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Research paper

Impacts of Land-Use Changes on Water Quality by an Application of GIS Analysis: a Case Study of Nerus River, Terengganu, Malaysia

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Abstract

The impact of land use change on water quality of Nerus River Kuala Terengganu is an event that needs to be taken seriously in this study. The objectives of the study area are to carried out 13 parameters water quality samplings and analysis of Nerus River as well as to classify water quality concentration based on NWQS and WQI classifications; to interpret 2000 and 2013 land use/land cover maps of Nerus River Basin and to evaluate water quality data by statistical technique such as similarities and dissimilarities between sampling stations to determine pollution sources. Methods that were used in study area GIS will use to classify land cover/land use changes in the catchment between 2000 and 2013 land use maps. Water quality analysis and monitoring were done based on three sampling stations during both dry and wet seasons, involving analysis 13 water quality parameters. Water quality classification is using the National Water Quality Standard (NWQS) and the Water Quality Index (WQI). Statistical analysis such as similarities and dissimilarities between sampling stations was applied. Results of the study show that the river was classified as class II (slightly polluted), III (moderately polluted) in accordance with previous studies.

Keywords: *Nerus River; water pollution; water quality; land use changes; GIS-based analysis.*

1. Introduction

Surface water resources have played an important role throughout history in the development of human civilization in the world. River water continues to be able to sustain their contribution for all human beings and other organisms [1]. Besides, rivers play a significant role in assimilating or conveying municipal and industrial wastewater and agricultural runoff. Generally, discharge from Municipal and industrial wastewater is a main source of pollution, whereas surface runoff is a seasonal phenomenon, significantly affected by climate within the river [2]. It is necessary to monitor pollutants in the aquatic environment as many pollutant compounds can pose a threat to both human health and ecosystems [3]. Water quality is a term used to describe the physicochemical and biological characteristics of water in connection with the intended use and a set of standards [4]. River water quality is important for water environment management, as the spatial-temporal distribution of water quality can provide dynamic information for decision makers in water environment management [5]. However, raining also plays a very important role in contributing to urban pollution where it washes the polluted the atmosphere of vehicle fumes, boiler, factories and industrial sites. Water quality assessment can, therefore, be as the evaluation of the physicochemical and biological properties of water in reference to natural qualities, human health effects, and intended uses [6]. Activities related to urbanization and agriculture basically are main contributors to alterations in the chemical composition of aquatic habitats [7, 8]. This study clarifies the effects of land use on the water quality properties of the Nerus River. To address this problem, the land use map is discussed together with the calculated water quality index (WQI) for river water quality data and the application of principal component analysis (PCA). The Nerus River is one of the rivers in of Kuala Terengganu, East Coast of Peninsular. This area is subdivided into agricultural land use and urban land use activities. In this regard, zoning of pollution and presentation of the correct image of the qualitative status of surface waters using GIS software helps any managerial decision-making whose environmental implications are directly or indirectly related to surface water taken with more awareness [9]. The water quality of the Nerus River has always been affected by land use and land cover activities along the river. Water quality examined based on a change in river land use record between 2000 and 2013. The Nerus River basin, especially the middle and lower regions, has experienced considerable urbanization over the past 13 years, while the lower region is characterized by intensive palm oil agricultural activity as well as the large sand mining operation located along the river. The study area is characterized by mixed horticulture in the area close to the river banks, typically practicing non-systematic activities. The total area of the Nerus River is 77 km^2. Its catchments area totals 851 km^2, of which forest comprises 30.7%, urban areas (including residential) 21.9%, rubber estates 17.7%, oil palm plantations 9.7% and mixed horticulture (village) 5.2%, together with minor areas of other land uses such as scrub (a plant community characterized by vegetation dominated by shrubs), cleared land and orchard [10, 11].

Urban areas and mixed horticulture, which are mostly found along the river bank, may have caused environmental degradation of the Nerus River (as well as adjacent areas) by changing the water quality characteristics, with prospects for possible long- term deterioration [11, 12]. This lead us to look at how different land cover and land uses developments can affect water quality, as well as both land and ecosystem health. Therefore, the study of water pollution of the river is of particular importance because of the river receives huge effluents from livestock farms, industrial and agricultural activities as well as urban runoff which cause deterioration of the river water quality [13]. In general, human activities related to land use around Nerus River pose a threat to the aquatic ecosystem and the where the river water usually uses as a domestic supply. In addition, the composition of surface runoff in the drainage area is considered as the initial cause of the change in the quality of a river [10, 11]. In this regard, zoning of pollution and presentation of the correct image of the qualitative status of surface waters using GIS software helps that any managerial decision-making whose environmental implications are directly or indirectly related to surface waters is taken with more awareness [14]. Also, this article discusses the effects of the evolution changes from land use and climate change in the Nerus River from 2000 to 2013, and to evaluate the contamination level using Water Quality Index (WQI) of Malaysian rivers analysis and factor analysis in order to assess the effect of unregulated discharge on the quality of the river. Deals with spatial monitoring of order to follow the variations in the water chemical quality, determine the most suitable sites and optimize management of water resources in Nerus River. Finally, The objectives of the study area are to carried out 13 parameters water quality samplings and analysis of Nerus River as well as to classify water quality concentration based on NWQS and WQI classifications; to interpret 2000 and 2013 land use/land cover maps of Nerus River Basin and to evaluate water quality data by statistical technique such as similarities and dissimilarities between sampling stations and multivariate analysis such as PCA to determine pollution sources.

