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Research paper



Environmental Management on Natural River Based on Water Quality Deterioration in Terengganu River Basin, Terengganu, Malaysia

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Abstract

This study is aimed to look at the level of water quality deterioration in Terengganu River Basin. Environmental management studies on the deterioration of water quality in Terengganu River Basin have been using data collection and analysis methods. The Gravimetric method was used to analysis the TSS measured in mg/L. 250 ml water samples was needed for each study area (each station). All preparation and preservation of the samples are in accordance with standard procedures provided by the American Public Health Society (APHA) and United States Environmental Protection Agency (USEPA). The results show that Terengganu River Basin is classified in level III that is contaminated. The Terengganu River Basin is contaminated at the downstream to the middle of the river due to anthropogenic activity. Moreover, the results indicate that the amount of AN and TSS is higher and is a major contributor to the deterioration of water quality in the Terengganu River Basin. Management of water resources should be improved and noted. This study has proposed several steps in managing water resources such as settlement of land use solutions, regulatory methods, river quality monitoring programs, minimizing waste, wall construction, the use of Geographic Information System (GIS) and legislative measures.

Keywords: *Terengganu River Basin; America; mitigation methods; Geography Information System (GIS).*

1. Introduction

Water resources are one of the most important elements in all aspects of life in the world or for the development of an area. Malaysia is a country rich in natural water resources. This is because, Malaysia has a southwestern and northeastern monsoon that causes the country to average an average annual rainfall of more than 2500 mm. From annual water resources recorded the total land mass of 330, 000 km^2 to 990 billion m^3. According [1, 2], 7% or 64 billion m^3 of the total has drained underground water and 36% or 360 billion m^3 have returned to the atmosphere known as evapotranspiration. There are plenty of water sources that can be found, namely river water, waterfalls, seawater and so on. The river is one of the main water sources and has many uses. Among the uses of the river are water supply for agricultural, beverage, industrial, tourism and hydroelectric sources. Water resource management in the river requires systematic management to provide quality water resources. Many planning on the development of water resources management has been conducted to address water quality problems. Among them is the concept of environmental flows. This concept has been specifically designed to protect the aquatic downstream from danger [3]. The importance of the river as the main source of water has led to this study.

The clean and good of water quality requirements are essential for a particular area, especially for communities living in the Terengganu River Basin. The systematic water resource management is needed to reduce the cost of treatment, preventing leakage of pipes that will result in water degradation and maintaining water distribution to the community [4]. The monitoring of the Water Quality Index (WQI) is one of the methods to assess the quality and health of all rivers. Furthermore, studies on water quality index have been conducted by many researchers and are aimed at creating various water management systems such as river, lagoon, lakes and beach systems [5-8]. In this regard, the Department of Environment has classified rivers into a few classes such as class I, II, III, IV and V, based on the National Water Quality Standard (NWQS) and WQI. This is one of indicator to measure the quality of water and to detect water pollution (Table 1).

The context of environmental sustainability has been considered for environmental flows in Malaysia [9]. This is a fundamental principle in implementing development and finding ways to stabilize water use as well as to compete with environmental protection. Multi-criteria analysis is one of the important tools for ap-

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proach in the process of water allocation and environmental flow assessment is a method for measuring environmental criteria [10]. The DOE in Malaysia has operated a total of 146 river basins and has more than 1,000 river water quality monitoring stations manually and automatically. In addition, the Department of Irrigation and Drainage (DID) as well as agencies in all states also monitor water quality. This is the main method that is implemented to see the water quality level. In this regard, the quality of the water will be monitored by the NWQS.

Table 1: National Water Quality Standards (NWQS) for Malaysia [11]

Parameter	Class					
	Unit	I	II	III	IV	V
PH	-	> 7	6 – 7	5 - 6	<5	>5
DO	mg/L	>7	5 -7	3 - 5	1 - 3	<1
BOD	mg/L	<1	1 – 3	3 - 6	6 - 12	>12
COD	mg/L	<10	10 – 25	25 - 50	50 - 100	>100
TSS	mg/L	<25	25 – 30	50 - 150	150 - 300	>300
AN	mg/L	<0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	>2.7
Water Quality Index (WQI)		<92.7	76.5 - 92.7	51.9 - 76.5	31.0 - 51.9	>31.0

Class I	Conservation of natural environment Water supply I – Practically no treatment necessary Fishery I – Very sensitive aquatic species
Class IIA	Water supply II – Conventional treatment required Fishery II – Sensitive aquatic species
Class IIB	Recreational use with body contact
Class III	Water supply III – Extensive treatment required Fishery III – Common of economic value and tolerant species; livestock drinking
Class IV	Irrigation
Class V	None of the above

