Improvement of Water Quality using Effective Microorganisms

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Abstract. Effective Microorganism (EM) have been widely used as a method to improve river water quality. Johor Bahru City Council (MBJB) made an effort to use Effective Microorganism (EM) to preserve Sungai Sebulung located at Kampung Melayu Majidee. The project was started on 1st June 2005 throughout the Local Agenda 21 Plan. The most suitable EM and widely used in Malaysian rivers is known as EM Activated Solution (EMAS) and EM Mudballs. EMAS is a mixture of molasses which usually from sugar cane and EM in non-chlorinated water or rice rinse. EMAS is commonly applied in gardening, indoor plants, laundry and fish pond. EM mudballs are made by mixing ordinary clay, red earth or top soil with EMAS, thoroughly kneading them and forming into the size of tennis balls. Some mudballs have an additional mix of Bokashi, a fermented organic matter made using rice bran, oil cake, fish meal, sawdust. The objective of this study is to find out water quality status of Sungai Sebulung after being treated with EM and compare the water quality data with Water Quality Index (WQI), to investigate whether EM are effective in river conservation at Sungai Sebulung and to know the factors that causes pollution at Sungai Sebulung. Effective Microorganism (EM) treatment method is effective in reducing Temperature, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and ammoniacal nitrogen (AN). By referring the 6 parameters of Water Quality Index (WQI), the overall class of this river also improved from Class IV to Class III. This shows that EM is effective in reducing several types of pollutants as mentioned earlier. It is also effective in improve the overall class of the river. Only several parameter that EM didn't manage to reduce which is pH, dissolve oxygen (DO) and also total suspended solid (TSS).

Introduction

This study was conducted to identify the effectiveness of using Effective Microorganism (EM) to improve water quality at Sungai Sebulung. Johor Bahru City Council (MBJB) used two types of EM which is EM Activated Solution (EMAS) and EM Mudballs. To preserve Sungai Sebulung. EM Mud Balls are intended for anaerobic bacterias in the riverbed and EM solution acts to decompose ammonia and sulfuric acid to odourless elements through its phototropic bacterial activity [1].

Objective of Study

The objectives of this study are to find out water quality status of Sungai Sebulung when being treated with Effective Microorganism (EM) and compare the water quality data with Water Quality Index (WQI). The second objective is to investigate whether Effective Microorganism (EM) are effective in river conservation at Sungai Sebulung and the last objective is to know the factors that causes pollution at Sungai Sebulung.

Scope of Study

Sungai Sebulung is located at Kampung Melayu Majidee. This river has been chosen because it is one of the rivers that implement Effective Microorganism (EM) Technology in maintaining good water quality of the river. Before carrying this study, detailed information about the river need to be taken. Total suspended solid (TSS), temperature, pH, dissolve oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen (AN) and Phosphate are the parameters identified in this study. There are two type of analysis being carried out. In-situ

analysis was conducted at the rivers itself to check pH, temperature and DO. Laboratory analysis was conducted for BOD, COD, TSS and AN.

Significant of Study

Effective microorganisms (EM) was being chosen as the solution to reduce the water pollution at Sungai Sebulung because it has no particular substance that can harm the aquatic life in the river. Besides, by applying the effective microorganisms in the river at Sungai Sebulung, the cost used to treat and clean the environment of the river can be reduced as EM use only waste material. From this study, it is hoped that this conservation program will be successful. This step is to ensure that this method is the most suitable method that should be practiced.

Literature Reviews

Rapid modernization and industrialization have led to lower the river water quality. EM is one of the successful method in the cleaning of water in nature. The main aims of the mudballs is to stop the growth of algae, to break down sludge, to suppress pathogens, and to eliminate the foul smelling odors caused by high levels of ammonia, hydrogen sulfide and methane. Besides, EM also used to control the levels of total suspended solids (SS), dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD) and pH. By educating the society and involving private sectors on EMAS and EM mudball usage, the government hopes to eventually create the awareness amongst everyone to play the respective roles in improving the river water quality. The initial idea is to get all individuals to use especially the EMAS, at home and then pouring it down to the drains whereby the solution will then be flowed from the drains to rivers, thus indirectly cleaning the waters in the process [2].

