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The Evaluation of Spatial Variation of Water Quality in Sungai Setiu Basin, Terengganu

(Penilaian Perubahan Reruang terhadap Kualiti Air di Lembangan Sungai Setiu, Terengganu)

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ABSTRACT

This study investigates the spatial variation of water quality parameters in Sungai Setiu Basin at ten different locations from March 2010 to February 2011. The water quality was assessed using the Water Quality Index by Malaysian Department of Environment (DOE-WQI) and classified according to the Malaysia Interim National Water Quality Standard (INWQS). Six water quality parameters embedded in the DOE-WQI were dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, ammoniacal nitrogen (AN) and total suspended solid (TSS). In addition, this study also examined the changes in water quality over the past 10 years by comparing the present water quality to the previous works. The overall mean WQI value obtained was 84.0 which indicate that the Sungai Setiu basin is in clean condition and all measured water quality parameters gave value within the permissible limits of the INWQS classification except for pH which fall in Class III. It can be concluded that water quality in Sungai Setiu does not varies greatly over a decade. Hence continuous monitoring is needed to improve the water quality and minimize water pollution.

Keywords: DOE-WQI; INWQS classification; physical parameters; Sungai Setiu basin (Malaysia)

ABSTRAK

Kajian ini dijalankan untuk mengkaji variasi reruang bagi parameter kualiti air antara sepuluh lokasi yang berbeza di lembangan Sungai Setiu bermula pada Mac 2010 hingga Februari 2011. Kualiti air dinilai menggunakan Indeks Kualiti Air oleh Jabatan Alam Sekitar, Malaysia (IKA-JAS) dan dikelaskan mengikut Piawaian Interim Kualiti Air Kebangsaan, Malaysia (INWQS). Enam parameter yang digunakan dalam IKA-JAS telah dianalisis iaitu oksigen terlarut (DO), permintaan oksigen biokimia (BOD), permintaan oksigen kimia (COD), pH, ammoniakal nitrogen (AN) dan jumlah pepejal terampai (TSS). Di samping itu, kajian ini juga menentukan perubahan kualiti air sejak 10 tahun yang lalu melalui perbandingan dengan kajian yang terdahulu. Hasil kajian menunjukkan bahawa nilai purata IKA yang diperoleh adalah 84.0 dan ini menunjukkan lembangan Sungai Setiu adalah dalam keadaan bersih dan semua parameter kualiti air yang diukur telah memberikan bacaan dalam had yang dibenarkan mengikut pengklasifikasian INWQS kecuali nilai pH yang berada dalam kelas III. Dapat disimpulkan bahawa kualiti air di lembangan Sungai Setiu tidak menunjukkan perubahan yang ketara untuk tempoh sedekad. Walau bagaimanapun, pemantauan berterusan diperlukan untuk meningkatkan kualiti air dan mengurangkan pencemaran air.

Kata kunci: IKA-JAS; lembangan Sungai Setiu (Malaysia); parameter fizikal; pengklasifikasian INWQS

INTRODUCTION

River is the most important freshwater resource for human and it is essential for many purposes such as agricultural, recreational, irrigation and industrial activity. The quality of river water is identified in terms of its physical, chemical and biological parameters thus the river quality status will act as an indicator of river condition and potential for beneficial uses. Nowadays deterioration in river water quality is a prominent issue throughout the world and probably a serious threat to the nation. Pollution of river water originated from both organic and inorganic pollutants, as pollutants often enter into river systems and are ultimately transported to the marine environment (Suratman et al. 2016) thus may lead to hazardous risks to humans, animals and also plants and also affect economic development and social prosperity (Milovanovic 2007).

The quality status of a river can be examined using Water Quality Index (WQI) in accordance to its specific interest and for a variety of uses such as agriculture, aquaculture and domestic use (Naubi et al. 2016). WQI was initially developed by Brown et al. (1970) which later improved by the National Sanitation Foundation (NSF) in 1975. WQI is a mathematical instrument used to relate a group of parameters to a common scale and combining them into a single number (Lescesen et al. 2015) and so far this practice has successfully overcomes many problems and allows the public and decision makers to receive water quality information (Pesce & Wunderlin 2000).