2. Methodology

2.1. Study Area (Terengganu River Basin)

The study was conducted around the Terengganu River Basin. Terengganu is a rich country with water resources. Terengganu has eleven main river basins, Terengganu River, Kemaman River, Dungun River, Besut River, Setiu River, Paka River, Marang River, Keluang Besar River, Mercang River, Kertih River and Ibai River. The main tributaries in Terengganu are Berang River, Nerus River, Telemung River and Tersat River and have 5000 km^2 catchment area as a whole. The river basin is a surface water runoff area where water sources will flow directly to the rivers, rivers, lakes and seas [12, 13]. Terengganu River Basin is located on the East Coast of Peninsular Malaysia (40 41' - 50 20'N, 102031' - 1030 9 ' E) and has a tropical rainforest climate with humid temperatures throughout the year. Fig. 1 shows the locations for sampling station at the Terengganu River Basin. The water samples were collected from 29 different predetermined sampling stations from downstream to upstream area along Terengganu River Basin (Fig. 2).



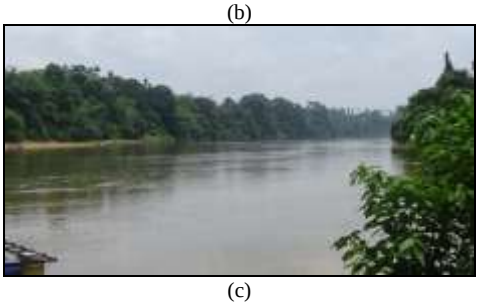
Fig. 1: 29 Location of Terengganu River, Terengganu, Malaysia



(a)



(b)



(c)

Fig. 2: Study includes include (a) Downstream, and (b) Middle stream (c) Upstream

The average annual air temperature in the state of Terengganu is between 26 and 28 ºC and receives average rainfall of about 3300 mm. Normally, in March to November it will experience the northeast monsoon season, which is heavy rain. From the secondary findings proved that the total annual rainfall distribution trends at the Terengganu River Basin ranged 2000 mm (January) to 6000 mm (December) every year from 2001 until 2010 (Fig. 3). The secondary findings indicate that the trend in the study area has significant changes in water quality level. During this season, the study area could be considered as the wettest region since all rainfall indices tested are higher than in other neighbouring state of

the Peninsular. Malaysia is one of countries receive are average rainfall of more than 2000 mm per annum. The distribution of rainfall in Terengganu from 2001 until 2010 showed the maximum of intensity rainfall during November until January every year. The total annual rainy days in the study area ranged from 130 to 197 with an average of 175 days/year or 15 days/month. The highest total number of rainy days were obtained at Kampung La (T2 5524001) and Ulu Setiu (T9 542600) especially on November until January respectively. The highest number of rainy days per month (16 days) was recorded during the wet season in 2006 (December), while February and April 2001 until 2010 recorded the lowest number of rainy days.

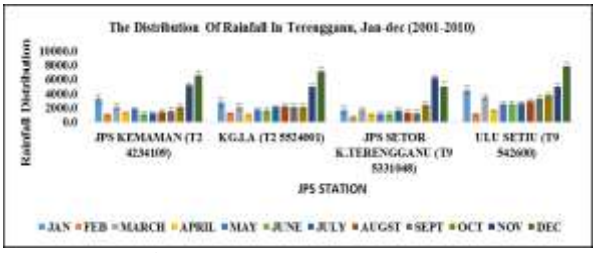


Fig. 3: Annual Rainfall Distribution Trends at the Terengganu River Basin Ranged (*Jabatan Pengaliran dan Saliran Malaysia* (JPS) dan *Jabatan Meteorologi Malaysia* (Malaysian Meteorological Department) (MMD))

2.2. Research Methodology

In this study, it requires a deep and systematic understanding of water resources management. This is aimed at achieving the goals and objectives of planning water resources development in the Terengganu river basin as well as addressing issues in the context of water quality when water resource management planning is underway. The method used in this study is data collection and analysis. All the sample preparation and preservations conducted were following on the standard procedures provided by APHA and USEPA Methods. The Gravimetric Method was used to analysis the TSS measured in mg/L. In lab analysis about 250 ml water sample was needed for each study area (each station). The measurements of in situ parameters were pH, temperature, Ammoniacal Nitrogen (AN), and Dissolved Oxygen (DO). All of these parameters were determined by using the water-quality Multiprobe Model DO meter YSI 58. This multiprobe meter was calibrated before field sampling. Then, the water sample for Chemical Oxygen Demand (COD) were preserved, kept at low temperature prior transportation to the laboratory and analyzed using DR 2800 Portable Spectrophotometer. Laboratory analysis was performed based on the standard method of analysis (APHA 1998) [14, 15].