Tons of newspaper write up about applications of EM to the polluted river all over Malaysia. Based on Hunza Properties Berhad write up, Penang Government Initiative for Environmental Management (PGI-EM) using EM Biotechnology, is a project initiated by the Penang State Government with the help of EM Biotechnology Experts. Inoculation of EMAS into Sungai Kelian began on March 25, 2009. On the day, 10,000 EM mudballs were thrown in the sludge of Sungai Kelian. Subsequently, 1,200 L of EMAS were either inoculated or sprayed into Sungai Kelian every 10 days and 1,000 EM mudballs were thrown into Sungai Kelian every week. On July 2, 2009, the river is now cleared of sludge and the base of the river is now filled with beach sands. On July 3, 2009, the group of gentlemen noted that there are no foul smell from the river and few groups of small fishes were swimming along the river bank. All this in a short period of 3 months. Measurements taken of six parameters (SS, DO, COD, BOD, ammonical nitrogen and pH) showed that the water quality has improved from Class IV to Class III (suitable for water supply, with extensive treatment) [3].

Other newspaper write up is a community project to promote the positive effects of mud balls in order to enhance water quality was recently held at Universiti Tunku Abdul Rahman's (Utar) Kampar campus. Malaysia For Youth (iM4U) held this program and participate by both students of Utar and residents from Kampar. This program is done to raise awareness on the use of mud balls to purify disused mining ponds to preserve the ecosystem. Event's organising chairperson said mud balls are widely used in sewage treatment, and accepted in the aquaculture field due to its efficiency. Besides, mud balls are also can control ammonia levels and suppress pathogens present in rivers, ponds and lakes. Mud balls are very easy to make, and are widely used to clean polluted waterways because they would inhibit the growth of algae, and breakdown any sludge or silt in the water [4].

Even though the write up about EM Mudballs can treat river pollution, if the pollution continuously flows into the river, and the mudballs are not regularly being thrown, the river might be polluted again. As for the example in December 2006, the Drainage and Irrigation Department spent RM100,000 to dump EM mudballs into Taman Aman Lake in Petaling Jaya, Selangor. It was not followed up with more mudballs treatment and prevention of pollution into the lake. And so, the lake remains dirty. Abdullah Ismail also encourages communities to use EM at home. Dumping kitchen waste need to be stop and can be compost it using EM, then pour the liquid that is produced

into drains and rivers. He says this EM-enriched solution will help keep drains, sewers and streams clean. But for EM mudballs to work, they have to be continuously tossed into the river. A single pitch cannot mop up all the dirt and would only amount to wasted funds [5].

Unlike newspaper, there are only several study on the effect of EM in improving the river water quality. Nawari [6] found that after rehabilitation work was done, both of Anak Sungai Skudai and Sungai Senai falls in Class III from Class IV. EM is one of the method used as the rehabilitation work. The highest pH reading recorded was 7.7. The highest TSS value obtained was 42.7 mg/L which still lies in Class I according to NWQS. Highest AN concentration is in Class V with a value of 3.2 mg/L. DO, BOD and COD had a value of 4.6 mg/L, 12.1 mg/L and 37.3 mg/L respectively [6]. Moreover, Suraya [7] found that EM also can be used in biofilter system and said to be effective in improving water quality where for overall the concentration of parameters SS, COD, BOD, AN and turbidity decreased after the treatment. The biofilter is most capable in improving SS and turbidity where the highest removal efficiency achieved is as high as 67.31% and 72.42% respectively. The percentages of removal for COD are in the range 4.7% to 51.63%. Poor performance were shown in AN and BOD improvement. The average removal efficiency recorded for the five events is only 3.7% and 2.4% for AN and BOD respectively [7].

