is declining to 7.9 even though the pH level in this study is unstable.

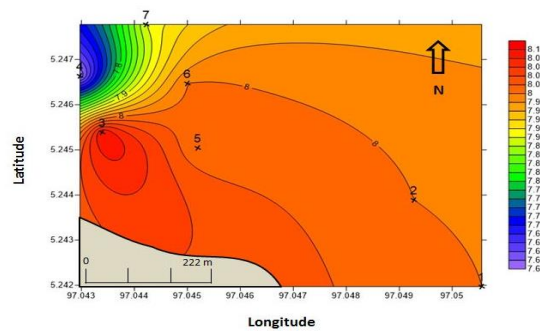


Figure 4. pH distribution at Krueng Geukueh waters, North Aceh Regency

Brightness

The measurement result of brightness by in situ testing process is ranged around 1.5 – 2.5 m, with the average number of 1.9 meters. The lowest number of brightness is at point 1, 2 and 3 with the brightness level of 1.5 meters (5 meters in depth) while the highest one is at point 7 where the Secchi disk is still visible at 2.5 meters in depth. The brightness level is generally affected by the cloudy weather when the research was conducted, so the sunlight is less bright and did not cut through the waters. The location chosen was around the estuary affecting the brightness to be low because of the domestic and industrial waste disposal condition from the freshwater which flows from the estuary to the sea. The brightness is increasing as far as it from the beach. According to Castro and Huber (2008), water around the beach tends to contain many matters brought by the river. This is important since all of the organism photosynthesis processes need light to grow. If the sea water is not bright enough, the photosynthesis process will happen less than the usual. The brightness level could be influenced by biological factor caused by the content of microorganism and the physical factor caused by suspended and dissolved solids in the water, weather condition and other factors such as measuring time. Brightness condition at sampling process is very low because of the cloudy weather. The high numbers of plankton also obstruct water brightness. Referring to the decree of ministry of environment No. 51 Year 2004 regarding quality standard of marine tourism, brightness level > 6 does not support marine tourism activities and considered as turbid.

Brightness distribution at Krueng Geukueh waters (Figure 5) is dominated at the southeast and southwest area of point 1, 2 and 3 with brightness ranged 1.5 meters and the cloudy weather is very affecting in this research. Northeast – slightly to the northwest at point 4, 5 and 6 have the brightness level of 2.0 meters. The maximum number of brightness level is at the north part of point 7, when the condition is at receding toward the tides and it started to be sunny. Tidal current generally comes from the north to southeast which shows that the more it far from the sea, the higher brightness level could be identified because of less influence from the estuary.

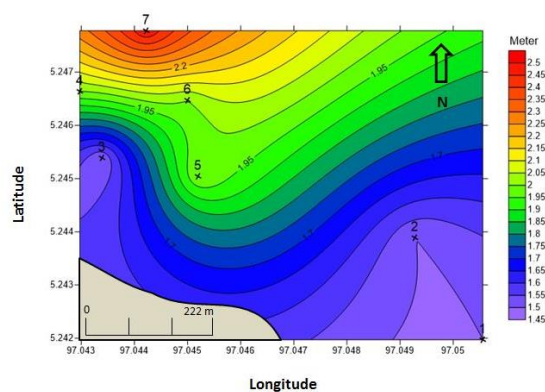


Figure 5. Brightness distribution at Krueng Geukueh waters, North Aceh Regency

TSS

The result of total suspended solids (TSS) is around 10.4 – 38.0 with average of 17.5 mg/L. The lowest point was at point 7 with the value of 10.4, where the highest value is at point 5 for 38 mg/L. Point 5 indicates the high level of pollution which obstruct light penetration to the water which caused disruption of photosynthesis process for marine biota. From this result too, the total suspended solids (TSS) according to the decree of ministry of environment No. 51 Year 2004 for harbour area is considered in the threshold which is 80 mg/L. Quality standard for marine tourism is outside the threshold which is 20 mg/L.

TSS distribution (Figure 6) highly concentrated at the part near to coastal area, since it is close to the harbour gate that has a breakwater to protect the beach from erosion so high sediment is created in front of the breakwater. The further it is from the coastal area, the lower concentration of TSS found in this research.

