Biosaintifika 9 (2) (2017) 370-379

Biosaintifika

Journal of Biology & Biology Education

http://journal.unnes.ac.id/nju/index.php/biosaintifika

Correlation of Physical-Chemical Parameters to Total Coliform Value in Jawi River, Pontianak, West Kalimantan

✉Rahmawati[1], Laili Fitria[2], Liza Syafitri[2]

DOI: 10.15294/biosaintifika.v9i2.10187

[1]Faculty of Mathematics and Natural Sciences, Universitas Tanjungpura, Pontianak, Indonesia
[2]Faculty of Engineering, Universitas Tanjungpura, Pontianak, Indonesia

History Article

Received 4 May 2017
Approved 31 June 2017
Published 17 August 2017

Keywords

correlation; physical-chemical; coliform; MPN; Jawi River

Abstract

Coliform bacteria can be used as an indicator of the presence of pathogenic bacteria, such as *E.coli* bacteria that cause diarrhea. The aimed of this study is to determine the relationship between physical-chemical parameters namely temperature, pH, DO and BOD to the density of coliform bacteria in Jawi River, Pontianak. The sampling was conducted at one point each in the upstream, midstream and downstream area of the Jawi River during two tidal conditions of the Kapuas River in September 2016 at 09:40 (at low tide) and at 15:40 (at high tide). The correlation of physical-chemical parameter to coliform value was tested Pearson Product Moment. The results showed that coliform bacterial density increased from upstream to downstream with 150-1500 MPN/100 ml at high tide and 930-11000 MPN/100 ml at low tide. The results showed that the coliform bacterial density value had a positive relation with pH and BOD parameters and negative relation with temperature and DO parameters. So, it can be concluded that there is a correlation between physical parameters, such as temperature and chemical parameters such as pH, DO and BOD to microbiological parameters especially Coliform bacterial density. The benefit of this study is to give information about water quality of Jawi River and its correlation with density of Coliform bacterial, so that people are expected to pay more attention to the use of clean water to avoid the disease caused by coliform.

How to Cite

Rahmawati, Fitria, L., & Syafitri, L. (2017). Correlation of Physical-Chemical Parameters to Total Coliform Value in Jawi River, Pontianak, West Kalimantan. *Biosaintifika: Journal of Biology & Biology Education*, 9(2), 370-379.

✉ Correspondence Author:
Jl. Prof. Dr. Hadari Nawawi, Pontianak, West Borneo 78124
E-mail: rahma_bio02@yahoo.com

p-ISSN 2085-191X
e-ISSN 2338-7610

INTRODUCTION

Water quality is influenced by changes in land use, such as an increase in domestic, agricultural and industrial activities which have an impact on BOD concentrations (Priyambada et al., 2008). This is similar to the idea of Agarwal et al. (2011) stated that most rivers in urban areas of developing countries are industrial waste, such as in Africa and Asia which have rapid industrial growth and affect environmental conservation conditions. Anhwange et al. (2012) and Abida et al. (2008) suggest that the accumulation of discharges such as urea, animal manure and vegetable cuts into aquatic bodies became the growth factor of algae and other aquatic plants as a result of an increase in the number of microbial activity. Uncontrolled distribution of waste discharges may lead to degradation of water quality such as a decrease in dissolved oxygen content and the death of aquatic animals.

Jawi River in Pontianak is the primary channel which lies between the West Pontianak District and the Pontianak District as well as being the estuary for the secondary channel from the surrounding residential areas. According to Ramadhani (2012), the continuous discharge of domestic waste in the Jawi River affects water quality in waterways such as the consumption of dissolved oxygen. Based on the results of research of Khotimah (2009), it is showed that the highest coliform bacterial density was found at the mouth of the Jawi River. The use of polluted river water may affect the health status of the users with the emergence of water-borne disease, one of which is diarrhea. Contaminated water affects the health of human populations around the world, especially for developing countries (Cabral, 2010). In developing countries, 43 cases of the disease are caused by water-borne diseases, with diarrheal diseases as the first leading cause of death especially in children (Rahman et al., 2013). The same thing is expressed by Kumar et al. (2011) and Farkas et al. (2013) that pollution in rivers may spread diseases such as cholera, typhoid fever and diarrhea.

Generally, the presence of bacteria in the water is influenced by abiotic factors such as temperature, pH, oxygen demand and moisture and biotic factors that include negative and positive interactions between populations. Water to be used for drinking, domestic, agricultural and industrial purposes is essential to be tested first on the physical, chemical, and microbiological parameters of the water. Some physical parameters tested are temperature, color, odor, turbidity and TDS (Total Dissolved Solid), chemical parameters include pH (potential of Hydrogen), BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), DO (Dissolved Oxygen), alkalinity and hardness (Patil et al., 2012), as well as microbiological parameters in the form of microbial content, the presence of coliform bacteria as an indicator of pathogenic microbes. Therefore, it is necessary to investigate relationship of density of coliform bacteria with physical-chemical parameters, particular parameters of temperature, pH, DO and BOD along Jawi River channel region. Selection of these parameters based on the growth factor of Coliform bacteria that adjust the conditions of temperature, pH, oxygen levels and nutrients in the water it occupies.