Effective Microorganism (EM) Technology

The concept of effective microorganisms was developed by Japanese horticulturist, Teuro Higa of the University of Ryukyus in Japan. He reported in the 1970s that a combination of approximately 80 different microorganisms is capable of positively influencing decomposing organic matter such that it reverts to a life-promoting process. His studies have shown that EM may have a number of applications, including agriculture, livestock, gardening, landscaping, composting, bioremediation, cleaning septic tanks, algae control and household uses [8].

Effective Microorganism (EM) Concept

EM consists of beneficial bacteria that were used for the purpose to prevent disease by preventing the growth of pathogenic bacteria, and increase the efficiency of organic matter intake. EM can prevent formation of chemical reactions of non-beneficial bacteria that will help in increasing the environmental microbiology that leads to healthy environment. Bacteria in the EM solution can increase dissolved oxygen (DO), stabilize pH in water, reduce odor, reduce nutrients in the pond, reduce sediment or sludge in pools, lowering the level of biochemical oxygen demand (BOD) and chemical oxygen demand (COD), reducing the level of hydrogen sulfide gas production, reducing the level of organic matter in the water, reducing iron and manganese level, and improving the level of turbidity [9].

Effective Microorganism (EM) Composition

Effective Microorganism (EM) consists of lactic acid bacteria (LAB), photosynthetic bacteria (PsB) and yeast. When this three bacteria are mixed with organic matter, beneficial compound such as vitamin, hormones, enzyme, organic acid, mineral and various anti-oxidants will be produce [9].

Application of EM Technology in Sungai Sebulung

During August 2008, the local community had been taught on how to use the EM. The community used EM Technology to fertilize the garden area as EM helps in plant growth. Besides, EM can be used as washing agent which can neutralized the discharge. 60 units of kitchen garbage recycle bin had been provided by JBCC to the community to produce organic fertilizers and the EM liquid. EM Mudballs are thrown into the river by the community, NGO's, JBCC and visitors to clean the river. Before the project started, Sungai Sebulung is in Class 5. It is expected to improve to Class 3 [10].

Research Methodology

Location of the Study

Sungai Sebulung length is approximately 5 km. It is located at latitude, N 01° 30' 44.11" and its longitude, E 103° 44' 49.29". This river is located in Kampung Melayu Majidee, Larkin, Johor Bahru. It is 10 km from Johor Bahru causeway. Sungai Sebulung is surrounded by squatter house. The houses are relatively close to each other. Sullage is all drained directly into the river. Additional effect that brought pollution through fertilizers and pesticides used in tree and flower along the river.

Sampling

Samples were collected from 6 stations. Before sampling, several data of the location have been recorded to differentiate each station, which are the date, station number, coordinate and weather conditions.

Table 3.1: table of Weather for every sampling session

Date of Sampling		
29/2/2016	1/3/2016	18/3/2016
Weather		
Sunny	Sunny	Cloudy

Table 3.2: Table of coordinates for each station

Station	**Coordinate**
1	01° 30'42.1" N 103°44'39.5" E
2	01° 30'43.1" N 103°44'43.2" E
3	01° 30'43.9" N 103°44'48.6" E
4	01° 30'44.0" N 103°44'50.5" E
5	01° 30'44.2" N 103°44'57.4" E
6	01° 30'42.1" N 103°44'50.6" E

In-Situ Analysis

We need to carry out In-Situ analysis as we need to identify the exact reading of pH, temperature and dissolve oxygen (DO) of Sungai Sebulung.

Laboratory Analysis

The test analysis conducted are conducted at Environmental Laboratotary at UTM Skudai. This tests are used to determine the results of water quality parameter which are total suspended solid (TSS), temperature, pH, dissolve oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen (AN) and phosphate.

Results and Discussions

All of results that being obtain from the test that had been conducted for both *in-situ* test and laboratory test were being analyzed. This is important to make sure that the water quality index can easily being calculated.