3. Results and Discussion

3.1. Water Quality Status in Terengganu River Basin

Water resource management is an important aspect that needs to be addressed. This is because water resources management involves all aspects of beneficial water use. In this regard, the management of water resources in the Terengganu River Basin needs to be improved. Based on the results of the analysis, the water quality from the upstream to downstream of the Terengganu River was deteriorated. Table 2 shows that significant variable inputs with linear relationships to predict WQI in the Terengganu River Basin. This study also uses one-to-one method or input interests. This method is used to determine whether significant variables ($p < 0.05$) are caused by linear correlation between input-output. The highest percentage was AN (66.2%) and followed by COD (20.75%). The AN and CO parameters are high in the Terengganu River Basin due to the anthropogenic activity around the river basin and subsequently polluted Terengganu River Basin. At the same time, the table above also shows the lowest percent is DO (0.34%) and pH (0.15%). In addition, parameter analysis also showed that AN (50.31%) and TSS (48.03%) percent were the highest compared to other parameters.

Based on the analysis, AN and TSS are the main parameters that contribute to the Terengganu River Basin, especially in the upstream and downstream areas. In this regard, there are several factors that cause the quality of water in the Terengganu River Basin to be polluted and deteriorated. Among the factors are the research station adjacent to the disposal of municipal waste, industry, agriculture and some untreated aquaculture activities into the Terengganu river system and cause the results of the analysis to be affected. In addition, the decomposition process found that the pH and DO values were low and the values for TSS and AN were high [16, 17]. The pH and DO values are high because they contain organic content derived from these activities. In order to prevent Terengganu's water quality being polluted, river water management measures should be enhanced in Terengganu River Basin.

Table 2: Input importance variables in linear relationship to predict WQI at Terengganu River Basin, 2016

R-Square Reference = 0.9737			
Leave Variable	R-Square Leave Variable	R-Square Difference	Percent Contribution
DO	0.9718	0.0019	0.34
BOD	0.9499	0.0238	4.36
COD	0.8603	0.1134	20.75
AN	0.6120	0.3617	66.2
TSS	0.9289	0.0448	8.2
PH	0.9729	0.0008	0.15
Total	5.2957	0.5464	100

Soil erosion is one of the causes of the occurrence of TSS concentration being higher. This is because land erosion is one of the most complex problems that is hard to predict especially for tropical areas with high rainfall [18, 19]. When the sediment lifting process cannot be overcome, it will bring various problems to the care and management of the river. Among the consequences is that the river water becomes turbid, the water is not neutral, removes an unpleasant odor and color [18]. In addition, the TSS parameter concentration also increases due to external factors brought about by rainwater runoff [20-22]. In addition, anthropogenic activity such as municipal, industrial, aquaculture and aquaculture also contributed to the occurrence of TSS concentration [23, 16, 17]. This is evident when a high concentration of TSS in Terengganu River Basin is 48.03%. This is due to the presence of sand mining activities around the Nerus River which may cause the riverbed to be loose and easily eroded. The rate of erosion can be controlled when the stable method of forest canopy is carried out. This is because this method can reduce surface erosion. The intercepted process is a layered layer of canopy which acts as a filtration thus reducing soil erosion during rainfall [14]. Therefore, high potential activities that cause the management of water resources in the Terengganu River Basin deteriorate must be controlled and monitored systematically.

Based on the DOE-WQI computational value (Table 3), the waters of the Terengganu River Basin from the upstream to downstream of the river are classified as class III, at a contaminated level. In this case, all stations show WQI levels not too low than 60% which are ideal for recreational activities where body contact is still safe. However, there is the treatment required to prevent the river's water quality to become worse. In this case, management and control methods should be carried out to prevent the deterioration of river water quality as a means of conservation. The results showed that low water quality was at downstream stations and in the middle stream. Downstream and central areas have low water quality because the area is close to anthropogenic activities such as industrialization, agriculture, sand mining and residential areas (WQ1 until WQ14). In contrast, high river water quality is at the head of the river where it is near the Kenyir Dam.

Table 3: Water Quality Index of Terengganu River Basin at the 29 Stations

Streaming Station (WQ)	Average Value WQI	Class (I, II, III and IV)
1	60.576	III
2	67.164	III
3	71.358	III
4	70.288	III
5	71.888	III
6	70.173	III
7	65.706	III
8	59.289	III
9	71.019	III
10	73.324	III
11	73.759	III
12	73.531	III
13	74.228	III
14	65.866	III
15	74.210	III
16	74.434	III
17	74.410	III
18	73.380	III
19	74.054	III
20	73.134	III
21	74.569	III
22	73.741	III
23	73.316	III
24	74.757	III
25	74.327	III
26	74.130	III
27	74.281	III
28	72.885	III
29	73.731	III

3.2. Recommendation of Water Quality Management in Terengganu River Basin

Based on the studies conducted, the cause of water quality in the Terengganu River Basin was deteriorating. Therefore, there are several steps for water resources management in Terengganu River Basin. Among them is settlement of land use change. In this case, activities involving land use changes such as agriculture, industrial, waste disposal and sand mining, especially in the Terengganu River Basin, should be systematically controlled as to establish legal control to control land use activities [3, 24, 25]. Mitigation is also one of the steps in improving the management of water resources in Terengganu River Basin. In this case, the developer must play an important role in the success of gation method. When sediment problems are not well m will disrupt the water resource management process and economic, social and human well-being especially thos the Terengganu River Basin area to be affected for a [18, 26-28].

