Impact of Rice Paddies Plantation Activities on Surface Water Quality in Mukim 5,Seberang Perai Utara, Malaysia

Harlina Ahmad, Mazratul Amyra Abdul Rashid, Norli Ismail, and Noridayu Mohamed

***Abstract*—**Rivers are the main sources of water for agricultural purposes in Malaysia. A study was carried out in paddy plantation and the irrigation channels at Mukim 5, Penaga, Seberang Perai Utara, Pulau Pinang. The irrigation water for the Sungai Muda and the Pinang Tunggal sub-schemes was taken from the Muda river through the Bumbong Lima pump station and the Pinang Tunggal pump station, respectively. The six parameters of physical and chemical characteristics of surface water quality were measured and analyzed were pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonical nitrogen (NH3-N) and suspended solids (SS). The water samplings were conducted during the period before planting, during planting and after planting in one season. Results showed that the pH values were between 5.19 to 6.70, DO was between 0.76 to 3.81 mg/l, BOD was in the range of 1.36mg/l to 5.9 mg/l, COD was in the range 114 to 160 mg/l, the concentration of NH3-N was between 0.69 to 2.4 mg/l and the value of SS was between 8 to 219 mg/l. The water quality index for the study can be categorized under class III and slightly polluted. The results of this study can be a basis for future studies on irrigation water quality in the other projects.

***Keywords*—**environment, rice paddy plantation, water parameters, water quality index.

I. Introduction

WATER is essential for human life and other activities. Many studies have pointed out that pesticide runoff from paddy fields are responsible for the contamination of rivers [3], [8], [11], [12]. It was also proved that rice paddy is one many sources of environmental contamination by most pesticides in Malaysia [9]. Due to the prerequisites of the paddy rice production such as continuous water logging, agrochemicals applied in paddy fields represent a threat to the environment as they are transported with flow water in dissolved and/or sediment-bound phases towards receiving waters [13]. In rice growing regions such as Spain, Italy and Greece in the Mediterranean as well as in Japan there were some recent studies conducted indicate that loss from paddy fields to receiving water bodies can reach up to 18% of the applied pesticide [9]. Damaged soils through over-saturation and salt build-up often occur due to improper irrigation practices, accompanied by inadequate drainage. This irrigation generates environmental problems that can threat not only agricultural production systems but also human health and the environment. Irrigated agriculture affects water quality in several ways, including higher chemical-use rates associated with irrigated crop production. The objective of the study is to investigate the affect of paddy field planting activities onto adjacent irrigation water quality scheme area at the selected paddy field in Mukim 5, Seberang Perai Utara Scheme, Malaysia.

II. Methodology

A. Description of The Study Area

This study was conducted in the area is 5 square km of paddy field lots in Kg Padang Tembusu in Mukim 5, Penaga, Seberang Perai Utara. The samplings involved two main irrigation channels of the paddy plantation lots that were Sg. Tembus and Sg. Lahar Endin. There were 10 sampling points chosen in this study. As shown in figure 1 sampling points no. 1-4 were located along Sg. Tembus irrigation channel until river estuary. Sampling points 7-9 were located along Sg. Lahar Endin until river estuary. Sampling point S10 was randomly selected in the paddy lot itself. The description for the points was summarized on Table 1.