Dissolved Oxygen

Figure 1 shows average DO at Sungai Sebulung. From the graph, average DO value slightly drop from S1 to S3, inclined until S5 then drop back at S6. The average value recorded for each station was 3.59 mg/L. By referring this value of DO to the National Water Quality Standards (NWQS), it can classified as Class III. The concentration of DO by previous data were 3.1 mg/L [9] and 3.08 mg/L [1], shows that the current DO concentration is slightly higher but the river's class remains the same at Class III.

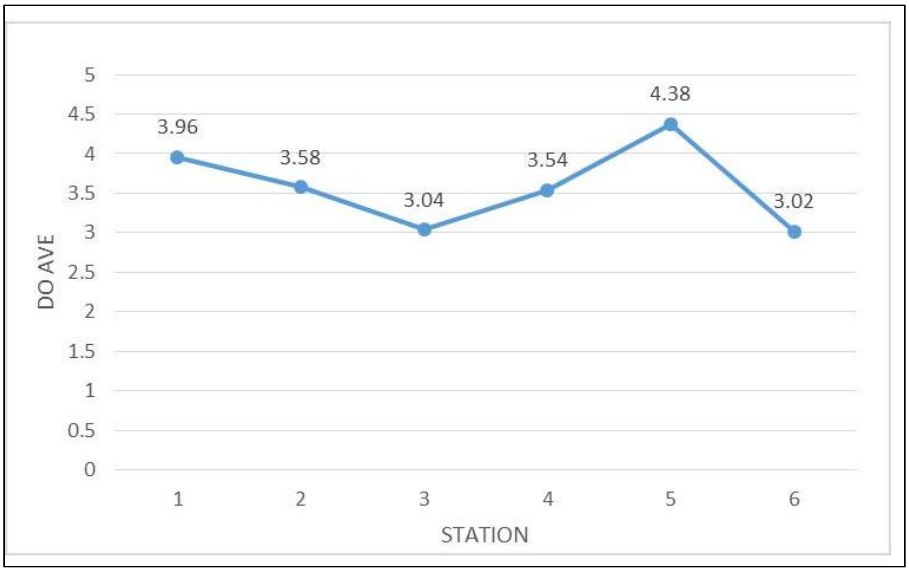

Figure 1: DO concentration versus Sampling Stations at Sungai Sebulung

Temperature

Figure 2 shows average temperature recorded at Sungai Sebulung. From the graph, average value of temperature increase from S1 to S4 then slightly decreased approaching S6. The average value recorded for each station was 29.39°C. This shows that the river does not flow with high temperature and have normal temperature for each station. The temperature obtained from the previous data were 29.3°C [9] and 28.64°C [1], shows quite similar results with the current temperature.

