Water-inquiry learning model development (an empirical experience of the Brantas River)

Water-inquiry learning model development (an empirical experience of the Brantas River)

B Handoyo[1*], S Said[2]
[1]Departement of Geography Universitas Negeri Malang, Indonesia
[2]Jaring Jaring Komunikasi dan Pemantauan Kualitas Air, Jombang Indonesia

*e-mail: budi.handoyo.fis@um.ac.id

Abstract. In the east Java, Brantas River is the one of the longest river. The river flows as far as 320 km with an area of 12,000 km^2 across ten cities until the coast of Java sea. The potential of surface water of the Brantas river is about 12 billion m^3 which is utilized by 14 million (40%) of East Java population as the main source of raw water of domistic consumption, agricultural irrigation, health, industry, electric energy, recreation, and fishery. However, since the era of 80's, the river water condition has decreased its quality significantly. Turbidity of water in the upstream part of the river in the range of 14-18 mg/l exceeds the maximum turbidity of 5 mg/l, the pollution of mercury heavy metals at some sites reaches 0.09 mg/L or 90 times of the standard of drinking water. E-coli bacteria in water samples in the downstream region reached 64,000 bacterial/100 ml cells above the standard 1,000 bacterial /100 ml cells. The pollutions have an impact on the health quality of river banks or flood plain. About 2-4% of children aged and adolescents have cancer. Based on the observation, there are 68 schools atleast that is located at the long side of the river with the number of students more than 8000 person. They are potential generations to maintain the quality of river water in the present and future. Therefore, to cultivate their skills and awareness on the importance of maintaining water quality since 1997 was established communication network for monitoring water quality agency was named Jaring-Jaring Komunikasi Pemantau Kualitas Air (JKPKA). In the move, the agency cooperates with PT Perum Jasa Tirta I as the autonomy board of Brantas River management as the main funder. This paper aims to describe the roles of the JKPKA in involving students to monitore Brantas river water quality that has been going on 20 years more. For the involvement of students in monitoring water quality, JKPKA developed a scientific, cooperative, contextual, and constructive learning model was mentioned Water Inquiry (WI). There are five steps of the model: (1) Formation of cooperative group, (2) Field observation, (3) Data analysis and discussion, (4) Communication, and (5) Evaluation and reflection. For 20 years, since 1997-2017, JKPKA has involved more than 4300 students and 60 teachers to monitor the water quality of Brantas river with Water Inquiry method. In the future be recommended that the JKPKA can be developed into river schools for more systematic, structured, and massive movement in involving students for water quality monitoring.

1. Introduction

Indonesia is one of the largest countries in the world with many rivers. Overall, Indonesia has an area of 5,193,250 km², consisting of land and water areas. Its terrestrial region is an archipelago, consist of five large islands and more than fifteen thousand small islands, and one of the big island is the Java island. The island has several watersheds that play an important role in sustaining a water demand for people who now its number more than a half of the Indonesian population [1].

One of the river in Java Island is Brantas river. It flows as far as 320 km with an area of 12,000 km^2 across ten cities until the coast of Java sea. The water potential of the Brantas river is about 12 billion m^3 which is utilized by 14 million (40%) of east java population as the main source of raw water of domistic consumption, agricultural irrigation, health, industry, electric energy, recreation, and fishery. Research in the

Comprehensive development research of the Brantas river basin of the Indonesia show that "up to year 2000, development utilisation of the Brantas river basin are: flood control (protected of about 56,000 ha of land), irrigation (supply water for about 345,000 ha pady field), electricity (producing electricity of about 900 million kWh/year), drinking water (supply raw water of about 200 million m3/year), industrial water (supply raw water of about 120 million m3/year), fishery, recreation, etc. The Brantas river basin has supported around 25 % of national stock of rice" [2]