WQI intended to provide a simple and understandable tool for managers and decision makers on the quality and possible uses of given water body (Bordalo et al. 2006) and act as an indicator of water quality changes and as a tool for a clearer public view on river water quality subject. It has been considered as one criterion for river water classifications, based on the use of standard parameters for water characterization (Bordalo et al. 2006; Fawaz et al. 2013) and also act as a management tool in water quality assessment and it integrates complex data to generate a score that describes the status of water quality to the public as well as decision and policy makers (Bharti & Katyal 2011; Terrado et al. 2010).

The degradation of water quality is a clear indicator in the diminishing of the river basin environmental health. In Malaysia, according to the environment quality 2013 reported by the Department of Environment, 5.3% of a total 473 rivers were polluted with 36.6% slightly polluted. The sources of pollution normally come from domestic and industrial sewerage, effluents from livestock farms, manufacturing and agro-based industries, suspended solids from mining, housing and road construction, logging and clearing of forest and heavy metals from factories. For instance, the lack of awareness, unconsciousness and the attitude of people could potentially become a serious threat to the river quality.

The Department of Environment (DOE) is the responsible body to monitor the condition of Malaysian rivers and also to develop a guideline in water quality together with identification of pollution sources. The level of water quality in Malaysian rivers was calculated based on Malaysian Department of Environment Water Quality Index (DOE-WQI) and classified according to the Malaysia Interim National Water Quality Standard (INWQS). The DOE-WQI is the core for river water assessment related to the pollution load categorization while INWQS provides the classification according to beneficial uses.

The DOE-WQI is being practiced in Malaysia more than 30 years since it was first introduced in 1978 and the calculation of WQI is an opinion-poll formula. DOE-WQI outlined six parameters to define the status of surface water quality and those parameters are dissolved oxygen (DO), pH, chemical oxygen demand (COD), biological oxygen demand (BOD_5), total suspended solids (TSS) and ammoniacal nitrogen (AN). The WQI is derived by entering the six water quality parameters mean values into the calculation using the following formula:

$$\text{WQI} = 0.22*\text{SIDO}+0.19*\text{SIBOD}+0.16*\text{SICOD}+ 0.15*\text{SIAN} + 0.16*\text{SITSS}+0.12*\text{SIpH}$$

The value of those parameters are transformed into sub-indices (SI) before applying to calculate the WQI and Table 1 shows the calculation of the sub-indices of WQI parameters. A river with a WQI value in the ranges of 0-59%, 60-80% and 81-100% would be considered as polluted, slightly polluted and clean, respectively (DOE 2006).

Malaysia INWQS is a standard which was orientated on quality of water according to the beneficial uses which can be considered to be suitable for a specific use as long as it is within the range specified for the designated classes and the definition of each class shown in Table 2. It focused on water for domestic water supply, fisheries and aquatic propagation, livestock drinking, recreation and agricultural use (DOE 2006). The standards also help in identifying water quality problems causes such as improper treated

TABLE 1. Calculation of WQI (DOE 2006)

Sub-indices DO (% saturation)	
$x \leq 8$	SIDO = 0
$x \geq 92$	SIDO = 100
$8 < x < 92$	$\text{SIDO} = -0.395 + 0.03x^2 - 0.0002x^3$
Sub-indices BOD (mg/L)	
$x \leq 5$	SIBOD = 100.4 - 4.23x
$x > 5$	$\text{SIBOD} = 108^{-0.055x} - 0.1x$
Sub-indices COD (mg/L)	
$x \leq 20$	SICOD = -1.33x + 99.1
$x > 20$	$\text{SICOD} = 103e^{-0.0157x} - 0.04x$
Sub-indices ammonia, AN (mg/L N)	
$x \leq 0.3$	SIAN = 100.5 - 105x
$0.3 < x < 4$	$\text{SIAN} = 94e^{-0.573x} - 5\lvert x-2\rvert$
$x \geq 4$	SIAN = 0
Sub-indices TSS (mg/L)	
$x \leq 100$	$\text{SITSS} = 97.5e^{-0.00676x} + 0.05x$
$100 < x < 1000$	$\text{SITSS} = 71e^{-0.0016x} - 0.015x$
$x \geq 1000$	SITSS = 0
Sub-indices pH	
$x < 5.5$	$\text{SIpH} = 17.2 - 17.2x + 5.02x^2$
$x \leq x < 7$	$\text{SIpH} = -242 + 95.5x - 6.67x^2$
$7 \leq x < 8.75$	$\text{SIpH} = -181 + 82.4x - 6.05x^2$
$x \geq 8.75$	$\text{SIpH} = 536 - 77x + 2.76x^2$