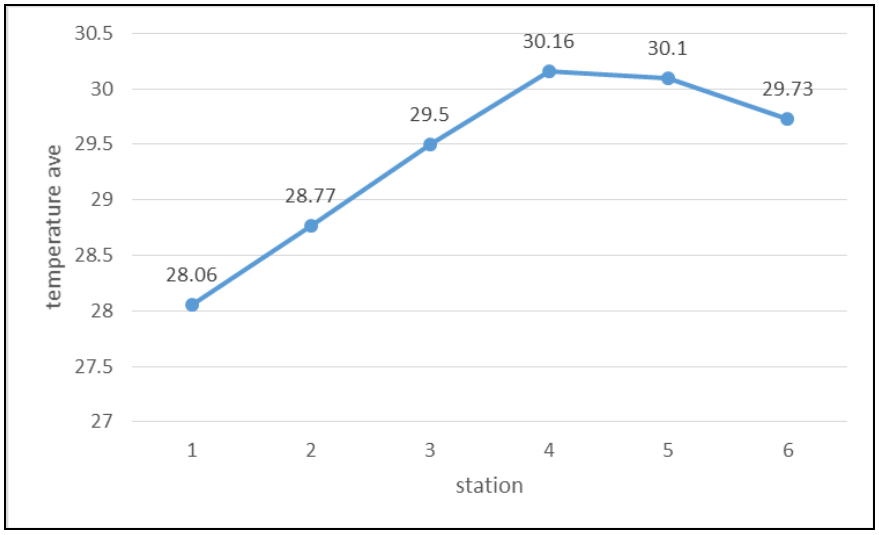

Figure 2: Temperature versus Sampling Station at Sungai Sebulung

pH

Figure 3 shows pH at Sungai Sebulung. From the graph, average pH value increased from S1 to S3, remain almost constant at S3 to S5, and increased back towards S6. The average value recorded for each station was 7.31. By referring to the National Water Quality Standards, it can classified as Class III. The concentration of DO by previous data were 6.10 [9] and 6.49 [1], shows that the current pH value is quite high but the river's class remains the same at Class III.

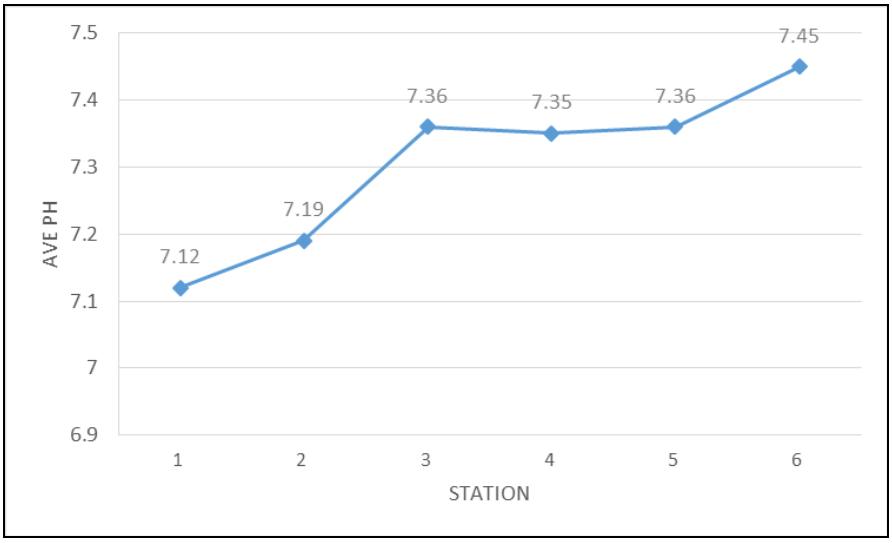

Figure 3: pH versus Sampling Station at Sungai Sebulung

Biological Oxygen Demand (BOD)

Figure 4 shows BOD concentration at Sungai Sebulung. From the graph, average BOD value is not consistent from one station to another as the value increased and drop alternately. The average value recorded was 18.39 mg/L. The last station which is S6 has the highest value of BOD that can affect the river's biodiversity. This is due to S6 is located at downstream and at the end of Sungai Sebulung where all the rubbish and waste mostly being trap in. By referring this value of BOD to the NWQS, it can classified as Class V. The concentration of DO by previous data were 29.3 mg/L [9] and 20.26 mg/L [1] shows slight improvement in BOD concentration. This shows that Effective Microorganism is effective in reducing BOD of Sungai Sebulung.