Unfortunatly, since the era of 80's, the river water condition decreased its quality significantly. The physical and chemical conditions of the river have been degraded in quality. Physically, water conditions have decreased as a result of the organic and unorganic impacts that are channeled in the water. Result of the study show that the river water contains various types of waste, both organic and non-organic [3]. Type of organic waste in the form of leaves, twigs and bamboo. Meanwhile, non-organic waste in the form of plastic, plastic bags, used clothes, and 'plastic underwear'. Chemically the river water also experienced acontamination chemical materials. Brantas River was classified as lightly and moderately polluted, with the exceeding parameters during 2010-2015 in order to the most amount to the least were TSS 34.47%; DO 4.85%; Cr6 + 0.45%; TDS 0.17%; pH 0.00% [4]. Investigation of the Surabaya River Pollution Control Action Plan Study showed that the BOD net load was 125 ton BOD / day and domestic wastes (households, hotels, restaurants, etc.) of 205 ton BOD /day. From the upstream to downstream of Brantas River has been detected concentrations of 42-220 ng/L estradiol compounds. The concentration of estradiol in Brantas River compared with in Europe (0.1-88 ng/L) is higher. The concentration of estradiol in Brantas River is dangerous condition, because it can spur the feminization of fish that ends the extinction of fish [5].

The results of water quality analysis based on the monthly WQI method showed that 40% were mildly polluted (grade 3), 10% were moderately polluted (grade 4), 25% were heavily polluted (grade 5) and 25% dirty (grade 6). Period of 32% mildly polluted (grade 3), medium 36% polluted (grade 4), 4% seriously polluted (grade 5), and 28% gross (grade 6). In the rainy season 48% was lightly contaminated (grade 3), 24% polluted medium (grade 4), 28% gross (grade 6), 36% mildly polluted (grade 3), 24% tainted moderate (grade 4), 16 % heavily polluted (grade 5), 24% gross (grade 6). According to the STORET Method that there was 15% was moderately polluted (class C), and 85% was heavily polluted (class D). The annual period, the rainy season and the dry season are 100% heavily polluted (class D).

In addition, turbidity of water at the upstream part of the river in the range of 14-18 mg/l exceeds the maximum turbidity of 5 mg/l, the pollution of mercury heavy metals at some sites reaches 0.09 mg/L or 90 times of the standard of drinking water. E-coli bacteria in water samples in the downstream region reached 64,000 bacterial/100ml cells above the standard 1,000 bacterial/100 ml cells. The pollutions have an impact on the health quality of river banks or flood plains. Brantas water conditions affect the health of the local population. Brantas river water contaminated with various wastes spreads various diseases of the people who live around it. In addition to harmful diarrhea, from river pollution is a hormone-disrupting compound (SPH), which is also associated with some common diseases suffered by people such as diabetes/DM type 2, and also cancer [6].

Actually, decreasing water quality is not only experienced by Brantas river or other rivers in Indonesia. The similar phenomena were also experienced by rivers in many countries. For example river pollution in urban areas of Iran is on the river Zarjub and Goharrud. According to research of the both rivers were contaminated by waste Industrial areas, hospitals, and poultry farms were main factors of water pollution[7]. However, the majority of the population on the banks of the rivers Zarjub and Goharrud show a high interest in environmental conservation. Overall, 62.7% of the residents had moderate and 20% had high environmental awareness. Research conducted on water pollution that occurred in China shows that water pollution can affect mental and physical health. Water pollution more significantly affected mental and physical health among low-income people[8].

Based on the empirical studies were described above that the quality of Brantas river water has decreased due to contamination of pollutants. The pollution resulted the decreasing of water quality as raw material of clean water, agricultural irrigation, tourism, and other functions. River water pollution

due to an awareness of the population of water quality was still lacking. Less water quality awareness is characterized by limited water quality knowledge, less caring attitude, and poor problem solving skills.