Pujiastuti et al. (2013) stated that water temperature affects the process of metabolic exchange of living things and affects the dissolved oxygen level and the growth of fish populations. The pH of water affects plants and aquatic animals, so it is often used for the condition of the good or poor state of the water as the living environment of water biota. Dissolved oxygen is one of the dissolved gases in the waters with varying levels and influenced by temperature, salinity, water turbulence and atmospheric pressure. Oxygen is also needed in the process of decomposition of organic compounds into inorganic compounds. The source of dissolved oxygen comes from the diffusion of oxygen present in the atmosphere, either directly in stagnant conditions or due to agitation (mass water upheaval) due to the presence of water or wind waves. According to Varale & Yashodhara (2012) BOD is the average amount of oxygen used by bacteria when decomposing organic substances into inorganic substances in the aerobic phase. The process of decomposition and activity of bacterial metabolism use dissolved oxygen. Dissolved oxygen is used to calculate the amount of BOD content in the tested sample.

Coliform bacteria is used as indicator of fecal pollution or human and animal feces in the waters because coliform bacteria are intestinal bacteria derived from human intestines and other warm-blooded animals, such as chickens, cows and pigs (Badiamurti, 2010; Rajendra et al., 2012). Thus, the bacteria should not be present in the used water, in terms of health, aesthetics, hygiene and the possibility of dangerous infections (Pujiastuti et al., 2013). This became the basic purpose of this study, which is to determine the relationship between physical-chemical parameters such as temperature, pH, DO and BOD against the density of coliform bacteria in the river Jawi, Pontianak.

METHODS

This research was conducted in Jawi River, Pontianak City (Figure 1). The study was conducted from September 2016 to November 2016 covering sampling, physical and chemical factor measurements, calculation of Coliform bacterial density, and data analysis. Analysis of DO and BOD samples was conducted at the Laboratory of Land Quality and Health, Faculty of Agriculture and Coliform analysis was conducted at Microbiology Laboratory, Faculty of Engineering, Tanjungpura University, Pontianak.

The tools used for this research on the field were the measuring beam, the ball that has been given ballast, measuring tape, rope, sample bottles of 250 ml and 1 L, Winkler bottle, thermometer, pH-meter. Tools used in laboratory were beaker glass, Erlenmeyer glass, test tube, test tube rack, petri dish, ose needle, bunsen, micropipette, dropper drops, hot plate, plastic wrapping, incubator, Laminar Air Flow, autoclave, durham tube, analytic balance and spatula. The materials used are aquades, carbolic, alcohol 70%, LB (Lactose Broth) media, BGLB (Brilliant Green Lactose Broth) and EMB (Eosin Methylene Blue) agar.

Sampling was conducted on September 16, 2016 at the highs and lows of the Kapuas River, at 09.40 WIB (low tide) and at 15:40 (high tide) at the upstream (Parit Haruna), midstream (Suwignyo) and downstream (Gertak I Jawi River). Sampling DO and BOD were taken using size 1 L bottles and Winkler bottles and were duplicated. The first stage of sampling for the DO and BOD parameters was rinsing the sample bottle with the sample water to be taken three times to homogenize the condition of the bottle with the sample water. Then, the water sample was taken by dipping the bottle under the water surface and closed until it was airtight. Microbiological sampling used 250 ml sample bottles that have been sterilized by using autoclave. The sample bottle was dipped below the water level (± 20 cm), the position of mouth of the bottle is opposite to the flow direction. The mouth of the bottle was immediately closed and put in the cool box. Microbiological sampling was done in 3 times repetition (Khotimah, 2009).

Temperature measurements were made by inserting a thermometer into the sample water for ± 5 minutes until the temperature figure on the thermometer was stable. The pH meter measurements were made by entering the pH meters into the sample and the results was recorded when the numbers indicated on the device were stable. Measurements of DO and BOD parameters using iodometric titration method were performed at the Laboratory of Land Quality and Health.

Calculation of total value of coliform used MPN test with sample volume value that is 1 ml, 0,1 ml and 0,01 ml on 3 series of test tube (WHO, 1996). The coliform test refers to SNI 01-2332.1-2006, including estimation test, assertion test and complementary test. The formula used to find the value of the density of Coliform is (APHA, 2005):

$$MPN/100\,ml = value\ of\ MPN\ table/100\ ml \times \frac{first\ column\ of\ treatment\ (1\ ml)}{smallest\ tube\ dilution\ (0,1\ ml)}$$

(Equation 1)

The analysis of temperature, pH, DO and BOD parameters to coliform bacterial density was using Pearson Product Moment correlation test, so that correlation value and direction of relationship between parameters have been known to be analyzed. If the value of R approaches 1 or -1, then there is a relationship between the variables, but if the value of R is 0, then there is no relationship between variables tested. Pearson Product Moment correlation test is using the following formula (Sugiyono, 2016):

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \times \sum y^2}}\text{, with } \alpha = 5\%$$

, with α = 5% (Equation 2)

Thus, the hypothesis used for Pearson Product Moment correlation test is:

1) $H_0 : R = 0$; 2) $H_a : R \neq 0$

Figure 1. Sampling point in Jawi River, Pontianak City

RESULTS AND DISCUSSION

The value of DO and BOD Jawi River water varied at each point and affects water quality standards as shown in Table 1 and Table 2. The temperature value at low tide was lower than during high tide, this is because of differences in sampling time that affect the ambient temperature (Saputri, 2014). In addition, the temperature difference at each point is also influenced by the seasons, geographical location, weather differences, air humidity and the intensity of sunlight

(Ahinpathi & Puttaiah, 2006; Romanto, 2013). The water temperature of Jawi River were ranged from 28 - 31°C and classified in class I, II, III standard quality. Berutu (2001) said if the water temperature ranges from 27 - 29°C even 30 - 31°C, it is still in the normal temperature for tropical waters. According to Sunardi (2017), changing in water temperature may affect the freshwater condition as it links directly to water cycle, such as changing water column stratification and resources availability, mainly nutrients, light or intensified grazing by heterotrophs.

The pH of Jawi River was in the range of 6,8 - 8 and classified in class I, II and III quality standards. At the upstream and middle point, the pH value was lower than the downstream point because in the upstream area, there are still some people who use the water of Jawi River for the purpose of washing clothes, tableware and even bathing, so that the waste water from these activities went directly into the water flow. According to Romanto (2013), the remainder of these activity are allegedly carrying organic material to be decomposed by water microbes.Wardhana (2014) stated that pH values are also influenced by waste discharges that convert the concentration of hydrogen ions in water to acid or base due to the chemical content contained therein. Atobatele et al. (2008) suggested that the decrease in pH is also associated with increased rain intensity. Decrease in pH in the rainy season can reduce the quality of dissolved oxygen due to the entry of organic matter carried by the rain. Adeyemo et al. (2008) stated that the optimal pH for the survival of aquatic organisms is 6.5 – 8.2.

The content of dissolved oxygen depends on temperature, the presence of plants for photosynthesis, physiological activity and physiological processes of plankton, the degree of light penetration dependent on depth and turbidity of water, degree of water hardness and the amount of organic matter described in water (Astel et al., 2006; Vikal, 2009; Rosli et al., 2010). The water flow of the Jawi River gets runoff from the housing complex, market and shop. Son (2013) stated that generally the concentration of DO in a waters is temporary or seasonal and fluctuates.

The decrease in the BOD value in water was caused by the effective sedimentation and deoxygenation process of river water or waste materials which were affecting the river environment and the characteristics of the waste without prior treatment which directly discharged into water bodies (Fardiaz cit. Saputri, 2014). Differences in BOD values in each point were also caused by the influx of pollutants received by water bodies from surrounding areas such as residential areas, shops and open land (Trofisa, 2011). River with low BOD values had low nutrient levels and included as a part of DO concentrations. Unspoiled and uncontaminated waters have a BOD value of less than 5 mg/L (Agbaire & Oyibo, 2009). BOD value is usually higher in the rainy season than in the dry season (Ezekiel, 2001). In this study, the sample analysis for BOD parameters was performed at high and low tide, marked with higher BOD values at high tide due to inclusion of loads of contamination from the Kapuas River into the Jawi River. Most of the organic waste that can be broken down by microorganisms is in the water, but there are some organic components that are difficult to decompose such as lignin and cellulose. The component will cover the water area, degrade the water area and cause the decrease in dissolved oxygen concentration (Usman, 2015). Organic materials containing carbon, nitrite, phosphate, ammonia and some minerals are nutrients for the growth and breeding of pathogenic microorganisms (Sidharta, 2000). In addition, the presence of nutrients also affects the amount of algae production (Varunprasath & Nicholas, 2010). High consuming rate of nutrition make biomass and microorganisms primary productivity in the ecosystem were inversely to pH, nitrate concentration, temperature and other hydrobiological parameters (Setiabudi, 2016).

The value of the density of the Coliform bacteria of the Jawi River water varied at each point and affected the water grade standard as shown in Table 1 and Table 2. After a complementary test using EMB media, Jawi River water positively contains *E.coli* bacteria at each sampling point during high tide and low tide. Some people who live close to the Jawi River still use the water for bathing and washing purposes, either used directly or aspirated using a pump to the people's home. The existences of these activities also affect the water quality of the Jawi River and have the potential to have an impact on public health. The research result Cahyaning et al. (2009) shows the link between river water utilization for bathing and washing kitchen utensils with increasing cases of diarrhea and skin diseases.

The temperature and DO parameters are related to the total of Coliform bacteria with the direction of inverse relationship, where, if the Coliform bacterial density value continues to increase at each point, the temperature and DO values will decrease, so the curves shown in Figures 2 and Figures 4 are mutually inversely proportional. This also occurs in the resulting correlation

Table 1. Results of Jawi River Water Quality Analysis

Location	Result									
	High Tide					Low Tide				
	Temperature (°C)	pH	DO (mg/L)	BOD (mg/L)	Coliform (MPN/100 ml)	Temperature (°C)	pH	DO (mg/L)	BOD (mg/L)	Coliform (MPN/100 ml)
Parit Haruna (upstream)	28	7	5.67	15.17	150	30	6.8	6.78	13.64	930
Jl. Suwignyo (midstream)	29	7.8	5.51	13.05	430	31	6.9	7.96	9.49	2400
Gertak I Sungai Jawi (downstream)	28	8	1.14	27.96	1500	28	8	3.98	16.52	11000