The next step is through the River Water Quality Monit gram. The program aims are intended for water resou agement such as improving river water quality, detectin and identifying sources of pollution. This program has b aged by Environment Malaysia Sdn.Bhd (ASMA). In th there are 920 manual water quality monitoring statio throughout the river basin in Malaysia. The main river lution parameters in Malaysia are TSS [29]. The TSS pa to determine the quality status of the Terengganu Ri either clean, medium, contaminated or contaminated a classified into Class I, II, III, IV and V based on the WC NWQS [30-32]. Minimizing wastes is one of the most a steps in managing water resources in river basins. In th can be done by reducing the concentration and volume especially industrial activity through resource control cling programs. One of the possible approaches is to bui treatment plant and domestic wastewater in the industr treated water can be reused for cleaning machines and n Whereas, the water to be drained into the river basin treated before it is discharged into the river basin and it the standards set by the Environmental Quality Act 1974

The erosion of a cliff is a naturally occurring corrosion that results from gravitational force. This gravitational force will result in high pressure resulting in erosion of the cliff [34-36]. When this erosion is not controlled it will cause trees around the riverbed to fallen and thus increase the amount of TSS. In this case, the construction of the walls is one of the steps to reduce erosion from occurring. The wall was constructed using a gabion structure or known as a stone cage. Additionally, through the use of Geographic Information System (GIS) in water resource management. This system is one of the systems that store information in the form of thematic maps. In this case, the GIS system is able to disclose all required information specifically [33]. For example, the GIS system will show all industries adjacent to the river basins. This can, in no way, enable the authorities to track industries that waste untreated wastes into rivers that cause river water quality to decline. At the same time, using the GIS system, it is able to improve the efficiency of water resources management [37].

The management of water resources in other river basins is through legal means by monitoring or monitoring closely. In this case, authorities such as the Drainage and Drainage Department (DID) must play an important role, for example directing all industries to install industrial waste filter systems. This is to prevent the untreated waste from being channeled directly into the river. In addition, the community must also be familiar with water resource management as it supports every program or activity held in relation to the management of river resources, especially programs involving river water quality.

For example, One State One River Program. This program is an initiative to preserve the quality of river water from polluted. In this case, every management undertaken must follow the guidelines laid down by integrated river basin management (IRBM), using the best management methods such as prevention, rehabilitation and river management [38]. The objective of this program is to achieve clean and valuable river with water quality in Class II by 2015 [39]. In addition, the program is also to reduce the number of river pollution, river died and abandoned to clean, living, natural river and support river life. Therefore, the program is suitable for the Terengganu Basin to control the Terengganu River from contaminated.

4. Conclusion

In conclusion, the study proves that the WQI value for downstream to the middle of the river is higher than the actual level of WQI. Terengganu River Basins in downstream and central polluted rivers may be caused by waste and effluent products derived from development, housing, sand mining and agriculture activities. Based on NWQS, the most measured parameter is still in class I from upstream to downstream station. In this regard, various anthropogenic activities have resulted in significant changes in the quality of river water quality. The results presented here provide a basic reference on the monitoring of Sungai Terengganu basin in the future. Furthermore, water resource management, especially in river basins is an important aspect to be improved and observed. The results showed that the water quality in the Terengganu River Basin was affected and deteriorated mainly in the downstream and central areas. This is due to several activities such as waste disposal, municipal, industrial and untreated agriculture into the river system.

Additionally, there are other activities that cause the quality of the river to be affected as aquaculture and sand mining activities that cause TSS concentration to be higher. In this case, all parties should work together in maintaining the quality of water especially in river basins. Various initiatives have been implemented by the government in managing water resources. Among the initiatives undertaken by the government are the "love of our river" campaign that involves all the villagers and towns in each state. The campaign is aimed at ensuring that every community is responsible for the care and maintenance of the river. At the same time, authorities such as the Department of Environment (DOE)

should play an important role as to monitor whether in the industries or river water regularly so that the water resources management in the river basin can run well and provide quality water to community. Subsequently, in this study we have proposed several steps in the management of water resources in the Terengganu River Basin. This is to ensure that the Terengganu River Basin is free of water pollution and can provide quality water to the community.

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