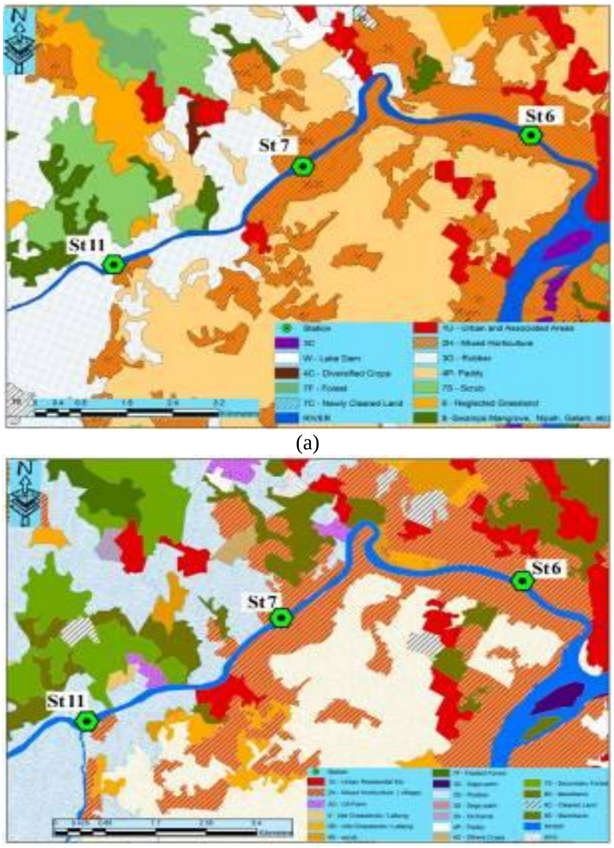
2. Methodology

2.1. Study Area

Nerus River is one of the rivers of the east coast of Peninsular Malaysia, in Kuala Terengganu city between 103º00' E to 103º06'E and longitude of 05º13'N to 05º23'N, encompassing a total area of 851 km^2, Its source is located at Gunung Sat and flows southeastern in towards the mouth of Nerus River which discharges its water into Terengganu River estuary before finally discharging into the South China Sea [10, 11]. The river water is used for irrigation, domestic water supply, industrial and other uses, sharing with Terengganu River as the main sources for man use, especially for Irrigation, agriculture and domestic use, since they pass the major cities and villages and palm oil factories in the Terengganu city. It also passes through the populated urban area and receives and carries different kinds of agricultural and urban solids and liquid wastes produces by agricultural based industries and domestic sewage [10-12]. This study clarifies the effects of land uses on the water quality condition of the Nerus River. To address this problem, the land use map GIS is used as base together with the NWQS and calculated water quality index (WQI) for the river water quality classification and principal component analysis (PCA) pollution sources determination.

2.2. Land Use of the Study Area

Land use and land cover of the Nerus River Basin comprise of urban development, agriculture, and natural habitat. These aspects together all play both positive and negative roles on the water quality within an ecosystem. Urban development mostly has a negative effect on water quality. Urban development reduces the uptake of water, which causes water in urban areas to collect chemicals and pollutants [15, 16]. In this study, the 2000 and 2013 land use and land cover maps were used to compare land use activities in the Nerus River. It was found that urban area, rubber, oil palm, mixed horticulture, treated forest and settlement areas had increased, but agriculture, forests, water body, cleared land had decreased. The spatial distribution of land use and land cover changes of the forest at different time periods in 2000 to 2013are shown in (Fig. 1).



(a)

(b)

Fig. 1: Land use/cover in study area; (a) in 2000, (b) in 2013 and the sampling sites at Nerus River, Kuala Terengganu, Malaysia

2.3. Land Use Changes

Upon considering the possible influences of land use on water quality [17-19], the land use classes were categorized into five groups: (i) Forested land use including wooded areas and mixed vegetated areas, (ii) Agricultural land use including row and non-row crop agriculture, (iii) Urban land use including residential, commercial and industrial lands, (iv) other land use including barren land and other unused lands, (v) water bodies including rivers and reservoirs.