Table 2. Quality Standard of Jawi River Water Class

Location	Water Quality Standard of Government Regulation No. 82 Year of 2001								Decree of The Directorate General of PPM and PLP	
	High Tide				Low Tide				High Tide	Low Tide
	Temperature	pH	DO	BOD	Temperature	pH	DO	BOD	Coliform	
Parit Haruna (upstream)	I - III	I - III	II	IV	I - III	I - III	I	IV	C	C
Jl. Suwignyo (midstream)	I - III	I - III	II	IV	I - III	I - III	I	III	C	D
Gertak I Sungai Jawi (downstream)	I - III	I - III	III	IV	I - III	I - III	III	IV	D	E

values of -0.32 during high tide and -0.892 at low tide for temperature parameters, as well as -0.986 at high tide and -0.91 at low tide for DO parameters. Eisakhani & Malakahmad (2009) stated that the number of Coliform bacteria would be lower when the temperature level, and DO are higher. This is due to the pollutant source of Coliform which is related to the activity of human secretion. The same is consistent with the research of Bensig et al. (2012) and Singh et al. (2014) which states that the DO parameter is negatively correlated to the total Coliform.

The pH and BOD parameters are related to the total of Coliform bacteria with the direction of proportional relationship, if the Coliform density value continues to increase at each point, the pH and BOD values also rise, so that the curves shown in Figures 3 and Figure 5 are directly proportional. This also occurs on the resulting correlation value of 0.7904 at high tide and 0.9982 at low tide for pH parameters, as well as 0.9462 at high tide and 0.7227 at low tide for BOD parameters. This is consistent with research by Bensig et al. (2012) which also concluded that the BOD parameter correlated positively with total Coliform bacteria. Singh et al. (2014) also concluded that the pH parameter was positively correlated with total Coliform. The pH, BOD or total coliform values continue to increase from upstream to downstream at high and low tide. The organic exhaust that enters the waters affects the value of BOD and Coliform bacteria that degrade the organic material. The existence of degradation activity causes the pH content to change into base or acid due to changes in hydrogen ion concentration value.

The existence of coliform bacteria in surface water comes from the point source and diffuse source which has been concentrated in a long time. Point source pollution includes urban waste and contaminated tributaries. While diffuse source pollution includes pollution from agriculture and rainwater flows. The burden of water-borne