Therefore, to solve the Brantas river water quality problem that has been contaminated by the waste, it needs an integrated and sustainable solution. One effort to solve the river problem is to empower students along the Brantas river. A long th Brantas watershet there are 68 schools more with the number of students more than eight thousand. They are potential generations to maintain the quality of river water in the present and future. Therefore, to cultivate their skills and awareness on the importance of maintaining water quality since 1997 was established a communication network for monitoring water quality agency was named Jaring-Jaring Komunikasi dan Pemantau Kuliatas Air (JKPKA). In the move, the agency cooperates with PT Perum Jasa Tirta I as the autonomy board of Brantas river management as the main funder.

To involve students in improving knowledge, attitute, and skills on the water quality have been developed a model of learning Water Inquiry (WI) by Said and Handoyo on 2010. In the model there are five steps, namely (1) Formation of cooperative group for problem orientation, (2) Field observation for data collection, (3) Data analysis and discussion, (4) Communication, and (5) Evaluation and reflection [14]. The inquiry learning model is a planned learning process for formulating problems, planning investigations, making conjectures, seeking information, discussing with teams and applying appropriate explanations. Iquiry-based learning is an educational strategy in order to construct knowledge [10].

The learning model is based on constructive theory. It is stated that learning as a process in which the learner actively constructs or constructs new ideas or concepts is based on the knowledge already held in the past or existing at that time. Constructivistic learning theory emphasizes that students learn individually through their own knowledge, connecting new ideas and experiences to existing knowledge and experiences to form new or enhanced understanding [11].

In addition, the development of water inqury is also based on an active learning approach. It is stated that the learning system puts learners as active learners and has readiness to learn. Active learning is a process where the students are actively engaged in the development of facts, ideas, and skills through the completion of the instructor directed tasks and activities [12]. "Active learning is a way of introducing content from a learning process. [13].

Based on the thought, the problems of this study is: (1) is there an increase of the knowledge, attitude, and skills of water quality with an application of the Water Inquiry Bio Assesment? (2) how far the JKPKA produce competent students in water quality monitoring using the Inquiry Bio Inquiry method?

2. Method

To develop an environmental awareness-water, it is required an aplicable and sustainable design. In this discussion, student empowerment is conducted by following steps.

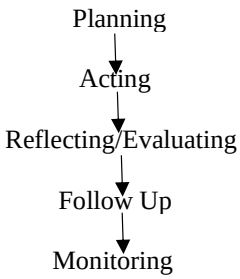

Figure 1. Model of Student Empowerment for Water Awareness

Procedures for student empowerment for water quality awareness of this activities are designed as follows.

1. To plan a empowerment activities starting from composing a proposal of monitorng river water quality activities with Water Inquiry-Bio Assessment. In the planning process, it is planned to formulate an activity plan and announce the plan to the school that will be invited to participate in water quality monitoring activities.
2. To carry out a water quality monitoring activities. The implementation of monitoring activities is carried out by applying water inquiry-Bio Assesment. There are five steps in the learning model: (1) Formation of cooperative group, (2) Field observation, (3) Data analysis and discussion, (4) Communication, and (5) Evaluation and reflection. Establishment of cooperative groups to identify water problems. Observations were conducted to collect life data of benthic and micro macros at the bottom of rivers and rocks. For data collection comes with tools, such as nets, loops, buckets, tweezers, and sieves. Data analysis and discussion is the step to analyze the data obtained by referring to the parameters of the bio parameters and discuss them. For the analysis can use the formula as follows.

$$Di = \frac{ni}{N} \times 100\%$$

Di = Spesies Domination Index (%)
ni = values of species abundance (unit of individual number/m^2)
N = total abundance of all species (unit if individual number/m^2)

3. Communication to present the results of analysis and discussion. Each group presents the results of discussion for 15 minutes. Evaluation and reflection is to assess the learning that has been done and identify the barriers and how far the results obtained.
4. Reflecting and evaluating. The reflection and evaluation activities were conducted after the application of Water Inquiry Bio Assesment model. Reflection is done by giving students time to communicate their learning experiences, how they feel, and what they will do in the future. Evaluation of learning is done by giving the opportunity to students to assess the learning process that has been experienced.
5. Design a follow-up plan and implement it in school. Follow-up activities are conducted by teachers at each school with activities such as field work for monitoring of water quality of the river around the school.
6. Monitoring the follow-up activities at school. Monitoring student's activities were conducted by face book and email facilites.