TABLE 2. Definition of Classes for INWQS (DOE 2006)

Class	Uses
Class I	Conservation of natural environment Water Supply 1 - practically no treatment necessary (except by disinfection or boiling only) Fishery 1 - 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

wastewater discharges, fertilizers runoff and chemicals from agricultural areas. The classification of INWQS divided into five classes namely Class I (WQI > 92.7), Class II (WQI 76.6 - 92.7), Class III (WQI 51.9 - 76.5), class IV (WQI 31.0 - 51.9) and Class V (WQI < 31.0) based on beneficial use of the water.

The prevention of pollution in river requires effective monitoring thus the present study aims to assess spatial variations of river water physico-chemical parameters to observe the quality trend of Sungai Setiu Basin.

METHODS

Sungai Setiu is located in Setiu district, the northern part of Terengganu and the east coast of Peninsular Malaysia with catchment of 188 km^2 in area and 52 km in length roughly. Setiu district is bordered by Besut to the north, Hulu Terengganu to the west and also Kuala Nerus to the south and it is generally fairly hot and humid all year round, averaging from 28ºC to 33ºC in the daytime and slightly cooler after sunset (Suratman et al. 2014). In addition, the river also strongly influenced by the northeast monsoon between November and March (wet season) and southwest monsoon from May to September (dry season). Sungai Setiu is crucial to the communities as it serves irrigation as well sources of water supply for domestic and agriculture use, fishing and wastewater dilution. Sungai Setiu is also associated with Setiu Wetland which the wetland receives fresh water inputs from the river that flows into the wetland from the southeast. Setiu Wetland is a unique area which covers many ecosystems such as estuary, mangrove, wetland and lagoon and it is said to be the only area with such diverse ecosystems in the east coast of Peninsular Malaysia, offering a vast array of biological diversity and many utilizable natural resources (Norhayati et al. 2006; Suratman et al. 2014).

The study was conducted from March 2010 until February 2011 whereby the water samples were collected from the basin 12 times with one month interval. There were ten sampling locations selected from the upstream to downstream, in order to give the real condition of water quality for the whole basin. Locations of the sampling stations are illustrated in Figure 1 while the coordinates of the stations are shown in Table 3. The major settlements are found at the downstream (S2) and middle part (S8) of the river station while the smaller settlements also found at station S4, S6 and S9 with limited area was found under use of commercial and residential purposes. Land use within the river basin is primarily correlated with aquaculture and agriculture activities especially at the downstream location.

Standard procedures were followed for water samples collection and water samples analysis and utmost care was taken during sampling to avoid any kind of contamination. Calibration of pH meter and YSI multi-parameter were conducted in the laboratory before field sampling according to the manufacturer's recommendation. The sample bottles were soaked in 10% aqueous solution of hydrochloric acid for three days and then rinsed with deionised water.

Physical parameters such as pH and DO were measured *in situ* using a YSI multiparameter data logger while for other parameters, the analysis were done in laboratory.

The water samples were collected near the river bank at about 0.2 m below the water surface by using clean Van dorn sampler and stored in polyethylene bottles. The bottles were kept in an icebox during the transportation to the laboratory for analysis. The collected water samples were filtered through 0.45 μm membrane filter in the laboratory immediately after sampling and then were preserved at 4°C in the low temperature refrigerator as per standard method (APHA 2012) or BOD, the values were measured using the desktop DO meter based on the DO difference before and after the sample was stored in an incubator at 20°C for 5 days. Table 4 shows the summary of water quality parameters analyzed and the methods used.