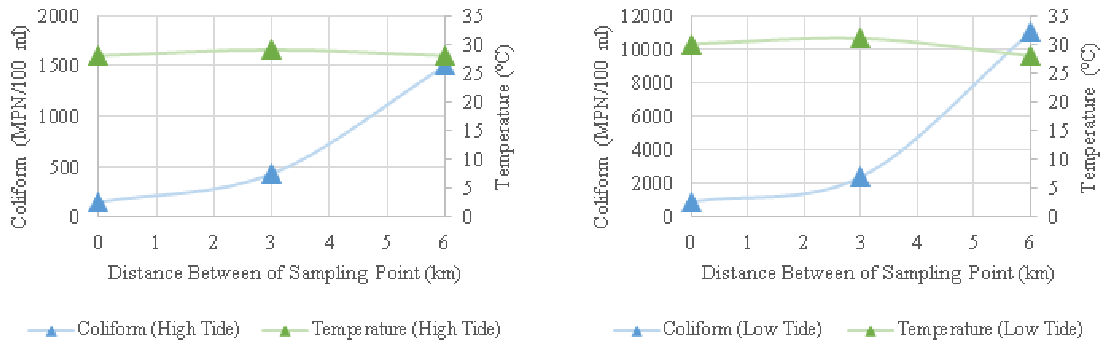

Figure 2. Relation of Coliform and Temperature Parametes at High and Low Tide

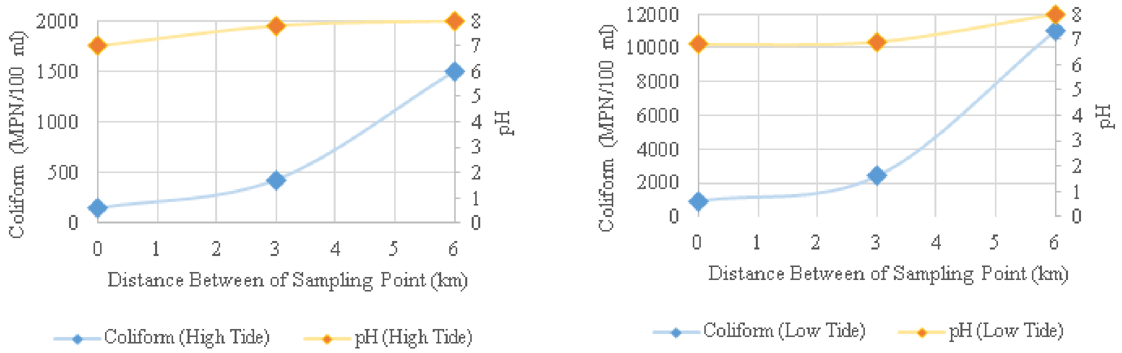

Figure 3. Relation of coliform and pH parameters at high and low tide

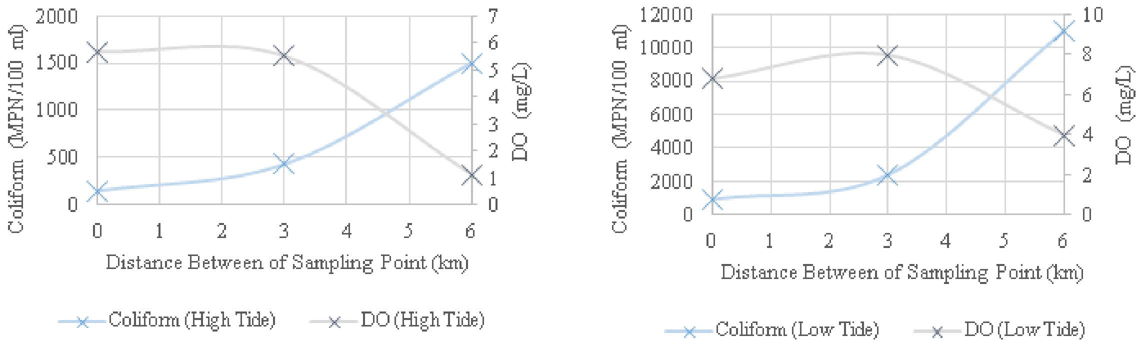

Figure 4. Relation of Coliform and DO Parameters at High and Low Tide

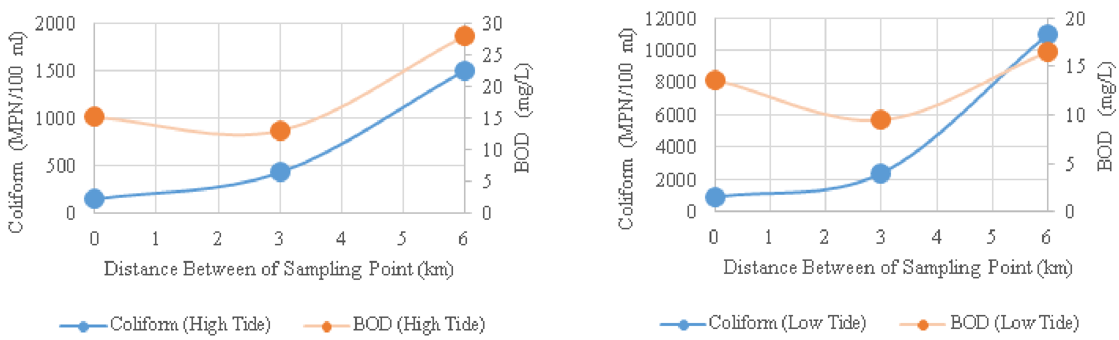

Figure 5. Relation of Coliform and BOD Parameters at High and Low Tide

bacteria around the catchment area is a natural factor due to the effects of weather (rain, sunlight, temperature), hydrology and topography (Kinzelman et al., 2004; Mills & Thurman, 1994). Rainwater flows also carry bacterial contamination from peripheral environments such as animal waste and pavement (Karlaviciene et al., 2009; Sidhu et al., 2013).

Rivers play an important role as the assimilation of urban and industrial waste discharges from rainwater flow (Sigua & Tweedale, 2003). Improper water quality can be hazardous to health, so efforts should be made to improve the management of water quality in water catchment areas (Astrom et al., 2007; Won et al., 2013). The existence of physical, chemical and microbiological parameters in waters are interconnected, as described in the preceding paragraph. Usman (2015) stated that the parameters of temperature, pH, dissolved oxygen and BOD are included as biotic factors that affect the existence of coliform bacteria. The result of the analysis shows that there was correlation between the biotic factors on the growth of coliform bacteria. Temperature and pH parameters act as indicators of certain bacterial species, such as coliform bacteria are tolerant to mesophyll temperature range (25 - 37°C) and neutrophil pH (6.7 – 7.5) as shown in the results of this study.

Astrom et al. (2002) stated that Coliform bacteria are not too dependent on dissolved oxygen demand, so it is characterized as anaerobic facultative that plays a role in the process of respiration and electron acceptor. In addition to oxygen, bacteria also require nutrients for metabolic processes obtained from organic matter in the waters. Decomposition analysis of organic matter in waters by bacteria can be seen from the result of BOD parameter measurement. The higher the organic material in water causes the dissolved oxygen content to be smaller because it is used by bacteria to oxidize organic matter. The principle of restructuring the organic materials in the water by means of aeration is used to increase the dissolved oxygen, so that the bacteria can perform the decomposition of organic matter in the water treatment process.