The subjects of this action are high school students amount 45 people. Location of activity at Brantas River Malang City. The data were collected by pre test and post test during the water quality monitoring activities. The analysis is done descriptively.

2. Result and Discussion

Empowering students to develop an awareness of water quality in the form of improvement of water quality knowledge, attitude to water quality, and water problem solving skills. Empowering water quality monitoring was done with the Water Inquiry Bio Assesent model. The results of empowerment can be presented as follows. This result is an example of the implementation of the students' development on water quality in 2017

3.1 Knowledge of Water Quality

of water quality includes the meaning of water quality, classification of water quality, determinant factors of water quality, measurement of water quality, and impact of water quality to the life. The result of pre test and post test of water quality is described as follows.

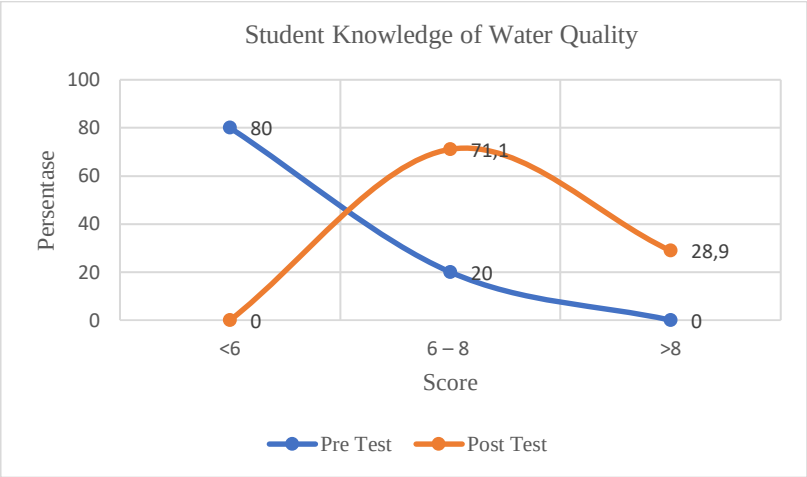

Figure 2. Student Kwowledge of Water Quality

Figure 01 shows the pre test and post test scores of students' knowledge of water quality and measurement. The score of pre-test showed average 51,57. Most students (80%) scored less than 6, and there is no students scored more than 8. This score shows that students' knowledge of water quality and measurement is still low or limited. Knowledge of low water quality can occur because the material of water quality and measurement are not explicitly taught. The curriculum and textbook also do not contain explicitly about water quality and measurements.

Meanwhile the post test score show a better tendency. The average score achieved by students were 78,00. Most of the students (71%) have score between 6-8, and others students have more than 8. This score shows that students' knowledge of quality water and the measurement were better after joining with the Water Inquiry Bio Assessment learning model. These results were also in line with different test between score pre test score and post test, F = 17,68, sig p <0.000. Its mean there is a significant difference between score average of the pre test and post test. Therfore it could be stated that the using of Water Inquiry Bio Assesment could improve significantly students' knowledge about water quality and its measurement.

3. Attitute to Water Quality

Attitude to the water quality is a tendency of the students to act on the exist water quality. The result of the pre test and post test of the students' attitude to the water quality is shown at the following figure.