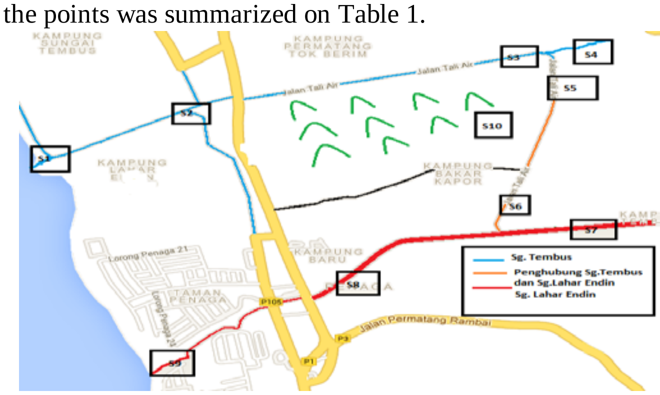

Fig. 1 Map of sampling location

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TABLE I
DESCRIPTIONS OF THE SAMPLING POINT

Points	Description
S1	Located at the end of the Sungai Tembus and also known as lade. There is residential area for fisherman and a path for boat go to ocean.
S2	Located along Sg.Tembus. There are a few residential areas.
S3	Located at the intersection between S4 and S5. The river water from the S4 transferred to the S3
S4	Located at the starting point of Sungai Tembus. Water transfer from S4 to S5 and S3
S5	Located at intersection between S4 and S3. S5 was in the connecting of the two rivers.
S6	The river water from S5 flows to S6. S5 is the connection for Sg Tembus and Sg. Lahar EndinThere was a lot of plant at the point.
S7	Located the beginning point of Sungai Lahar Endin. There is a small bridge construction site and the upstream from the S7 there is sewage treatment plant and a mee hoon factory. Nearer with road vehicles
S8	Located along Sg Lahar Endin. Near to main road and residential areas.
S9	Located at the end of the Sungai Lahar Endin and also known as lade. There are few of residential areas and a path for boat go to ocean.
S10	Located at the middle of paddy field. There are paddy planting activities occurred such as fertilizing and poisoning activities.

B. Analysis Data

The six parameters of physical and chemical characteristics of surface water quality measured and analyzed were pH value, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonical nitrogen (NH3-N) and suspended solids (SS). The parameters that were measured in-situ were pH, salinity, DO, flow rate and temperature. The values of pH can be determined by using pH meter (HACH, Sension 1). The samplings were based on the age of paddy and pesticide application on the field. The water samplings were conducted during the period before planting, during planting and after planting in one season. Before and during planting activities included sowing seeds and ploughing and after planting activities included removal of water from the paddy plot into the water body. The schedule of water irrigation was provided by Department of Irrigation and Drainage. The water quality was analyzed based on Standard Methods for Examination of Water and Waste Water (APHA, 2005) [2] and the results obtained were compared with National Water Quality Standards for Malaysia (NWQS). In evaluating the status of the river water quality, the Department of Environment (DOE) Water Quality Index (WQI) were used. WQI calculated for each point using following equation.

$$WQI = 0.22SIDO + 0.19SIBOD + 0.16SICOD + 0.15SIAN + 0.16SISS + 0.12SIpH \quad (1)$$

III. RESULT AND DISCUSSION

A. pH

The pH values in the study area range from 5.19 to 6.70. The pH values were slightly acidic. As shown in figure 2, pH values at (S9) and (S1) were higher compared to others. The pH values measured in the paddy plot were relatively low at 5.83. The results obtained showed it varied between the planting activities and also between the sampling points. However, all the pH values were within the permissible limit (Class IV) for irrigated agriculture. Figure 2 showed that pH value decreased before and during planting activities in the paddy plot (S10). The use of chemical fertilizer such as pretilachor and lambda-cyhalothrin to enhance the plantation has caused an increase in soil humus such as humid acid in the water sample. Hence, this might influence the pH value of water samples.

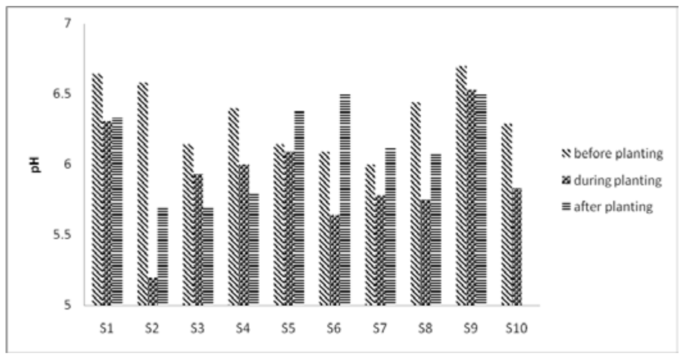

Fig. 2 Comparison of pH between planting activities
Note: after planting at S10 cannot be measured due to the dry condition

B. Dissolved Oxygen

The DO test is one of the most important analysis in determining the quality of the natural waters. The effect of oxidation of wastes on streams, the suitability of water for fish and other organisms and the progress of self-purification can be evaluated from the dissolved oxygen content. The oxygen content of water depends on physical, chemical biological and microbiological processes. At all sampling points, DO readings measured are between 0.76 to 3.81 mg/l. The maximum value of DO was recorded during planting 3.81 mg/l (Figure 3). The heavy rain might increase surface aeration that increased in flow rate of surface water and resulted in higher DO reading. All the result range can be categorized within Class IV according to the Department of Environment (DOE) Water Quality Index Classification.