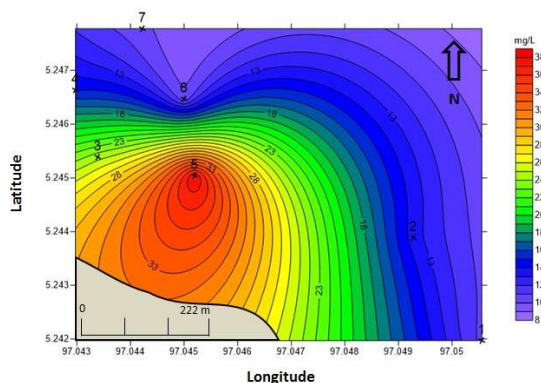


Figure 6. TSS distribution at Krueng Geukueh waters, North Aceh Regency

COD

Measuring result of COD is around 17.78 – 27.94 mg/L. The average number is 23.22 mg/L. The lowest COD is shown at the point 5 with the value of 17.78 mg/L, this could happen because of many water plants that absorb organic matters in the water. On the contrary, the highest number of COD is at point 3 with the value of 27.94 mg/L since it has the waste that difficult to biologically degraded so chemical oxidation process of organic compounds often occurs in this point (Fardiaz, 1992). COD distribution transversely (Figure 7) at the south, southeast and north of point 1, 2 and 7 are concentrated around 22.86 – 25.40 mg/L. The lowest concentration is at point 5 and 6 with the concentration ranged around 17.78 – 20.32 mg/L. At the western part, the highest COD concentration is located at point 3. It might be caused by many organic waste materials that brought by the flow to the sea.

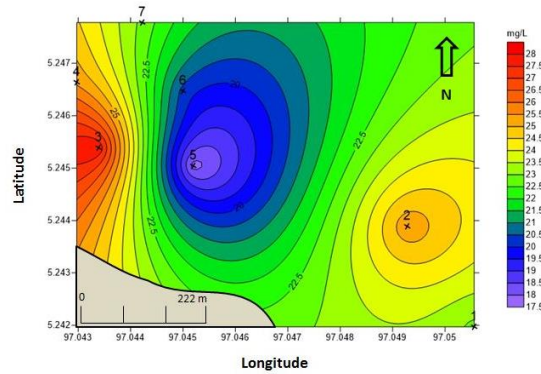


Figure 7. COD distribution at Krueang Geukueh waters, North Aceh Regency

BOD₅

Based on the analysis result, the amount of BOD₅ at the Krueang Geukueh waters is around 0.39 – 0.59 mg/L and the average number of it is 0.39 mg/L. The amount of BOD₅ at Krueang Geukueh waters shows that this water is considered as having low level of pollution as stated by Salmin (2005) that low pollution level is ranged around 0 to 10 mg/L. According to the decree of ministry of environment No. 51 Year 2004, this BOD₅ value is still in the threshold of quality standard of seawater for the marine biota which is 20 mg/L. Biological need of oxygen for a water body is the amount of oxygen needed by an organism in the water to breath for five days. BOD measuring is based on the ability of microorganism to parse the organic compound, so it is only for the compound that biologically easy to parse such as the compounds in the household. For chemical products such as oil compounds and other chemical waste, it will be difficult to parse or even impossible for microorganism to parse it (Barus, 2004).

BOD₅ distribution (Figure 8) at Krueang Geukueh waters close to the coastal area illustrated the evenly distributed concentration along the coast and does not indicate any significant difference at the entire research points. The southwest and north part indicates an increase of organic matters in the waters. There might be a meeting current between the one about to tide in the waters with water current at river that entering the sea caused by the rain in upstream, bringing organic matters that will be decomposed.