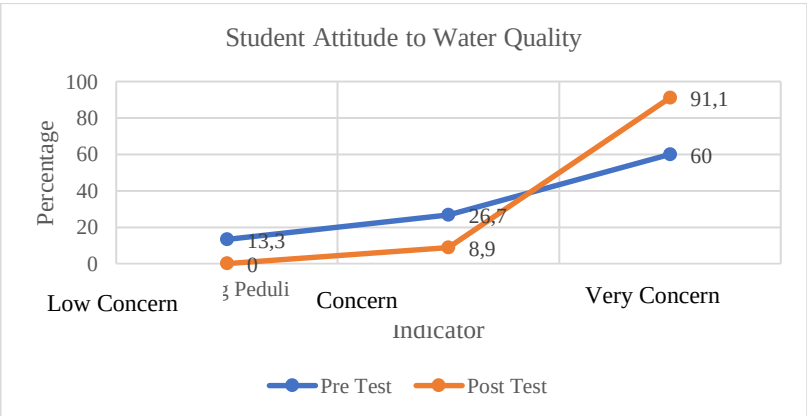

Figure 3. Student Attitude of Water Quality

Figure 02 shows the score of pre and post tests of students' attitudes to water quality. The result of the pre-test showed an average score of the students were 58,00. Approximately 25.7% of students were very concerned with the water quality, and only a little bit of the students (13.3%) were less concerned. The results show that the most students were concerned up to very concerned with the water quality. Meanwhile the post test results showed the average score of the students were 76,50. Most of the students (91.1%) were very concerned with the water quality, and there is no one was less corcerned. The results are also in lined by different test between the score of the pre test and post test, F = 16,39, sig 0,000. Its means, there is a significant difference between the attitude of students before and after the application of learning model Water Inquiry Bio Assesment.

3. Skils for Water Problem Solution

Water problem solving skill is a skills in solving a water problems related to the problem identification, problem formulation, development of alternative solutions, decision making, actions and communication. The score of the problem solving skills of pre test and post test as follows.

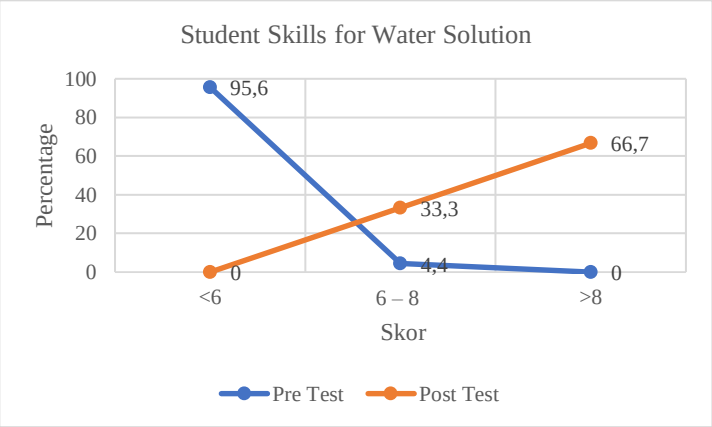

Figure 4. Student Skils of Water Quality

Figure 03 shows the students score of pre test and post test of water problem solving skills. The result of the pre-test show average score was 49,80. Most the students (95.6%) are not skilled in solving water quality problems, and only a small of the students (4.4%) have a good water quality problem-solving skills. The results showed that almost all students do not yet have water quality problem-solving skills. This can happen because water quality problem-solving skills are not yet a part of the learning outcomes. Meanwhile the result of the post test showed a better tendency. The average score of the students were 76,50. Most of them 66.7% were skilled in problem solving, and as many as 33.3% are skilled enough in solving water problems. The result of the different test also showed that there are significant differences between the score of pre test and post test, F = 16,39, sig = 0.000. Its means that there are significant differences in water quality problem-solving skills after using of Water Inquiry Bio Assessment.