The land use of Nerus River Basin consists of main forest, marshland, agriculture, orchard/shifting cultivation, diversified crops, mixed horticulture, oil palm, urban areas (commercial and residential) settlement areas and water bodies. Agriculture is the dominant land use, followed by forest, urban areas and water bodies of Nerus catchment as presented in (Fig. 1 and Table 1). However, Nerus River as a tropical catchment area is experiencing rapid urbanization, and the river water is used for irrigation, domestic water supply, industrial and other uses. [11]. Furthermore, the increased size of urbanized area was also reported by [35], and the urban development which occupied in the Nerus River catchment was due to extensive land exchange from agriculture to urban industrial commercial use [16].

Table 1: The 2000 to 2013 of land use category for Nerus River, Terengganu

No.	Category	00	02	04	06	08	10	13
1	Urban	2.989	3.141	3.425	3.577	4.075	4.578	4.907
2	Forests	38.320	38.280	37.854	37.530	37.179	36.561	35.419
3	Agriculture	54.226	58.109	54.356	52.083	52.564	52.395	51.633
4	Water body	209	227	417	118	2461	285	52
5	Cleared Land	804	795	1.537	1.323	1.140	931	708
	Grand Total	96.082	89.833	95.154	95.421	95.419	95.842	95.581

Geographical Information system (GIS) is a computer-based technology for handling geographical data in digital form. It is designed to capture, store, manipulate, analyze, and display diverse sets of spatial or geo-referenced data [20, 21]. On the other hand Arc GIS software 10.2 stores the information about the study area as a collection of thematic layers that can be linked together by geography. The GIS maps representing WQI of the Nerus River in Kuala Terengganu are shown in Fig. 2 to Fig. 14 for the period of 2000 to 2013 were obtained from the three sampling stations (St. 6, St. 7 and St. 11). Table 2 shows the color indicator used in the GIS maps according to WQI classification. The results of the chemicals analysis (mean value per sampling point). The sampling locations were integrated with the water data for the generation of spatial distribution maps [22]. Precision conservation's geographic extent encompasses agricultural fields and their surrounding physical features (e.g., terrain, soil, water bodies, etc.), natural conditions (e.g., vegetation, wildlife, aquatic organisms, etc.) and system influences (e.g., climatic regimes, human infrastructure, management practices) [23]. In order to determine if significant variations in water quality existed among site groups, relationships between the land use variables and water quality parameters.

Table 2: Color indicator for WQI in the GIS map

WQI value	Water Quality	
50>WQI	Excellent	Dark blue
50<WQI<100	Good	Blue
100<WQI<200	Poor	Green
200<WQI<300	Very Poor	Yellow
300<WQI<400	Polluted	Orange
WQI>400	Very Polluted	Red

2.4. Physico-Chemical and Biological Analysis

Water quality data used in this study were obtained from the Malaysian Department of Environment [35]. Time series data from 2000 to 2013 for selected parameters and stations were used in the present study. The physicochemical and biological characteristic of the area correlates closely with the rainfall pattern in the river. Pattern of rainfall in the months of October–December. Generally, the eastern areas of Malaysia receive high amounts of rainfall, causing the effect in chemical-physical properties of water as well as well as the effects of runoff and land use. Instead of twelve monitoring sampling stations that carried out by DOE, three monitoring sampling stations were selected is located in this river which are St. 6 (upstream) St. 7 and St. 11 (downstream). Thirteen parameters were selected in two different seasons, wet and dry, which can provide continuous measurements at three selected water quality monitoring stations in the Nerus River. Water quality was measured at the Sungai Nerus River and classified according to National Water Quality Standard (NWQS) and Water Quality Index (WQI) issued by Malaysian Department of Environment. They have included The physicochemical and biological parameters including of TEMP, pH, EC, DO, TUR, SAL, TDS, TSS, COD, BOD, NH_3-N, NO_3 and *E.coli*. The results of the water quality parameters along the river course are presented in Table 3 and Table 4. The results indicated a general trend for concentration to increase with increased discharge. In the upstream area, away from the urban center streams are usually less polluted physically or chemically due to less exploited by human civilization.