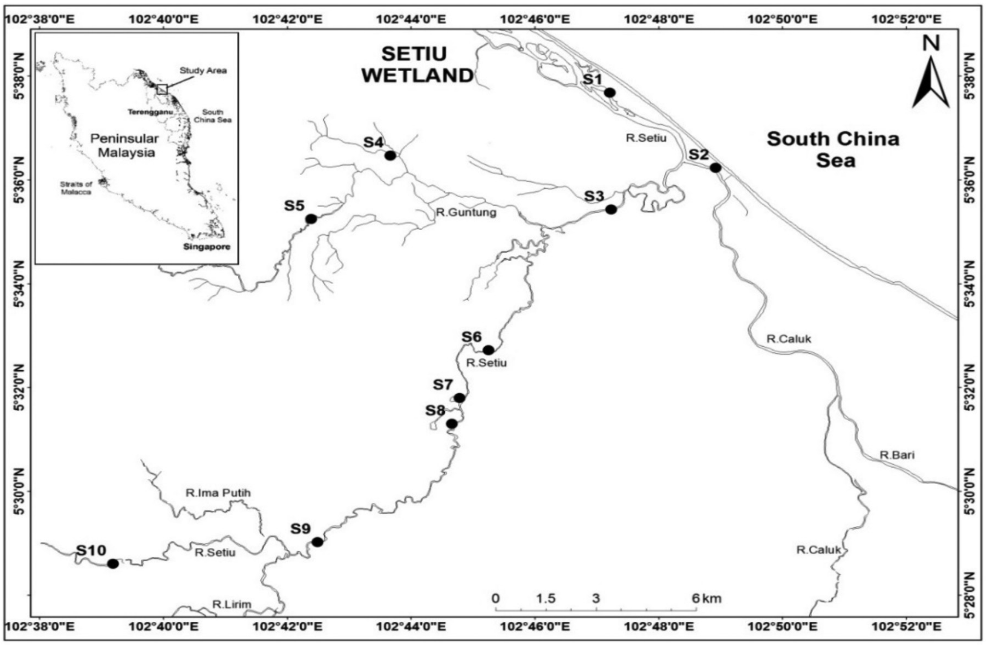


FIGURE 1. Locations of the river basin and the sampling stations

TABLE 3. Coordinates of sampling stations

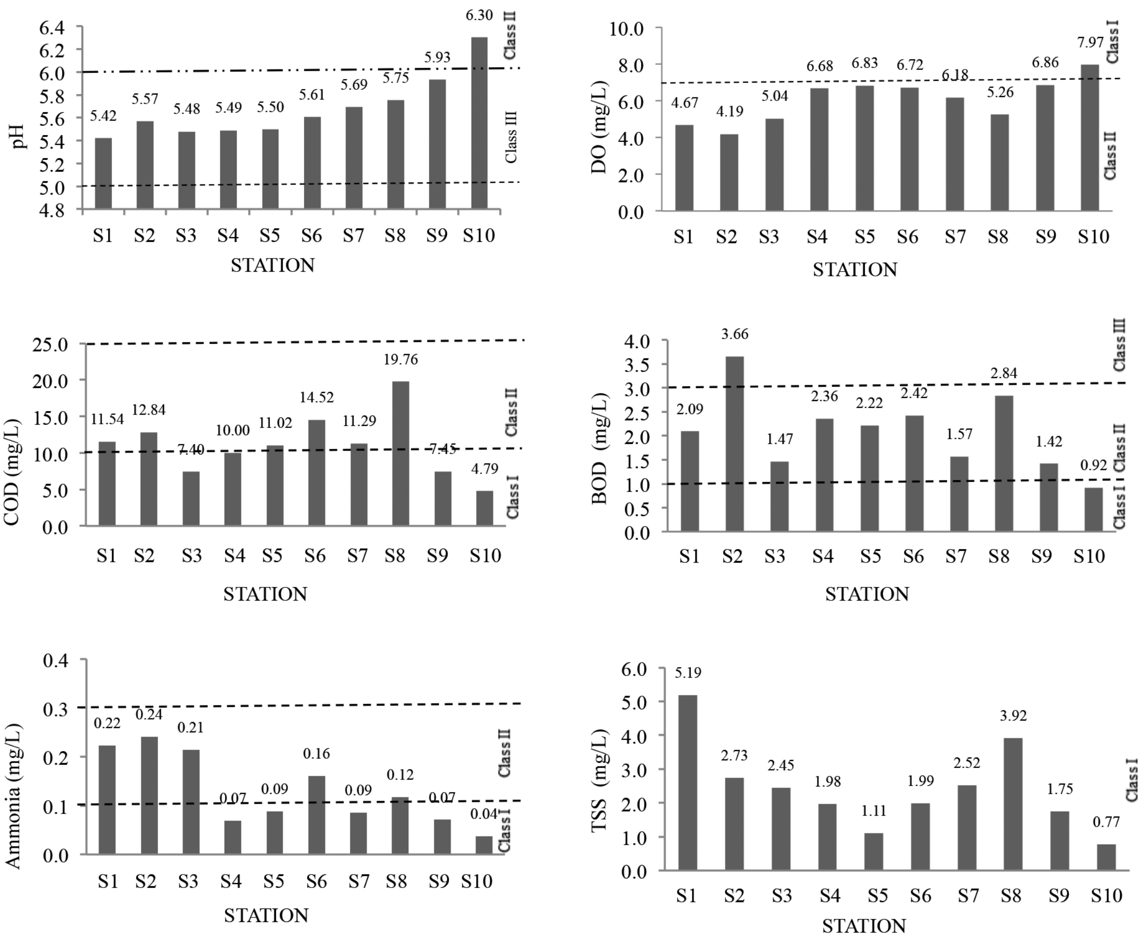
Station	Location Name	Coordinate	
		Latitude	Longitude
S1	Kampung Mangkuk	5°37’59.49”N	102°47’14.23”E
S2	Kampung Penarik	5°35’40.80”N	102°49’9.84”E
S3	Kampung Che Selamah	5°35’23.60”N	102°46’57.29”E
S4	Kampung Guntung Dalam	5°35’43.50”N	102°49’3.09”E
S5	Kampung Guntung Luar	5°33’22.07”N	102°40’30.95”E
S6	Kampung Tasek	5°32’48.73”N	102°45’26.92”E
S7	Loji Air Ibu Bekalan Setiu	5°31’46.82”N	102°44’47.37”E
S8	Bandar Permaisuri	5°29’48.60”N	102°43’23.22”E
S9	Kampung Besut	5°28’57.94”N	102°41’9.90”E
S10	Kampung Hulu Seladang	5°28’59.32”N	102°40’37.59”E

TABLE 4. Water quality parameters analysed and the method used

Water quality parameter	Unit	Method
Ph		*In situ* measurement, pH meter
Dissolved oxygen (DO)	mg/L	*In situ* measurement, YSI meter
Total suspended solid (TSS)	mg/L	APHA (2012) method. Filtration and residue drying
Chemical oxygen demand (COD)	mg/L	APHA (2012) method. Open reflux with chromic acid, titration with FAS
Biochemical oxygen demand (BOD)	mg/L	APHA (2012) method. 5 days incubation at 21°C, difference by oxygen by a DO prob
Ammoniacal nitrogen (AN)	mg/L	Grasshoff et al. (2007)

The rainfall data for Setiu was obtained from the Malaysia Meteorological Department (MMD) to get a better picture of the weather pattern during the study period.

Comparison of mean value between stations was done by using Analysis of Variance (ANOVA) where the present data were interpreted using single factor analysis of variance ($p<0.05$) to measure significant differences between sampling stations. Water quality data was then compared to the previous works conducted by Deraman (2002), Jessie (2008) and Zulfadhli (2005) in the same study area.