The findings of empowerment show that WIBA learning model can improve the awareness of water quality. The learning model is proven to improve water quality knowledge and its measurement, conserned attitude to water quality, and water quality problem solving skills. Improving students' knowledge, attitude, and skills is better, because the learning model can be a platform to broaden knowledge about water and its quality, caring attitude towards water quality, and skills in water quality solutions. The model has advantages, such as (1) strengthening the exploration drive of factual and

conceptual knowledge, (2) developing analytical thinking skills, (3) developing critical thinking skills, and (4) cultivating awareness of environment [14].

The findings of this empowerment were also in line with the research results which shows there was a causal relationship between knowledge, behavior, and participation with environmental awareness [15]. The findings also strenthening the theory of environmental consciousness expressed which states that the environmental awareness is a state of awakening of the soul to something, in this environment, and can be seen in the behavior and actions of each individual [16][17]. The same results were also strengtened that the environmental awareness is an effort to involve every citizen in growing and nurturing awareness to preserve the environment based on environmental values itself through the philosophy of living in peace with the natural environment[17]. Similarlywith the before statement also showed that "the educated group had better perception, more detailed knowledge, greater awareness, and a better attitude in regard to regional and global environmental problems than the community group". On the other hand, JKPA for 20 years, since 1997-2017, JKPKA has involved more than 4300 students and 60 teachers to monitor the water quality by using Water Inquiry Bio Assesment.

4. Conclusion

According to the findings of the research and discussion, it can be showed that: (1) the application of community empowerment model with the action of Water Inquiry Bio Assesment produce students who have good quality knowledge of water quality, care to the water quality, and skillfull on the problem solving of water quality. (2) From 1997 to 2018 JKPKA has been collaborating with Perum Jasa Tirta 1 Malang to empower approximately 4300 students who are competent in monitoring the water quality by bio assessment method. In the future be recommended that the JKPKA can be developed into river schools for more systematic, structured, and massive movement in involving students for water quality monitoring.

Acknowledgments

The authors would like to thank all parties, especially director of the Perum Jasa Tirta I who helped us in the smooth running of this research.

Refferences

[1] Fujimoto K. (2013) *Brantas River Basin Development Plan of Indonesia.* In: Nissanke M., Shimomura Y. (eds) Aid as Handmaiden for the Development of Institutions. Palgrave Macmillan, London

[2] Usman, Achmad Rusfandi. (No Year). Comprehensive Development of the Brantas River Basin the Republic of Indonesia. Retrieved March 22, 2018 from https://www.inbo-news.org/IMG/pdf/brantas_river.pdf.

[3] Sari, R. A., Prayogo, T. B., &Yuliani, E. (2017). Studi Penentuan Status Mutu Air di Sungai Brantas Bagian Hilir Untuk Keperluan Air Baku. Brawijaya University, Engineering Faculty. Retrived April 2, 2018 from http:// pengairan.ub.ac.id/wp-content/uploads/2017/01/Studi-Penentuan-Status-Mutu-Air-Di-Sungai-Brantas-Bagian-Hilir-Untuk-Keperluan-Air-Baku-Rani-Anjar-Sari-125060400111052.pdf.

[4] Rosmini, D., Septiono, M A., Putri, N. E., Shabrina, H. M., Salami, I. R. S., & Ariesyady, H. D. (2018). River Water Pollution Condition in Upper Part of Brantas River and Bengawan Solo River. IOP Conf. Series: Earth and Environmental Science 106 (2018) 012059.

[5] Krisnawati, Widya, T. Y., Nurasih, A., & Santoso, A. M., (2015). Perancangan Moolief Bioreactor Untuk Remediasi Air Sungai Brantas Kediri Tercemar Limbah Domestik Dan Industri. Prosiding Seminar Nasional Pendidikan Biologi 2015, Prodi Pendidikan Biologi FKIP Universitas Muhammadiyah Malang(UMM), Malang, 21 Maret 2015. Retrieved March 23, 2018 from http://biology.umm.ac.id/files/file/496-503%20Krisnawati%20.pdf.