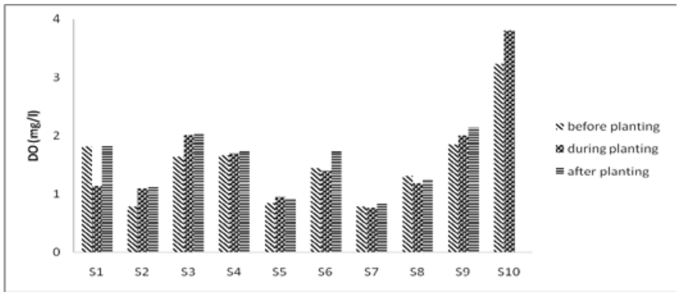

Fig. 3 Comparison of dissolved oxygen between planting activities
Note: after planting at S10 cannot be measured due to the dry condition

C.Chemical Oxygen Demand(COD)

Chemical Oxygen Demand test for natural water yields the oxygen equivalent of the organic matter that can be oxidized by a strong chemical oxidizing agent in an acidic medium. For samples from a specific source, COD can be positively correlated to BOD, organic carbon or organic matter. COD values were referred to the level of oxygen needs by the organic and inorganic matters in the water sample for oxidation process due to chemical reaction by microorganisms as they degrade organic and inorganic matters. The COD measured for all sampling stations were in the range of 114 to 160 mg/l. The water sample could not be taken due to the dry condition in the paddy plot after the planting activities at S10. The highest value of COD was recorded at the point (S1) after planting activities with the range of 160 mg/l (Figure 4). The high value of COD could be attributed due to the level of organic matters from the fertilizer during fertilization activities. The higher COD value might also be contributed by human activities at lade and residential areas nearby.

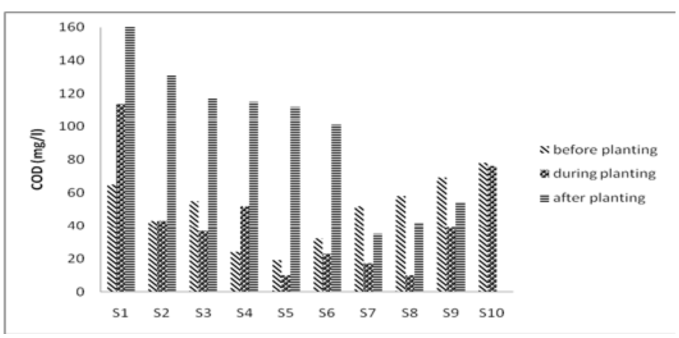

Fig. 4 Comparison of COD between planting activities
Note: after planting at S10 cannot be measured due to the dry condition

D. Total Suspended Solid

The suspended solid test quantifies all the solids in the water, suspended and dissolved, organic and inorganic. The SS determination is extremely valuable in the analysis of polluted waters. It is one of the main parameters used to evaluate water quality which determine the level of concentration of domestic wastewater and it also affects the turbidity of water. The value of SS at each sampling station varied between 8 to 219 mg/l (Figure 5). The highest value recorded at the paddy plot (S10) which was during planting activities because of the process of ploughing. The ploughing activities might gave impact to soil particle, flows with runoff to the water body and as a result an increase in the suspended solids of water sample. However, the concentration of SS was still within the permitted range according to Interim National Water Quality Standards for Malaysia.