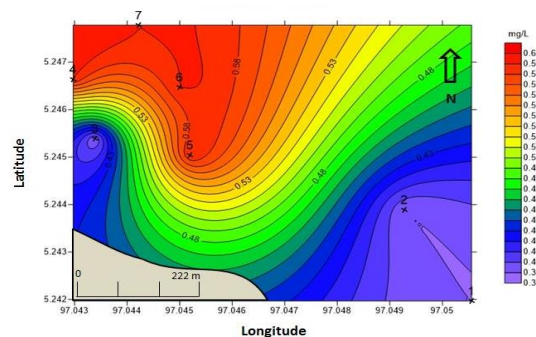


Figure 8. BOD₅ distribution at Krueang Geukueh waters, North Aceh Regency

Total Coliform

The total coliform resulted from the research is about 14 – 1600 APM/100 ml, with the average coliform is 502 APM/100 ml. The highest number of coliform is indicated at point 3 and 5 which is 1600 APM/100 ml, since domestic activity of people occurs in these points which generate waste. Therefore, the frequency of domestic and non-domestic waste influx is increasing and affecting the development of coliform bacteria. Arifudin (2013) discovered that the total coliform at sampling location at point 3 and 5 is above the threshold according to the decree of ministry of environment No. 51 Year 2004 regarding quality standard of seawater for marine biota, harbour waters and marine tourism where the threshold is 1000 APM/ 100 ml. The high number of waste will affect the growth of E. coli bacteria.

Coliform distribution (Figure 9) is dominating at 2 locations which are at the point 3 and 5. This fact is influenced by the condition at the time sampling is conducted which is in a high tide and near the activity of people. According to Wahyuni (2016), the density of coliform is higher in a high tide compared to the low tide. The temperature at point 3 and 5 is also fit the suitable temperature for coliform to grow which is 28.2 – 28.3oC. In accord to Suriawiria (2003) coliform is a mesophyll microorganism that grows well at the temperature of 25 – 37oC. Therefore, another factor besides the activity of people and the tidal condition is the temperature.

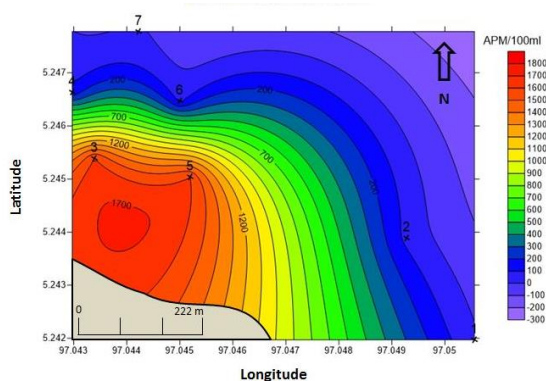


Figure 9. Coliform distribution at Krueng Geukueh waters, North Aceh Regency

Salinity

According to the result, the salinity is ranged around 32.4 – 32.4‰, with the average number is 31.9‰. The lowest salinity level is found at the point 1 where it is located near the estuary, which is 31.4‰. The low number of salinity in this area shows the influence of land such as the mixture of fresh water that brought from estuary of Krueng Geukueh Rivers. The salinity will decrease as much as rivers that empty into the sea. Daulat (2014) said that waters salinity that directly affected by human activity and the existence of rivers will have less amount compared to the one that directly related to the open water. According to Arief (1984), fresh water has a low level of salinity which generally less than 3‰ where sea water has the salinity of over 33‰. River flow will generate mixing process of rivers and seawater.

In the process of mixing, salinity value will range around the salinity level of fresh water and the salinity level of seawater. The salinity value will increase in approaching waters at point 7 which

is 32.4‰, since the mixture of fresh water is less. According to Simanjuntak (2009), this situation is highly related to the stirring of water masses from below to the surface and infiltration of water masses with high salinity that moved from sea to the beach. This condition is caused by the anthropogenic influences from the land that influx and mix to coastal waters so it affects the water salinity. Variety of seawater salinity would influence aquatic bodies according to water osmotic pressure. The higher salinity level, the greater osmotic pressure (Verawati, 2016). Salinity level of sea is around 30 – 40‰. At the hypersaline waters, salinity value could reach around 40 - 80‰. The alteration of salinity could cause danger for some organism (Castro, 2008).

At the salinity distribution (Figure 10), it is shown that salinity distribution pattern is low at the estuary area of point 1, concentration of salinity is increasing the more it approaches open sea. Salinity distribution of waters is caused by several factors such as water circulation pattern, evaporation, rainfall and stream water flow (Nontji, 2002). At the time this research is conducted in the early point, intensity of sunlight is still very low (cloudy) that leads to low evaporation. The most important factor causing the low salinity is the fresh water supply from the river.