[6] Istiawan, H. (2017). Sungai Brantas Tercemar, Ini Bahaya Senyawa Pengganggu Hormon bagi Manusia. Retrived April 2, 2018 from https://news.okezone.

com/read/2017/09/06/519/1770670/sungai-brantas-tercemar-ini-bahaya-senyawa-pengganggu-hormon-bagi-manusia.

[7] Noorhosseini, S. A., Allahyari, M. S., Damalas, C. A., & Moghaddam, S. S., (2017). Public Environmental Awareness of Water Pollution From Urban Growth: The Case Of Zarjub and Goharrud Rivers in Rasht, Iran. *Sciene of The Total Environmental*, 599-600 : 2019-2025.

[8] Wang, Q., & Yang, Z. (2016). Industrial Water Pollution, Water Environment Treatment, and Health Risk in China. *Environmental Pollution*, 218: 358-365.

[9] Febriana, I., Ibrohim, & Mahanal, S. (2016). Potensi Pembelajaran Inkuiri dalam Menumbuhkan Sikap Siswa terhadap Lingkungan. *Prosiding*. Semnas Pend IPA Pascasarjana UM, Vol. 1, 2016, ISBN: 978-602-9286-21-2.

[10] Pedaste, M., Maeots, M., Siiman, L. A., Jong, T. de., Riesen, A.N. van., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015) Phases of Inquiry-based Learning: Definitions and the Inquiry Cycle. Educational Research Review, 14 : 47-61.

[11] Brame, C. J. (2016). Active Learning. Vanderbilt University Center for Teaching. Retrieved March 24, 2018 from https://cft.vanderbilt.edu/active-learning/.

[12] Bell, D. & Kahrhoff, J. (2006). *Active Learning Handsbook*. Webster University Faculty Development Center. Retrieved March 24, 2018 from http:// www.cgs.pitt.edu/sites/default/files/Doc6GetStarted_ActiveLearningHandbook.pdf

[13] Hudson, C. C., & Whisler, V. R. (2008). *Contextual Teaching and Learning for Practitioners. Systemics, Cybernetics and Informatics*, 6 (4) : 54-58 ISSN: 1690-4524.

[15] Darmawan, B., Saam, Z., & Zulkarnaini. (2010). Hubungan Pengetahuan, Sikap, Perilaku dan Peranserta dengan Kesadaran Lingkungan Hidup Serta Kesanggupan Membayar Masyarakat Sekitar Bantaran Sungai Di Kota Pekanbaru. *Journal of Environmental Science*, 2 (4) : 103-116 ISSN 1978-5283.

[14] Said, S & Handoyo, B. (2010). Water Inquiry: Model Pembelajaran yang Memberdayakan Siswa. *Paper*. Disajikan dalam Workshop Guru-JKPKA di Tulungangung.

[15] Krisnawati, Widya, T. Y., Nurasih, A., & Santoso, A. M., (2015). Perancangan Moolief Bioreactor Untuk Remediasi Air Sungai Brantas Kediri Tercemar Limbah Domestik Dan Industri. Prosiding Seminar Nasional Pendidikan Biologi 2015, Prodi Pendidikan Biologi FKIP Universitas Muhammadiyah Malang(UMM), Malang, 21 Maret 2015. Retrieved March 23, 2018 from http://biology.umm.ac.id/files/file/496-503%20Krisnawati%20.pdf.

[16] Neolaka, A. (2008). *Kesadaran Lingkungan.* Jakarta: PT. Rineka Cipta

[18] Sudarmadi, S., Suzuki, S., Kawada, T., Netti, H., Soemantri, S., & Tugaswati, A. T. (2001). A Survey of Perception, Knowledge, Awareness, and Attitude in Regard to Environmental Problems in a Sample of Two Different Social Groups in Jakarta, Indonesia. *Environment, Development and Sustainability*, 3 (2) :169-169.