(The dotted line on the bar chart represent range of values based on DOE-WQI Classification)

FIGURE 2. Distribution of mean values for water quality parameters at each station

RESULTS AND DISCUSSION

Figure 2 represents the mean value for all parameters measured at each sampling location. Recorded data obtained were used to determine the quality status of the river either in clean, slightly polluted or polluted categories based on WQI-DOE and also to classify based on INWQS in accordance to the beneficial uses.

Mean pH values in this study ranged from 5.42 to 6.30 reflects the water is slightly acidic and the results showed significant difference (p<0.05) among the stations. The mean pH showed a decreasing trend from upstream station to downstream with highest value at station S10 (Class II). The variation of pH reading specifically at the downstream (Stations S1, S2 and S3) resulted from the excessive discharge of domestic waste from the residences into the river water. The decomposition of organic matter in the waste directly increase the carbon dioxide content thus lowers the pH in river water. With the exception of S10 which is within Class II water quality, all the other station fell in Class III category. pH value in this study similar with the mean ranges obtained by Deraman (2002) (5.6-7.10), Jessie (2008) (5.60 to 6.49) and Zulfadhli (2004) (5.10-7.53).

Mean DO contents varied from 4.19 to 7.97 mg/L and ANOVA test showed there were significant difference among the stations (p<0.05). This spatial trend was also reported by Deraman (2002), Jessie (2008) and Zulfadli (2005); higher DO contents were recorded at the upstream location of the river than the downstream. The uppermost location of the Sungai Setiu, Station S10 recorded the highest mean DO value (7.97 mg/L) and found to be consistent with mean values in the previous studies by Deraman (2002) (8.03 mg/L), Jessie (2008) (9.14 mg/L) and Zulfadli (2005) (8.13 mg/L). The water flow at this station (S10) was observed to be relatively rapid than other stations; rapid flow facilitates aeration hence resulted in high DO contents (Lopes & Silva 2006). The deterioration of DO value at the downstream location of the river (Stations S1, S2 and S3) attributed to the increase of the growth rate of bacteria that consume the organic matter contained in the untreated waste that has been discharged into the river. It is also relative to the middle part of the river, Station S8 which recorded low in DO concentration as these location has high population.

For COD, the results was found to be in the range of concentration 4.79 to 19.76 mg/L. Station S8 which located at the middle section of the Sungai Setiu showed the maximum COD value while the most upstream Station S10 shows the lowest which fell in Class I. Other station also shows high COD reading like Stations S1 and S2 which located at the downstream location of the river with domestic activity onsite while high concentration of COD at station S8 (Class II) was believed due to the high populated area as it located at the heart of Setiu district which attributed to the greater volume of domestic discharges and organic waste into the river. The obtained result is lower compared to Deraman (2002) (5.74 - 42.63 mg/L), Jessie (2008) (1.01-66.9 mg/L) and Zulfadli (2005) (23.44-36.90 mg/L) whose reported range of COD value in their study at the same location.

The mean concentrations of BOD was vary from 0.92 to 3.66 mg/L whereby higher BOD values recorded in stations S2 and S8 which fall in Class II while the lowest was at the most upstream station S10 (Class I). BOD parameters showed a significant different (p<0.05) between sampling stations. Observation done at station S2 shows there is domestic activities onsite thus BOD reading reflects the amount of organic substances that can be oxidized by microorganism. On top of that, these findings also agree with earlier works conducted by Deraman (2002) whom reported that range of BOD between 0.1 and 2.2 mg/L, Jessie (2008) recorded higher BOD (0.27-7.51 mg/L), while Zulfadhli (2005) reported BOD reading ranging from 0.06 to 3.54 mg/L. Most stations recorded highest in BOD reading inverted with low in DO reading and thus, it can be conclude that BOD concentration is inversely proportional with DO concentrations and this phenomenon is common as identified in many previous researches (Rosli et al. 2010). AN mean levels recorded during the period of study were between 0.04 and 0.24 mg/L and the statistical analysis for AN shows significant different (p-<0.05) between sampling stations. From the result obtained, can be concluded that the deterioration occur from upstream to the downstream location of the Sungai Setiu. AN concentration recorded highest reading at station S2 (Class II) and lowest at S10 (Class I) and the present of AN at station S2 was believed to originates from organic waste from agriculture activity onsite together with the surface runoff at the river bank. Besides, the comparison also favorably made with the earlier study conducted by Deraman (2002) and also Zulfadhli (2005). Both studies had quite similar distribution with the recent study where the AN ranged from 0.02 to 0.12 mg/L in 2002 and 0.02-0.11 mg/L in 2005 while Jessie (2008) reported higher AN value ranged from 0.05 to 0.89 mg/L. The AN concentration in Sungai Setiu Basin were believed to originates from point source discharges such as domestic waste and also organic waste from agriculture activity at the surroundings and it relatively toxic to aquatic life at high concentrations.