Table 3: Classification of the thirteen water quality parameters of Nerus River between dry and wet seasons 2000

	2000 (Dry)		WQI	2000 (Wet)		WQI	
Parameters	Range	Mean (SD)	Class	Range	Mean (SD)	Class	Sg
TEMP Deg C	26.74 - 30.76	28.25 (2.18)	I	26.36 -27.66	26.95 (0. 66)	II	0.38
pH	6.21 - 7.21	6.81(0.52)	I	6.17 - 6.68	6.46 (0.26)	II	0.36
DO mg/L	4.88 - 7.59	6.25 (1.35)	II	5.01 - 7.30	5.91 (1.21)	II	0. 60
COND µS/cm	24.50 - 100.0	52 (41.71)	I	28.5 - 202.0	88.0 (98.75)	I	0.59
TUR NTU	16.20 - 36.95	24.18 (11.17)	I	7.35 - 279.45	132.26 (137.40)	III	0.24
SAL ppt	0.01 - 0.05	0.025 (0.21)	I	0.01 - 0.08	0.036 (0.37)	I	0. 66
TDS mg/L	13.5 - 237.00	91.16 (126.38)	I	8.00 - 105.50	42.5 (54. 64)	I	0.24
TSS mg/L	9.50 - 52.00	23.83 (24.39)	I	9.50 - 163.50	91.16 (77.42)	III	0.22
COD mg/L	15.00 - 24.00	18.66 (4.72)	II	19.00 - 22.50	20.83 (1.75)	II	0.49
BOD mg/L	1.00 - 5.50	2.5 (2.59)	III	1.00 - 2.00	1.5 (0.50)	III	0.54
NH_3-N mg/L	0.01 - 0.99	0.33 (0.56)	III	0.01 - 0.44	0.16 (0.24)	II	0.64
NO_3 mg/L	0.12 - 0.19	0.16 (0.03)	II	0.05 - 0.28	0.17 (0.10)	II	0.98
E. coli CFU/100mL	350.00 - 3900.00	1600.00 (1994.36)	II	350.00 - 2350.00	1066. 66 (1113.92)	II	0.707

Table 4: Classification of the thirteen water quality parameters of Nerus River between dry and wet seasons 2013

	2013 (Dry)		WQI	2013 (Wet)		WQI	
Parameters	Range	Mean (SD)	Class	Range	Mean (SD)	Class	Sg
TEMP Deg C	23.81 - 29.58	27.36 (3.10)	I	25.39 -28.73	26.82 (1.71)	II	0.80
pH	4.36 - 6.99	5.91 (1.37)	II	4.86 - 6.91	6.08 (1.07)	II	0.87
DO mg/L	6.07 - 7.08	6.70 (0.55)	II	2.77 - 7.71	5.83 (2. 67)	II	0.76
COND µS/cm	20.50 - 256.00	118.83 (122.45)	I	25.50 -153.00	78.00 (66. 66)	I	0. 63
TUR NTU	36.30 - 78.35	51.61 (23.23)	II	38.60 -118.15	68.40 (43.36)	II	0.58
SAL ppt	0.01 - 0.02	0.014 (0.005)	I	0.01 - 0.08	0.036 (0.037)	I	0.36
TDS mg/L	11.5 - 170.50	86.33 (79.90)	I	12.00 -113.00	48.66 (55.89)	I	0.54
TSS mg/L	20.00 - 52.00	34.5 (16.20)	II	17.00 -109.00	50.66 (50.71)	III	0.26
COD mg/L	13.50 - 23.00	17.16 (5.10)	II	17.25 - 33.00	23.25 (8.51	II	0.34
BOD mg/L	2.50 - 4.00	3.33 (0.76)	II	2.50 - 3.50	3.16 (0.57)	II	0.77

NH_3-N mg/L	0.06 - 0.36	0.20 (0.15)	II	0.08 - 0.35	0.19 (0.13)	II	0.97
NO_3 mg/L	0.05 - 0.16	0.12 (0.06)	II	0.16 - 0.58	0.31 (0.22)	II	0.23
E. coli CFU/100mL	200.00 - 1000.00	500.00 (435.97)	II	250.00 - 1025.00	579.15 (373. 61	II	0. 66

3. Results and Discussion

The water quality of the Nerus River has always been affected by land use and land cover change activities within the river basin. In our study, seasonal changes of river flow caused by the subtropical monsoon climate might explain seasonal differences in the strength of impacts of land use on water quality. The results of our study indicate that land-use activities have significantly influenced water quality variations. Several studies have reported that the relationship between land use and water quality can vary seasonally [17-18, 24-26].