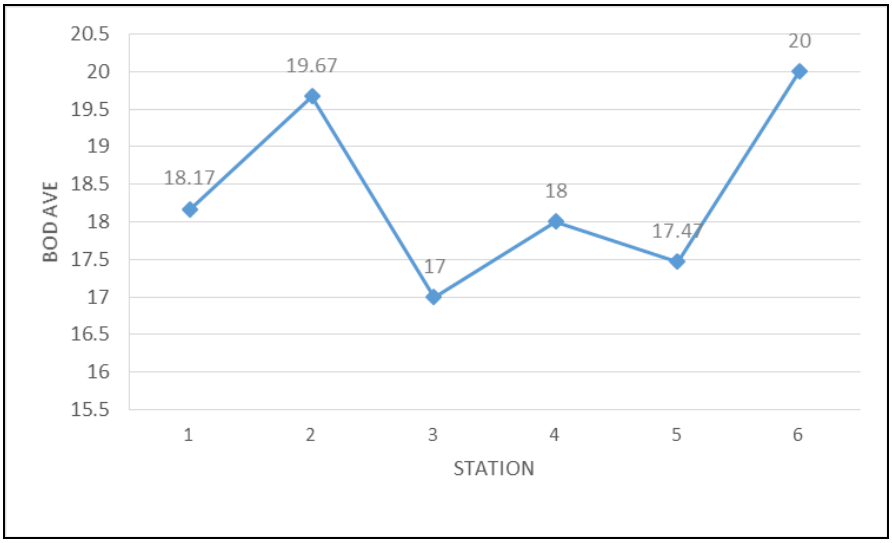

Figure 4: BOD versus Sampling Station at Sungai Sebulung

Chemical Oxygen Demand (COD)

Figure 5 shows COD at Sungai Sebulung. From the graph, average BOD value was not consistent from one station to another as the value increased from S1 until S3 and drop towards S5 and next increased at S6. The average value recorded for each station was 53.5 mg/L. By referring this value to NWQS, it can classified as Class IV. The concentration of COD by previous data were 48.2 mg/L [9] and 53.5 mg/L [1], shows that the current BOD value is remain the same from last year study.

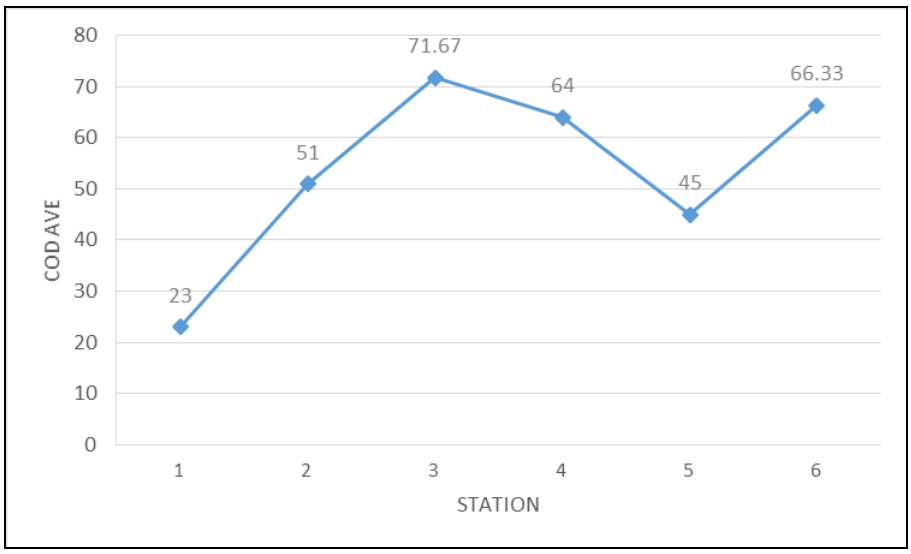

Figure 5: COD versus Sampling Station at Sungai Sebulung

Total Suspended Solid (TSS)

Figure 6 shows TSS at Sungai Sebulung. From the graph, average BOD value is slightly stable from S1 until S4 but having extra decreased at S5 but then increased back at S6. The average value recorded for each station was 19.89 mg/L. By referring to NWQS, it can classified as Class III. The concentration of TSS by previous data were 25 mg/L and 18.7mg/L [1,9], shows that the current TSS value decreased from the first study but slightly increased from 2015.