The TSS mean concentration recorded highest amount at station S1 (5.19 mg/L) and the lowest at station S10 (0.77 mg/L) and the concentrations were visible high at downstream area and gradually decrease when it came to upstream area. Statistical analysis of a one-way ANOVA showed that there was a statistically significant difference (p<0.05) between stations for TSS. The highest TSS recorded at station S1 (Class II) which located at the most downstream and it may be due to the agriculture and boating activity in this part of the river. Beside station S8 which is a highly populated area also recorded high TSS value and this subjected from the domestic effluents from residential into the river. Station S10 (Class I) which was located at the most upper part of the Sungai Setiu basin with small population recorded the lowest TSS concentration and this was believed due to less domestic waste discharge into the river. The condition of shallow water at station S10 and surrounded by stones that help to trap suspended particles also contributed to the low concentration of TSS. However, the range of TSS concentration obtained in present study was much lower compared to the study carried out by Deraman (2002) (0.4-80.6 mg/L) and Zulfadhli (2005) (0.67 to 106.85 mg/L) but slightly high compared to study conducted by Jessie (2008) (0.001-0.244 mg/L).

All the parameters measured were then used to calculate the WQI and the results showed in Figure 3. The obtained WQI ranged from 75.60 to 92.90 and the low WQI values were recorded at stations S1, S2 and S8 located at the downstream location while the highest WQI was recorded at station S10 which was located at the most upstream location. Stations S1 and S2 were marked as polluted site and these probably due to the accumulation of waste from the upstream and also unregulated discharges from surrounding area. However, station S8 which located at the middle section of the river also identified among polluted site and the degradation in quality at this site due to high populated area resulted in unregulated discharges into the river. Overall, the mean WQI value obtained was 84.0, respectively and it indicate that the quality status of Sungai Setiu Basin is in clean condition with minimum pollution effect. According to INWQS classification, WQI value of 84.0 falls in Class II (WQI 76.6-92.7).

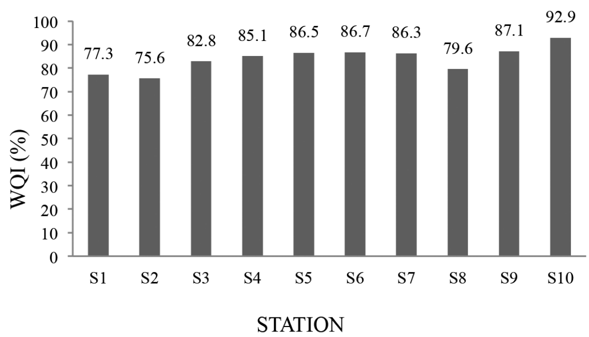


FIGURE 3. The WQI values for each station

Current WQI value obtained were then compared with recorded data from previous works in 2002 (Deraman), 2008 (Jessie) and 2005 (Zulfadli) to track the water quality trends. It should also be noted that in the data, not all stations were consistently sampled throughout the sampling years. A higher WQI value was observed in 2001 and 2008 and a low value for year 2005 (Figure 4). It is clear that between 2001 and 2011, water quality within the Sungai Setiu basin show some trends for mean WQI value and these variations probably due to the frequency of sampling whereas previous studies was performed over a short period of time probably less than 6 times of sampling compared to current study which conduct a year sampling with monthly interval. The residential activity and weather conditions during the sampling events also contribute to the WQI variations.