Based on the land-use maps and combinations of water quality indexes, differences in upstream, middle and downstream river stations were identified Fig. 1. Water quality change was examined based on characteristics of the river condition due to land use change between 2000 and 2013. The results of some parameters of the water quality along the river course are presented in Table 3 and Table 4. Analyses showed that forested land use has stronger negative impacts on most of the water parameters (e.g., EC, TEMP, TDS, NH_3-N, NO_3, during the dry season and rainy season. This effect may be driven by high water discharge and low water retention time in rainy season, which influences the retention capacity of vegetation [27, 28]. At the same time, urban land use is more strongly related to these parameters in the dry season because rivers in low flow are more affected by point-source loads from urban land [29]. The discharges from point sources in the urban land can be considered to be a constant source of pollution. The pollutants become diluted with the increased water discharge and high flow velocities during the rainy season [30, 31].

Also, these results indicated a general trend, which were usually shown by increase of pollutant concentration in downstream of the river. On the contrary in upstream, they were less physico-chemical or biologically polluted due to dilution. Other human activities were found to be significantly contributed some amounts of pollutants from industrial, commercial and residential land use types. The motor garages, petrol filling stations and car washing are notoriously known for the dumping of food solid wastes into the rivers. In order to investigate the spatial changes of the qualitative parameters in the Nerus River, water quality data were collected from three stations (St. 6, St. 7 and St. 11). Table 3 and Table 4 illustrates the mean value of 13 water quality parameters which compared with the NWQS and WQI classifications, the level of most of the parameters measured remained at Class II, III which is suitable for the sustainable conservation of the natural environment, Also suitable for irrigation and agriculture, for water supply. The results of the study indicate that land-use activities have significantly influenced the water quality variations. Based on the land-use maps and combinations of water quality indexes, differences in upstream, middle and downstream river sections were identified in Fig. 1.

3.1. PH

The pH value of the aquatic system is one of the important indicator of the water quality and the extent of pollution in the watershed areas [32]. Showed the different pH values between 2000 and 2013 pH which is varied between 7.21 at the downstream at (St. 6) during dry season 2000 to 6.17 at (St. 6) during dry seasons 2000. Also, the pH of water samples varied between 6.99 at (St. 6) the downstream during dry season 2013 to 4.36 at (St. 11) the upstream of the River during wet season 2013.

Basically, residential and urban areas were recorded the highest pH due to industrial effluents, chemical, metals, gas and power industries. Initially, decreases of pH was during rainy period but pH increases to its highest levels during dry period. (Fig. 2 (a)-(d)) shows that all the water samples are within the class II, based on NWQS for Malaysian rivers and WHO [33, 15]. Generally, the pH concentration increase as a result of the photosynthetic algae activities that consume carbon dioxide dissolved [34]. Also, the seasonal variation in rainfall. Overall, the range of pH from 6.5 to 8.5 is mainly appropriate for aquatic life. Therefore, it is very important to maintain the aquatic ecosystem within this range because high and low pH can destructive nature [35, 36].

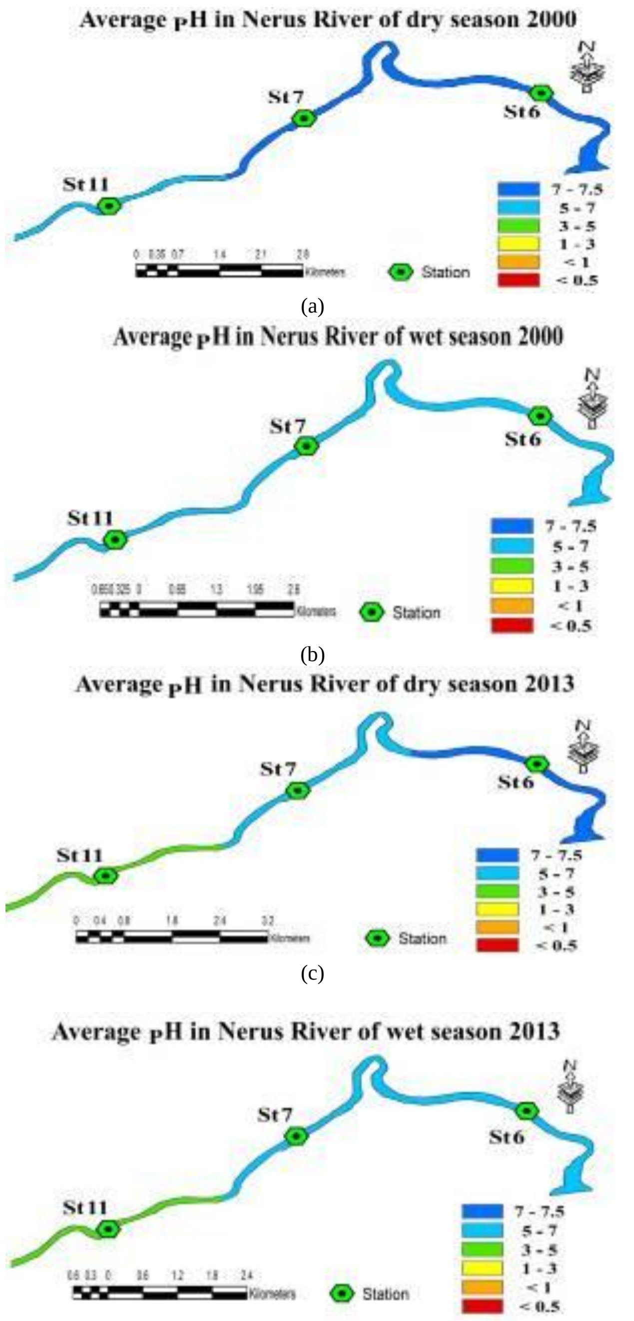
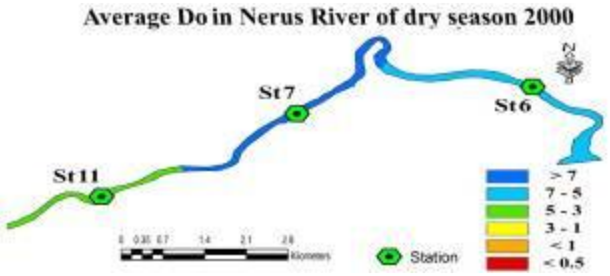