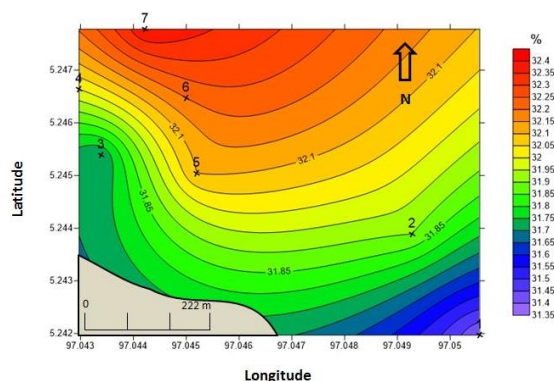


Figure 10. Salinity distribution at Krueng Geukueh waters, North Aceh Regency

Mercury

The resulting mercury measurement is around 0.001 – 0.006 mg/L. Measurement result of mercury content in point 1,2,3,4,5 and 7 is at the threshold of quality standard while the mercury content is above the threshold at point 6 for the location which contains 0.006 mg/L. Contamination of mercury might be from mercury use in industrial activities, laboratory, and other dangerous waste from household waste around the research point. The average number of mercury found in this research is 0.002 mg/L. According to the decree of ministry of environment No. 51 Year 2004 regarding quality standard of mercury contamination at seawater for marine biota is 0.001 mg/L, for marine tourism is 0.002 mg/L and harbour waters are 0.003 mg/L. Influx of mercury to human's body other than air is from food and water (Tugaswati, 1997). Therefore, further monitoring is needed for Krueng Geukueh waters with the amount of mercury contamination that above the threshold in the point of research since the research location is close to the housing residents who directly using Krueng Geukueh waters to support their life. Biologically, mercury could accumulate in the food chain and at the end will endanger human health.

Mercury distribution at (Figure 11) illustrates the mercury contamination spread around the seventh points of research. Based on Mukhtasor (2007) current is more effective as a distribution media and pollutant dilution which influx to the waters. Consequently, the condition of low tide into high tide (spring tide) might be causing pollutant to spread around the research points. Currents and wind could affect metal mercury that overspread at Krueng Geukueh waters. Besides the chemical factors, there are also other physical factors which generate this distribution including tidal factor and other oceanographic factors. Mercury is concentrated at point 6 (Northern area), since mercury is easily dissolved in the water and part of it is sinking to the bottom and concentrate in sediment. The sampling process is also done by stirring so it might also mix into the Vandon sampler.

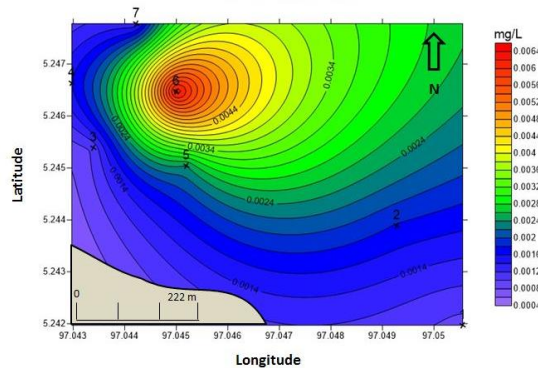


Figure 11. Mercury distribution at Krueng Geukueh waters, North Aceh Regency

Pollutant Index Measurement

The measurement of pollutant index for harbour area, marine tourism and marine biota under the law number 115 years 2003 is stated below:

Table 1.1 Pollutant index measurements for harbour

Parameters	Average (C _i)	Harbour (X)	
		Quality Standard (L _{ix})	C _i /L _{ix}
Temperature	28.2		
DO	5.34		
pH	7.9	6.5 – 8.5	0.40
Brightness	1.9	>3	1.16
TSS	17.5	80	0.22
COD	23.22		
BOD ₅	0.5		
Salinity	32		
Tot Coliform	502	1000	0.50
Mercury	0.002	0.003	0.67
(C _i /L _{ix}) Max			1.16
(C _i /L _{ix}) Average			0.59
IP _x			0.92
Overall Analysis Result			Good

Overall analysis result of Pollutant Index (PI) for harbour (Table 1.1) is in a good condition, the PI for this harbour is almost 1 (slightly contaminated) and the parameters contributing to this situation is the brightness. It is caused by the coastal area of waters that influenced by domestic activities at the harbour such as loading and unloading of goods. One of these activities is cement packaging and local people activities which donate sediments that decrease the brightness level, and the sampling time is also cloudy.