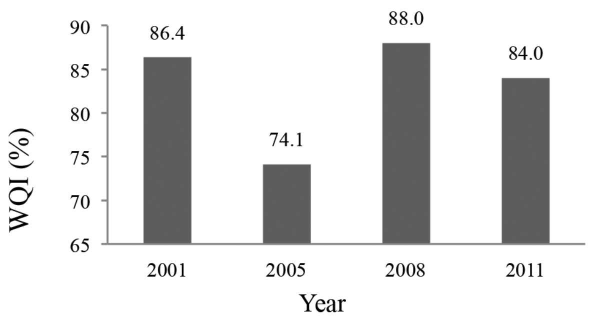


FIGURE 4. The WQI values for each station

There are also similar studies previously conducted elsewhere looking at the water quality of the Malaysian river. Table 5 shows the comparison of WQI value obtained in current study and selected river basins in Malaysia.

Water quality study in Sungai Terengganu and Sungai Nerus reported those rivers also categorized as clean river with WQI value of 86.9 (Sungai Terengganu) (Suratman et al. 2015) and 84.9 (Sungai Nerus) (Tahir et al. 2005). The good water quality recorded in those rivers was probably due to only smaller size of domestic sewage was discharge from settlements and also from agricultural activities onsite. However, it is different in the study conducted by Suratman and Tahir (2013) in Sungai Marang, Khalik et al. (2013) in Sungai Bertam and Sungai Perlis by Amneera et al. (2013) whereby the recorded WQI value indicates it has lower water quality and classified as slightly polluted. The degradation in those rivers was believed to be resulted from agricultural and domestic wastes either disposed directly or indirectly into the river resulting in a point source of water pollution.

The classification of Sungai Setiu according to INWQS was done based on the mean value of water quality parameters respectively. The information on water quality parameters obtained and classification of INWQS are shown in Table 6. The results showed that most measured parameters fall in Class I and IIA which was the river suitable for water supply and recreational use with direct contact with water body except for pH which fall in Class III. Thus conventional treatment required for water supply is needed.

CONCLUSION

The obtained WQI in Sungai Setiu Basin was 84.0 and this can be considered that the river has clean status with the quality of water decrease from upstream to downstream location of the river. According to the INWQS classification WQI value obtained fall in Class II while mean value of water quality parameters in this study were found to be in Class I (AN, TSS and BOD). Class II (DO and COD) and Class III for pH. Hence extensive treatment is required if only it is use for water supply. For the years 2001-2011, the trend shows increasing and decreasing patterns however water quality conditions remained relatively stable over years. The effects of human activities and the discharged of untreated domestic effluents are the principal cause

TABLE 5. The comparison of WQI value for selected river basins in Malaysia

Location	WQI (%)	Class	Status
Sungai Setiu[1]	84.0	I	Clean
Sungai Terengganu[2]	86.9	I	Clean
Sungai Marang[3]	74.0	II	Slightly polluted
Sungai Nerus[4]	84.9	I	Clean
Sungai Bertam[5]	78.0	II	Slightly polluted
Sungai Perlis[6]	61.9	II	Slightly polluted

[1] Current Study [2] Suratman et al. (2015) [3] Suratman & Tahir (2013)
[4] Tahir et al. (2005) [5] Khalik et al. (2013) [6] Amneera et al. (2013)

TABLE 6. Mean, range and classification of INWQS

Parameter	Mean	Range	Class of INWQS
pH	5.69	5.32 - 6.39	III
DO (mg/L)	6.04	4.19 - 7.97	IIA
AN (mg/L)	0.15	0.06 - 0.24	I
TSS (mg/L)	2.44	0.77 - 5.19	I
COD (mg/L)	11.06	4.79 - 19.76	IIA
BOD (mg/L)	2.10	0.92 - 3.66	I

of deteriorating quality of in Sungai Setiu. In order to minimize the impact of pollution in the study area, the assessment of pollution and pollution control should be proposed.

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