Fig. 2(a)-(d): Average pH value in different seasons and years in water sample

3.2. DO

DO is an important indicators in determining quality of water and it is the essential parameter for an index of several physico-chemical and biological process in water [37]. In this study, the value of DO from water samples during wet season ranged from 2.77 mg/L (St. 11) to 7.71 mg/L (St. 7) 2013 and from 4.88 mg/L (St. 11) to 7.59 mg/L (St. 7) 2000 during dry season (Fig. 3. (a)-(d)). Which indicated that the water was highly deoxygenated. The low values of the DO at (St. 11) are attributed to the palm oil, as well as the untreated sewage from the residential area that without expose to the treatment. In addition, contribution of the surface runoff from the animal farms and agricultural fields along the river banks in (St. 11) has lowered the DO value. The value of DO Increases to further downstream in the urban area of the river before merge with Terengganu River. Generally, four processes influence the DO content in water including aeration, photosynthesis, breathing and oxidation [38]. If DO value is high, the water quality level is also high and vice versa.

DO concentration of below 4 mg/l adversely impacts the aquatic life, whereas a concentration below 2 mg/l may lead to death for most fish species [39]. Based on the observed concentration of DO, and the average results obtained, all the stations were categorized as class II according to NWQS the and the standard level of Malaysia surface water [40].



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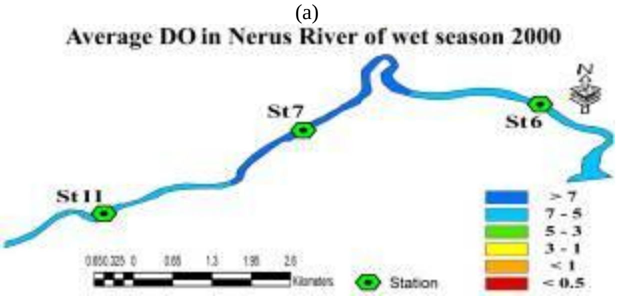

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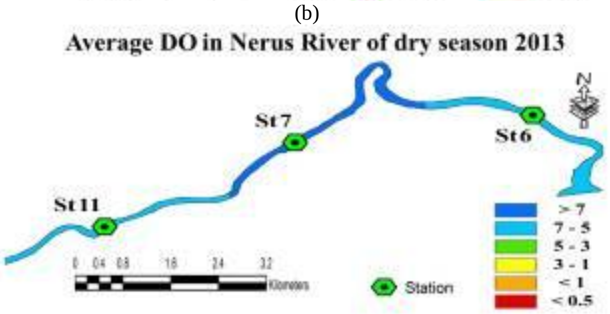

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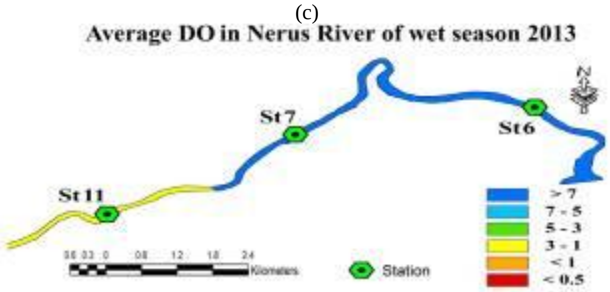
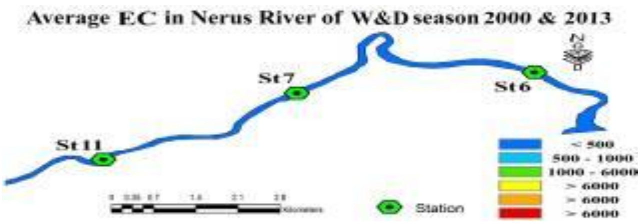