The surface water which will be used should be free from contaminants either physically, chemically or microbiologically. Optimization of processing and improvement of water quality related to the types of parameters aimed to be minimized (Han et al., 2012 & Sedmak et al., 2005). Control and elimination of sources of bacteria contaminating water sources can be done in several ways (Okoh et al., 2007), among which is an integrated liquid waste treatment system, which is responsible for collecting waste from residential, commercial and industrial pollutants (Ritter et al., 2002), The abundance of water in urban areas from both drainage and rainfall runoffs connected to the area of the waste treatment system (Even et al., 2007), and the use of septic tanks to collect and process waste from settlements (Cheung & Venkitachalem, 2004). In addition, the surface water management of the technical aspect comprises boil processing method by heating the water temperature up to 100°C for 1 minute. Any area with an altitude above 1000 feet above sea level should add water heating time to effectively kill bacteria. Chlorination treatment uses chemicals for the disinfection process. In this method, Cl_2 or NaOCl is added to water and produces hypochlorous acid (Richardson, 2002). Filtration treatment uses shards of ceramics, sand, gravel or zeolite (Makutsa, 2001). The bacteria will be separated from the water from the top filter compartment to the lowest compartment and water will go to the shelter (Iijima, 2001). The benefit of this study is to give information about water quality of Jawi River and its correlation with density of coliform bacterial, so that people are expected to pay more attention to the use of clean water to avoid the disease caused by Coliform.

CONCLUSION

The density of Coliform bacteria in the Jawi River at high tide continued to increase from upstream to downstream, ranging from 150-1500 MPN/100 ml at high tide and 930-11000 MPN/100 ml at low tide. If the water is associated with the classification of water class according to Decree of Directorate General of PPM and PLP No. 1/PO.03.04.PA.91 the water quality of Jawi River is classified C and D class at high tide and class C, D and E at low tide. Based on the correlation analysis, the pH and BOD parameters are related to the direction of directly proportional, the temperature and DO parameters are also related to the direction of inversely proportional. So, it can be concluded that there is a correlation between physical parameters, such as temperature and chemical parameters such as pH, DO and BOD to microbiological parameters especially Coliform bacterial density.

REFERENCE

Abida, B., Harikrishna, S., Irfanulla, K., Ramaiah, M., Veena, K., & Vinutha, K. (2008). Analysis of Flouride Level in Water and Fish Species of Sankey, Bellandur and Madivala Lakes of Bangalore, Rasayan. *Journal of Chemistry*, 1(3), 595-601.

Adeyemo, O.K., Adedokum, O.A., Yusuf, R.K., & Adeleye, E.A. (2008). Seasonal Changes in Physico-Chemical Parameter and Nutrient Load of River Sediments in Ibadan City, Nigeria. *Global NEST Journal*, 10(3), 326-336.

Agarwal., Animesh and Manish., & Saxena. (2011). Assesment of Pollution by Physicochmecial Water Parameters Using Regression Analysis: A Case Study of Gagan River at Moradabad-India. *Applied Science Research*, 2(2), 185-189.

Agbaire, P.O., & Oyibo, I.P. (2009). Seasonal Variation of Some Physico-Chemical Properties of Borehole Water in Abraka, Nigeria. *African Journal of Pure and Applied Chemistry*, 3(6), 116-118.

Ahinpathi, M.V., & Puttaiah, E.T. (2006). Ecological of Vrishabhavathi River in Bangalore (India). *Environmental Geology*, 49, 1217-1222.

Anhwange, B.A., E.B. Agbaji., & E.C. Gimba. (2012). Impact Assesment of Human Activities and Seasonal Variation on River Benue, Within Makurdi Metropolis. *International Journal of Science and Technology*, 2(5), 248-254.

APHA. (2005). *Standard Methodes for The Examination of Water and Wastewater. 20th Ed.* American Public Health, Association, American Water Works Association Water Environment Federation.

Astel, A., Biziuk, M., Przyjazny, A., & Maiesnik, J. (2006). Chemometrics in Monitoring Spatial and Temporal Variations in Drinking Water Quality. *Water Research*, 40(8), 1706-1716.

Astrom, K., Petterson, S., Bergstedt, O., Petterson, T.J., & Stenstrom, T.A. (2007). Evaluation of The Microbial Risk Reduction Due to Selective Closure of Raw Water Intake Before Drinking Water Treatment. *Journal of Water and Health*, 5, 81-97.

Atobatele, Oluwatosin E., Ugwumbe., & Alex, O. (2008). Seasonal Variation in The Physicochemistry of A Small Tropical Reservoir (Aiba Reservoir, Iwo, Osum, Nigeria). *African Journal of Biotechnology*, 7(12), 1962-1972.

Badiamurti, G.R. (2010). *Korelasi Kualitas Air dan Insidensi Penyakit Diare Berdasarkan Keberadaan Bakteri Coliform di Sungai Cikapundung*. Jurnal Program Studi Teknik Lingkungan. Institut Teknologi Bandung.

Bensig, E.O., Mary, J.L.F., & Fleurdeliz, F.M. (2012). Relationship of Coliform and Physicochemical Factors of Buhisan, Bulacao and Lahug Riers, Cebu, Philippines. *WALIA Journal*, 32(S1), 28-30.

Berutu, P. (2001).*Kajian Parameter Fisika, Kimia dan Biologi dalam Kaitannya dengan Kebersihan Ikan di Kawasan Perairan Danau Toba di Sumatra Utara*. Tesis Program Studi Ilmu Lingkungan. Universitas Gadjah Mada.

Cabral, J.P. (2010). Water Microbiology Bacterial Pathogens and Water. *Int. J. Environ. Res. Pub. Helath*, 7(10), 3657-3703.

Cahyaning, N., Aras, M., & Thamrin. (2009). Pengaruh Pemanfaatan Air Sungai Siak Terhadap Penyakit Diare dan Penyakit Kulit pada Masyarakat Pinggiran Sungai Siak (Kasus Kecamatan Rumbai Pesisir Pekanbaru). *Journal of Environmental Science*, 3(1), 46-57.