Table 1.2 Pollutant index measurements for marine tourism

Parameters	Average (C _i)	Marine Tourism (Y)	
		Quality Standard (L _{iy})	C _i /L _{iy}
Temperature	28.2		
DO	5.34	>5	0.83
pH	7.9	7 – 8.5	0.20
Brightness	1.9	>6	1.62
TSS	17.5	20	0.88
COD	23.22		
BOD ₅	0.5	10	0.05
Salinity	32		
Tot Coliform	502	1000	0.50
Mercury	0.002	0.002	1.00
(C _i /L _{iy}) Max			1.62
(C _i /L _{iy}) Average			0.73
IP _y			1.26
Overall Analysis Result			Slightly Contaminated

Overall analysis result of Pollutant Index (PI) for marine tourism (Table 1.2) is considered as slightly contaminated. The parameters contributing this condition are brightness and mercury. There are harbour activities marine tourism, housing residents and activity of fishing boat dock found in this research location, so the Krueng Geukueh water is highly affected by these activities. Marine tourism is one of the tourism that vulnerable to human activity and environmental change. The marine tourism activity that often done in Krueng Geukueh sea is fishing and taking bath. It is suspected as one of the contributors of mercury contamination that people use cosmetic product such as sunblock before taking a bath that makes it dissolved in the water. Large number of mercury contamination is caused by human waste. People have been using mercury oxide (HgO) and mercury sulphide as coloring agent and cosmetic ingredients for a long time. Sea water is one of the components that interact with the land, where waste disposal from the land will end up in the sea. Moreover, sea is also a recipient of pollutant that falls from the atmosphere. These wastes consisting of pollutant then infiltrate the ecosystem of waters, beach and sea.

Table 1.3 Pollutant index measurements for marine biota

Parameters	Average (C _i)	Marine Biota (Z)	
		Quality Standard (L _{iz})	C _i /L _{iz}
Temperature	28.2	28 - 32	0.90
DO	5.34	>5	0.83
pH	7.9	7 – 8.5	0.20
Brightness	1.9		
TSS	17.5	80	0.22
COD	23.22		
BOD ₅	0.5	20	0.03
Salinity	32		
Tot Coliform	502	1000	0.50
Mercury	0.002	0.001	2.00
(C _i /L _{iz}) Max			2.00
(C _i /L _{iz}) Average			0.67
IP _z			1.49
Overall Analysis Result			Slightly Contaminated

Overall analysis result of Pollutant Index (PI) for marine biota (Table 1.3) is considered as slightly contaminated, and the parameter contributed the most to this condition is mercury. The high amount of mercury contamination could interfere/contaminate another marine biota such as fish, shrimp, clam, seaweed and other organisms which live in the sea. If high amount of mercury is accumulated, it will harm the health in neural system, digestion, cardiovascular, kidney and harming the pregnancy process.

Conclusion and Suggestion

Based on the result of research conducted, it can be concluded that some amount of mercury is detected in several points of research which is on and above the threshold of quality standard as well as for the total coliform. Quality standard status for the harbour area of Krueng Geukueh is good, as for the marine tourism is slightly contaminated and for marine biota is slightly contaminated.

Writer suggest from the result of this research is to arrange a scheduled monitoring by relevant agencies and stakeholders who benefit from the Krueng Geukueh waters, North Aceh Regency, so the marine biota, harbour waters and marine tourism will not be disturbed. The result of this research will later be used as reference for a more focused research in term of mercury by

sampling the data time series, and measuring factors such as current, tidal condition, wind direction to gain more accurate data.

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