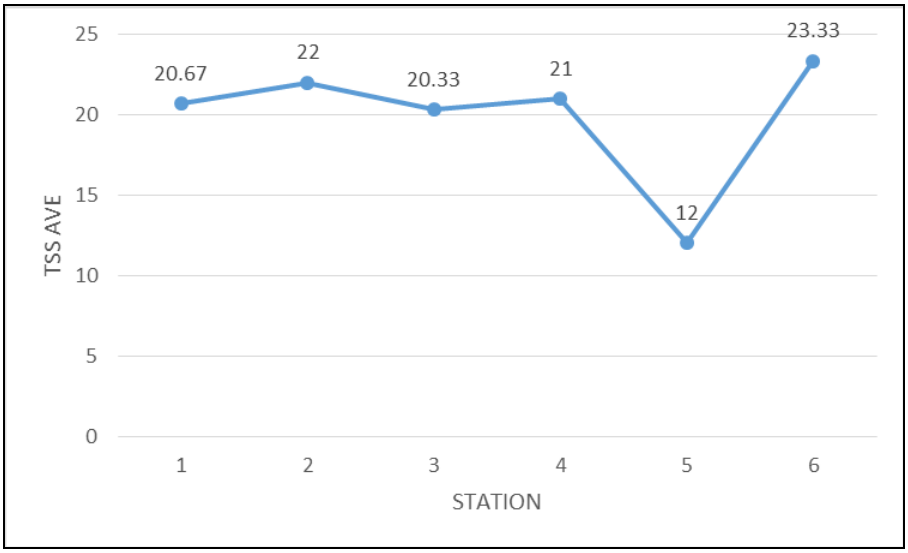

Figure 6: TSS versus Sampling Station at Sungai Sebulung

Ammoniacal Nitrogen (AN)

Figure 7 shows AN concentration at Sungai Sebulung. From the graph, average AN value increased from S1 until S3, decreased towards S5 but then increased back at S6. The average value recorded for each station was 4.24mg/L. By referring to NWQS, it can classified as Class V. The concentration of AN by previous data were 0.3 mg/L and 7.43 mg/L [1,9] shows that the current AN concentration increased from the first study but decreased from the second study. The reason why the AN value is very high is the usage of excess chemical fertilizers by the residents nearby. Along the side of river wall, lot of flowers and herb trees were being planted. This can causes the significant increment of AN concentration.

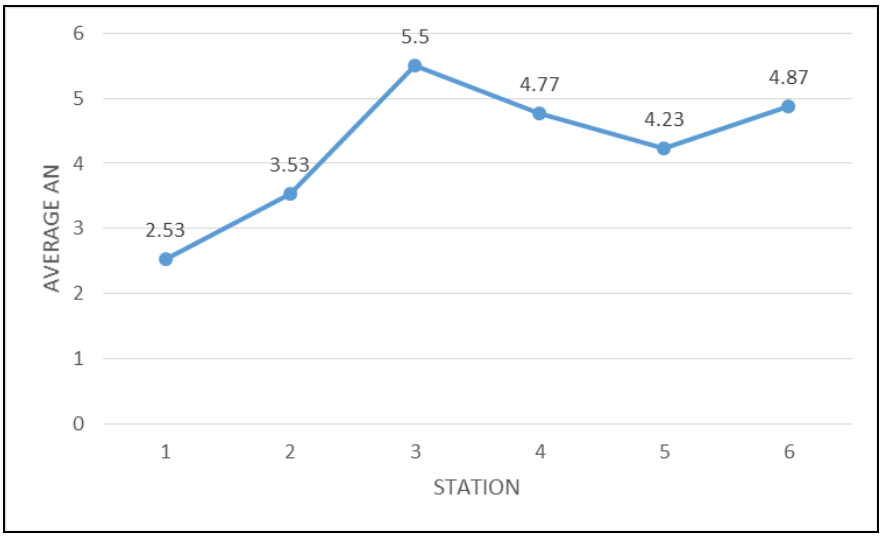

Figure 7: AN versus Sampling Station at Sungai Sebulung

Orthophosphate

Figure 8 shows phosphate at Sungai Sebulung. From the graph, average orthophosphate concentration increased from S1 to S3, decreased at S4 and remain almost stable at S5 but then decreased at S6. The average value recorded for each station is 4.24 mg/L. phosphate may come from fertilizer runoff form herbs plant planted by the villagers. Besides, sullage that contains detergents are channel directly into the river may cause increasing amount of orthophosphate. orthophosphate can contribute to excessive algal growth and eutrophication.