Cheung, K.C., & Venkitachalam, T.H. (2004). Assesment of Contaminant by Percolation of Septic Tank Effluent Through Natural and Amended Soils. *Environmental Geochemistry and Health*, 26 (2-3), 157-168.

Eisakhani, M., & Malakahmad, A. (2009). Water Quality Asessment of Bertam River and Its Tributaries in Cameron Highlands, Malaysia. *World Applied Sciences Journal*, 7, 769-776.

Even, S., Mouchel, J.M., Servais, P., Flipo, N., Puolin, M., Blanc, S., Chabanel, M., & Paffoni, C. (2007). Modelling The Impacts of Combined Sewer Overflows on The River Seine Water Quality. *Science of The Total Environment*, 375(1-3), 140-151.

Ezekiel, E.N., Hart., & Abowei, J.F.N. (2011). The Physical and Chemical Condition of Sombreiro River, Niger Delta, Nigeria. *Research Journal of Environmental and Earth Sciences*, 3(4), 327-340.

Farkas, A., Dragan-Bularda, M., Muntean, V., Ciataras, D., & Tigan, S. (2013). Microbial Activity in Drinking Water Associated Biofilms. *Central European Journal of Biology*, 8(2), 201-214.

Han, M., Zhao, Z.W., Cui, F.Y., Gao, W., Lui, J., & Zeng, Z.Q. (2012). Pretreatment of Contaminated Raw Water by A Novel Double-Layer Biological Aerated Filter for Drinking Water Treatment. *Desalination and Water Treatment*, 37(1-3), 308-314.

Iijima, Y., Karama, M., Oundo, J.O., & Honda, T. (2001). Prevention of Bacterial Diarrhea by Pasteurization of Drinking Water in Kenya. *Journal of Microbial Immunology*, 45(6), 413-416.

Karlaviciene, V., Svediene, S., Marciulionene, D.E., Randerson, P., Rimerika, M., & Hoglan, W. (2009). The Impact of Storm Water Runoff on A Small Urban Stream. *Journal of Soils and Sediment*, 9(1), 6-12.

Khotimah, S. (2009). Kepadatan Bakteri *Coliform* di Sungai Kapuas Kota Pontianak. *ProsidingSemirata FMIPA Universitas Lampung 2013*. 339-349.

Kinzelman, J., McLellan, S.L., Daniels, A.D., Cashin, S., Singh, A., Gradus, S., & Bagley, R. (2004). Non-Point Source Pollution: Determination of Replication Versus Persistence of Escherichia coli in Surface Water and Sediments With Correlation of Levels to Readily Measureable Environmental Parameters. *Journal of Water and Health*, 2(2), 103-114.

Kumar, Rita, N., Rajal S., & Nirmal, K.J.I. (2011). An Assesment of Seasonal Variation and Water Quality Index of Sabarmati River and Kharicut Canal at Ahmedabad, Gujarat. *Electronic Journal of Environmental and Food Chemistry*, 10(8), 2771-2782.

Makutsa, O., Nzaku, K., Ogutu, P., Barasa, P., Ombeki, S., Mwaki, A., & Wuick, R.E. (2001). Challenges in Implementing a Point-of-Use Water Quality Intervention in Rural Kenya. *American Journal of Public Health*, 91, 10.

Mills, M.S., & Thurman, E.M.(1994). Reduction of Nonpoint-source Contamination of Surface Water and Groundwater by Starch Encapsulation of Herbicides. *Environmental Science and Technology*, 28(1), 73-79.

Okoh, A.L., Odjadjaran, E.E., Igbinosa, E.O., & Osedo, A.N.(2007). Wastewater Treatment Plants as A Source of Microbial Pathogens in Receiving Watershed. *African Journal of Biotechnology*, 6(25), 2932-2944.

Patil, P.N, Sawant, D.V., & Deshmukh, R.N. (2012). Physico-Chemical Parameters for Testing of Water – A Review. *International Journal of Environmental Sciences,* 3(3), 1194-1207.

Priyambada, I.B., Oktiawan, W., & Suprapto, R.P.E. (2008). Analisa Pengaruh Perbedaan Fungsi Tata Guna Lahan Terhadap Beban Cemaran BOD Sungai (Studi Kasus Sungai Serayu Jawa Tengah). *Jurnal Presipitasi*, 5(2), 55-62.

Pujiastuti, P., Bagus,I., & Pranoto. (2013). Kualitas dan Beban Pencemaran Perairan Waduk Gajah Mungkur. *Jurnal EKOSAINS*, 5(1), 59-75

Rahman, S., Anoar, K.P., & Rezwanul, I. (2013). Identification and Quantification of Escherichia coli From Drinking Water in Bangladesh. *International Journal of Microbiology and Immunology Research*, 1(4), 47-51.

Rajendra, S., Dasgupta, R., & Malik, A. (2012). Microbiological Quality of Potable Water in Dehradun City. *International Research Journal of Pharmacy*, 3(6), 130-137.

Ramadhani, N.R. (2012). *Analisis Sebaran Oksigen Terlarut Saluran Sungai Jawi*. Skripsi Program Studi Teknik Lingkungan. UniversitasTanjungpura.