(d)

Fig. 3(a)-(d): Average DO value in different seasons and years in water sample

3.3. EC, TEMP, TDS and SAL

In this study, EC, TEMP, TDS and SAL all shows in (Fig. 4-7). The decreased of EC from upstream to downstream during 2000 and 2013. The EC values varied from maximum 256 µS/cm at (St. 11) during dry seasons in 2013 to a minimum of 20.5 µS/cm at (St. 7) also during dry seasons in 2013. Also, the quantity EC generally depends on several factors, such as precipitation, soil, rock types and human activities [41]. On the other hand, the TDS concentrations ranged from 8.00 mg/L to 237.00 mg/l. The highest concentration was recorded at (St. 11) during in dry season 2000 and the lowest at (St. 7) during in wet season 2013. And also, SAL concentrations were at an acceptable level at all stations and different seasons and years. In this study, high concentrations of EC, TDS and SAL in (St. 11) were attributed from the upstream and low downstream to the rock temperament, especially limestone, sampling time, dry season, and agricultural runoff along the river. Furthermore, high values in (St. 11) are also related to increased soil erosion [42]. The relationship between EC, TDS, SAL and TEMP is due to more of the salts being more soluble at high TEMP and the breakdown to their respective ions [43]. Additionally, the relationship water quality parameters are related to the effluents from industrial activities, water treatment plants and domestic sewage, the surface runoff from agricultural fields typically has a high content of dissolved salts associated with the minor fraction of pesticides and nutrients (phosphorus and nitrogen) [44]. Furthermore, the parameters values of all periods at each station were found the suitable, for domestic, use in irrigation and classified as Class I and II.



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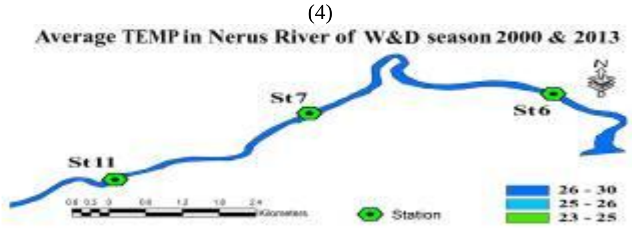

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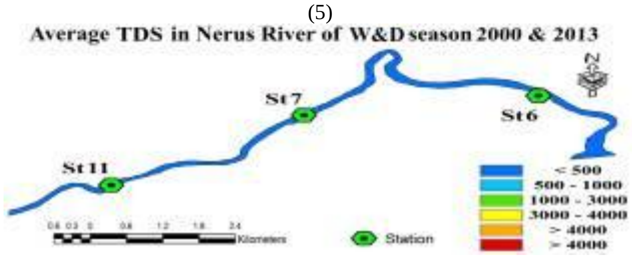

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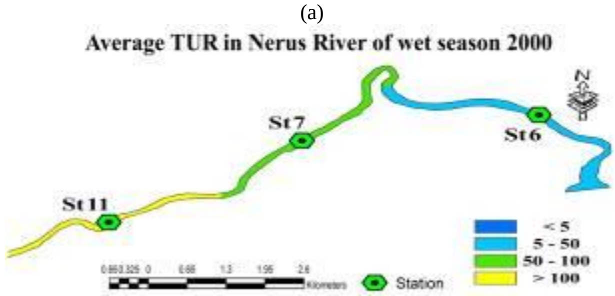
(7)

Fig. 4-7: Average EC, TEMP, TDS and SAL values in different seasons and years in water sample