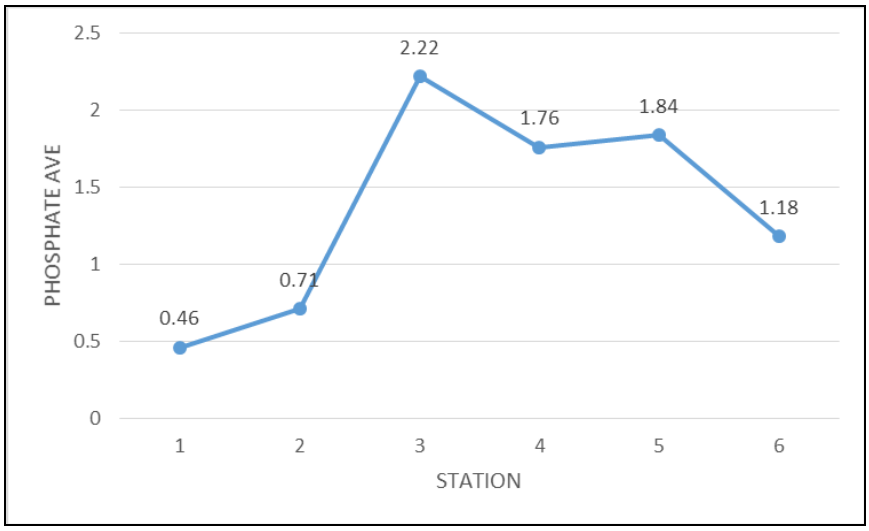

Figure 8: Orthophosphate versus Sampling Station at Sungai Sebulung

Water Quality Index (WQI)

WQI for Sungai Sebulung was classified as Class IV during first sampling on 1st March 2016. This is because during first sampling, the EM Mudballs are not being thrown yet into the river and the cleaning process is not being done yet. Classification of Sungai Sebulung increased into Class III at the second sampling (18th March) and third sampling (18th April). During second sampling, the EM Mudballs is being thrown a week before the water quality is being taken. The third sampling is done a month after the EM Mudballs being thrown. This indicate that there are changes in water quality classes for Sungai Sebulung from Class IV to Class III which the water quality become much better.

As for the average data for all three sampling that being taken, the classification of Sungai Sebulung is Class III. Based on the secondary data provided by previous study [9], the was Class III in 2009. And for 2015 [1] the river's class was Class IV This shows that the water quality of Sungai Sebulung has improved in terms of WQI.

Conclusion and Recommendations

Conclusion

Effective Microorganism (EM) treatment method is effective in reducing temperature, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and ammoniacal nitrogen (AN). By referring the 6 parameters data to Water Quality Index, the overall class of this river also improved from Class IV to Class III. This shows that EM is effective in reducing several types of pollution as mentioned before. Not just that, it is also effective in improving the overall class of the river. Only several parameter that EM did not manage to reduce which is pH, dissolve oxygen (DO) and also total suspended solid (TSS).

Recommendations

1. The inconsistency of EM Release to the river
   The residents themselves did not throw the EM according to the appropriate time. As for the EM to be effective in increasing the Sungai Sebulung water quality, EM mudballs need to be thrown from time to time. Therefore, the chief of the village or the organization of the village need to play an important role. They need to keep reminding the villagers to follow the exact time for the EM Mudballs to be thrown into the river.

2. Resident's Cooperation
   As for the residents, they had lived in this area for generations. They are not aware and may not have the knowledge about the importance of ensuring the river to flow with good water quality. Thus, MBJB should do more programs to increase their awareness and cooperation. During the third sampling, there are new program that had been held to increase awareness of the residents. This program is call "Kaedah Kitar Semula Sisa Makanan dan Sampah Organik Dapur dengan Bioteknologi EM". This container is being put at the back of each resident's house. The process also are clearly be seen on the container. This is one of the effective way to make residents recycle their leftover food, and it will become EM during certain amount of time.

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