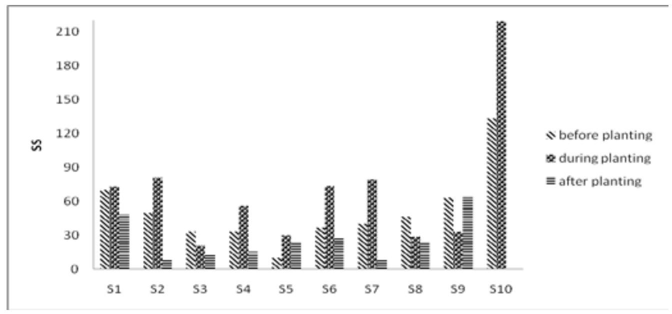

Fig. 5 Comparison of suspended solids between planting activities
Note: after planting at S10 cannot be measured due to the dry condition

E. Biochemical Oxygen Demand(BOD)

The 5-day BOD (BOD5) were used to measure the amount of dissolved oxygen used by bacteria to oxidize organic matter in the water sample during a certain period of time. It indicates the amount of organic inputs from various sources into the rivers. The BOD range between 1 mg/l to 6 mg/l. The highest value was recorded at the point (S1) and (S9) that was 6 mg/l (Figure 6). This is because of all the water from the irrigation and paddy plot joint there. Before and during planting activities included sowing seeds and ploughing might be contributed highest value in the paddy plot that is 5 mg/l. During this period, bacteria used more oxygen would be activated in the oxidation process of organic material because the process of fertilization. The lower BOD value indicates that the lower organic material in the water. The BOD concentration continually increased after planting activities because of decaying process and other contributor such as fertilizers which increase the organics in the water bodies [4].

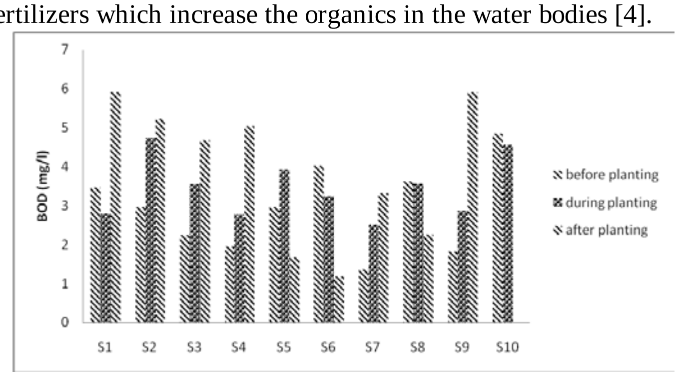

Fig. 6 Comparison of BOD between planting activities
Note: after planting at S10 cannot be measured due to the dry condition

F. Ammonical Nitrogen(NH_3N)

The presence of ammonium ions in water was connected with the process of the biochemical decomposition of protein substances contained in household and industrial sewage. The presence of ammonia-nitrogen in surface water usually shows domestic pollution. Usually ammonia concentrations are high during the early growing season due to the fertilization process in the field. Low concentrations appear at the end of the season when most of the ammonia have been used by rice plants. Figure 7 shows the concentration of NH3-N at each sampling point was between 0.69 to 2.40 mg/l.

The concentration at S7 was high but not exceeding the Water Quality Standard in Malaysia since the permitted concentration is between 0.1 to 2.7 mg/l for irrigation activities. The higher value 2.4 mg/l at point S1 and S9 might be due to excess of nutrients in the water body. The decomposition of excrement from aquatic organisms and from dead organisms might also be the reason of the high concentration NH3-N. However, at sampling point S7 the reading was higher compared to other sampling points due to at the upstream from the sampling point there are sewage treatment plant about one kilometer. The effluent also were discharge into the nearer irrigation channel. There is also mee hoon factory located near to the S7 point which also releases their effluent into the water body.