Richardson, S.D. (2002). The Role of GC-MS and LC-MS in The Discovery of Drinking Water Desinfection by Products. *Journal of Environmental Monitoring*, 4(1), 1-9.

Ritter, L., Solomon, K., Sibley, P., Hall, K., Keen, P., Mattu, G., & Linton, B.(2002). Sources, Pathways, and Relative Risk of Contaminants in Surface Water and Groundwater: A Perspective Prepared for The Walkerton Inquiry. *Journal of Toxicology and Environmental Health-Part a Current Issues*, 65(1), 1-142.

Romanto (2013). *Status Kualitas Air Sungai Ciambulawung, Banten*. Skripsi Fakultas Perikanan dan Ilmu Kelautan. Institut Pertanian Bogor.

Rosli, N., Gandaseca, S., Ismail, J., & Jailan, M.I.(2010). Comparative Study of Water Quality at Different Peat Swamp Forest of Batang Igan, Sibu Sarawak. *American Journal of Environmental Sciences*, 6(5), 416-421.

Saputri, A. (2014). *Analisis Sebaran Oksigen Terlarut Pada Sungai Raya*. Skripsi Program Studi Teknik Lingkungan. UniversitasTanjungpura.

Sedmak, G., Bina, D., McDonald, J., & Couillard, L. (2005). Nine-Year Study of The Occurence of Culturable Viruses in Source Water for Two Drinking Water Treatment Plants and The Influent and Effluent of A Wastewater Treatment Plant in Milwauke, Wisconsin (August 1994 through July 2003). *Applied and Environmental Microbiology*, 71(2), 1042-1050.

Setiabudi, G.I., Dietriech, G.B., Hefni, E., & Ocky, K.R. (2016). The Community Structure of Phytoplankton in Seagrass Ecosystem and Its Relationship with Environmental Characteristic. *Biosaintifika: Journal of Biology & Biology Education*, 8(3), 257-269.

Sidharta, R.B. (2000). *Pengantar Mikrobiologi Ke-*

lautan. Universitas Atma Jaya: Yogyakarta.

Sidhu, J.P.S., Ajmed, W., Gernjak, W., Aryal, R., McCarthy, D., Palmer, A., Kolotelo, P., & Toze, S. (2013). Sewage Pollution in Urban Stormwater Runoff as Evident From The Widespread Presence of Multiple Microbial and Chemical Source Tracking Markers. *Science of Total Environment*, 463, 488-496.

Sigua, G.C., & Tweedale, W.A.(2003). Watershed Scale Assesment of Nitrogen and Phosphorus Loadings in The Indian River Lagoon Basin, Florida. *Journal of Environmental Management*, 67(4), 363-372.

Singh, M., & Singh, S.K. (2014). Correlative Study of Physico-Chemical and Microbiological Parameters of Radha and Shyam Kund-Govardhan, Mathura. *The Experiment, International Journal of Science and Technology*, 25(3), 1726-1735.

SNI 01-2332.1-2006 tentang *Penentuan Coliform dan Escherichia coli pada Produk Perikanan*.

Sugiyono. (2016). *Statistika untuk Penelitian*. Bandung: Penerbit Alfabeta.

Sunardi., Rina, F., Budi, I., & Mutia, S.S. (2017). The Dynamic of Phytoplankton Community Structure in Face of Warming Climate in A Tropical Man-Made Lake. *Biosaintifika: Journal of Biology & Biology Education*, 9(1), 140-147.

Trofisa, D. (2011). *Kajian Beban Pencemaran dan Daya Tampung Pencemaran Sungai Ciliwung di Segmen Kota Bogor*. Skripsi Fakultas Kehutanan. Institut Pertanian Bogor.

Usman, W.S. (2015). *Bakteri Asosiasi Karang yang Terinfeksi Penyakit Brow Band (BRB) di Perairan Pulau Barranglompo Kota Makassar*. Skripsi Fakultas Ilmu Kelautan dan Perikanan.

Varale, A., & Yashodhara, V. (2012). Determination of BOD in The Underground Water. *Journal of Chemical and Pharmaceutical Research*, 4(10), 4601-4603.

Varunprasath, K., & Nicholas, A.D. (2010). Comparison Studies of Three Freshwater Rivers (Cauvery, Bhavani and Noyyal) in Tamilnadu, India. *Iranica Journal of Energy & Environment*, (14), 315-320.

Vikal, P. (2009). Multivariant Analysis of Drinking Water Quality Parameters of Lake Pichhola in Udaipur, India. *Biological Forum – An International Journal*, 1(2), 97-102.

Wardhana, W.A. (2014). *Dampak Pencemaran Lingkungan*. Yogyakarta: Penerbit Andi.

Won, G., Kline, T.R., & LeJeune, J.T. (2013). Spatial-Temporal Variations of Microbial Water Quality in Surface Reservoirs and Canals Used for Irrigation. *Agriculture Water Management*, 116, 73-38.

World Health Organization. (1996). *Water Quality Monitoring – A Practical Guide to The Design and Implementation of Freshwater Quality Studies and Monitoring Programmes*. Edited by Jamie Bartram and Rizhard Balance. Geneva.