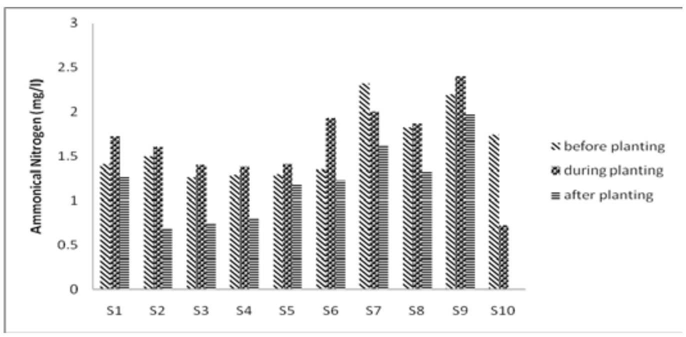

Fig. 7 Comparison of NH_3N between planting period
Note: after planting at S10 cannot be measured due to the dry condition

G. *Water Quality Index (WQI)*

Based on the WQI interpretation, the result indicated that water quality index for both rivers were slightly polluted and polluted. The range of polluted was between 45 to 70. Figure 8 below showed the index range for all sampling points and between the planting activities. The result shows that, the current water quality of the study was classified as class III and IV. Most of the point indicated that the water quality were within class III. The index range between 51.9 to 76.5. As shown on table 3, the water quality was slightly polluted. The pollution index is suitable for irrigation activities but need extensive treatment to be utilized for drinking purpose.

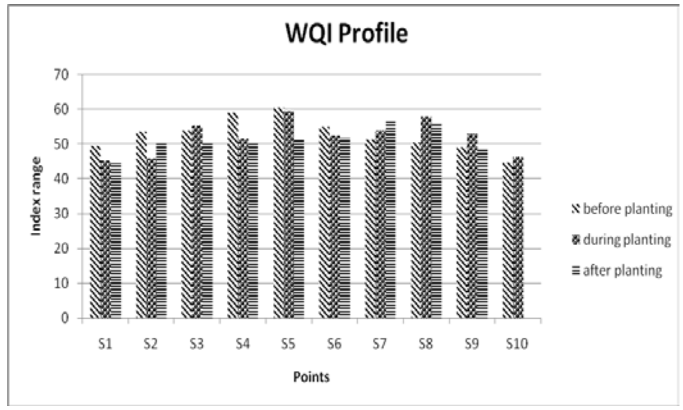

Fig. 8 The WQI data for the each points and paddy activities.

IV. Conclusion

The water quality varied based on the location of the sampling points and also the paddy planting activities. Generally, the irrigation channel at Kampung Padang Tembusu was classified by class III based in WQI. Water quality data indicated that the two river (Tembusu and Lahar Endin river) were slightly polluted due to the planting activities, domestic waste and food industrial pollution sources. These findings will effectively contribute toward better understanding of the chemical and physical parameters onto rice agro ecosystem.

Appendix

TABLE II
MALAYSIAN DEPARTMENT OF ENVIRONMENT(DOE) WATER QUALITY INDEX CLASSIFICATION [15]

Parameters	Unit	Classes				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/L	<0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
Biological Oxygen Demand (BOD5)	mg/L	1	1-3	3-6	6-12	>12
Chemical Oxygen Demand (COD)	mg/L	<10	10-25	25-50	50-100	>100
Dissolved Oxygen (DO)	mg/L	>7	5-7	3-5	1-3	<1
pH	mg/L	>7	5-7	5-6	<5	>5
Total Suspended Solid (TSS)	mg/L	<25	25-50	50-150	150-300	>300
Water Quality Index (WQI)	mg/L	>92.7	76.5 - 92.7	51.9-76.5	31-51.9	<31

TABLE III
MALAYSIAN DEPARTMENT OF ENVIRONMENT(DOE) WATER QUALITY CLASSIFICATION BASED ON WATER QUALITY INDEX(WQI) [15]

Parameters	Index Range		
	Clean	Slightly Polluted	Polluted
SIBOD	91-100	80-90	0-79
SIAN	92-100	71-91	0-70
SISS	76-100	70-75	0-69
WQI	81-100	60-80	0-59

ACKNOWLEDGMENT

The authors would like to extend their appreciation to the Universiti Sains Malaysia (USM) and the staff of Department of Irrigation and Drainage Seberang Perai Utara in Pulau Pinang for all the assistance rendered during the period of study. Acknowledgment is also made to USM short term grant (10001/PTEKIND/6312098).

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