3.4. TUR and TSS

The TUR & TSS have a very close relationship, TUR, it refers to water clarity. The greater the amount of TSS in the water, consequently reflect the turbidity values in the water. TUR values during the wet season 2000 were ranged from a minimum of 7.35 NTU (St. 11) to a maximum of 279.45 NTU (St. 6) with an average value of 132.26 NTU. In the same way, turbidity values ranged from 36.3 to 118.15 NTU in 2013, the lowest turbidity was recorded at St. 11 during dry season, whereas the highest value was in the same station at St. 11 in the wet season (Fig. 8 (a)-(d)).
While the lowest TSS value during the wet season 2000 was 9.5 mg/L at (St. 11) and the highest was 163.5 mg/L (St. 6). Likewise, in 2013, the TSS values ranged from 17 to 109 mg/l. The minimum value was obtained at St. 7 in wet season and the maximum at St. 11 also in wet season as shown in (Fig. 9 (a)-(d)). It was noticed that the upstream station, particular (St. 11), was recorded a lower TSS compared to downstream stations during dry periods compared to rainy season. There are a positive correlation between TSS and turbidity in all stations regardless of the differences in lithology, land use pattern and drainage area [45]. Human activities such as land use change from forests to other categories that occurred as a result from land clearing, logging, mining, and animal husbandryare identified as the main cause of the high TSS and TUR values. The agricultural runoff, deforested area runoff, and construction sites, as well as the mining activities contributed for the loading of suspended solids into the water bodies [46]. As represented in, the TSS and TUR values at all stations and all sampling periods were within the Class II and Class III of the NWQS for Malaysian rivers.

(a)

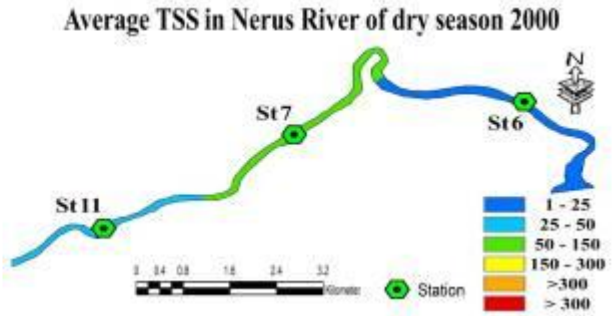


(b)

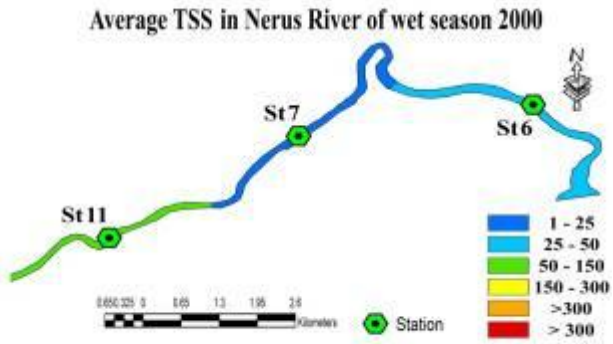
(c)

(d)

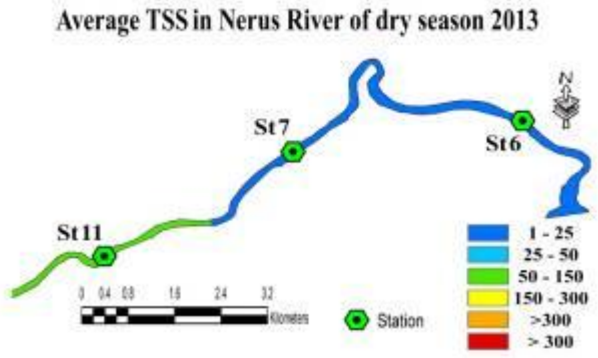
Fig. 8(a)-(d): Average TUR values in different seasons and years in water sample



(a)



(b)



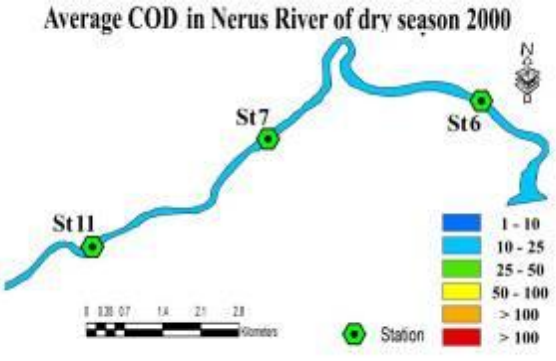
(c)

(d)

Fig. 9(a)-(d): Average TSS values in different seasons and years in water sample

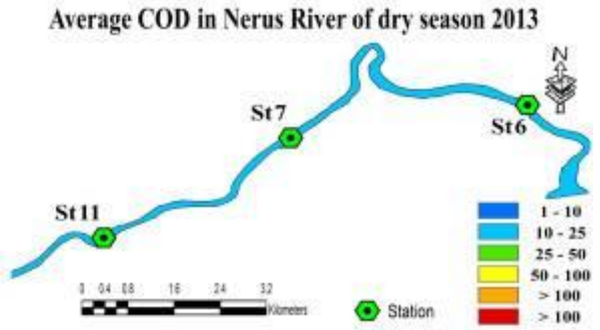
3.5. COD and BOD

Water quality parameter such as COD and BOD are very important parameter when evaluating water quality with respect to the presence of organic and inorganic pollutants. In this study COD and BOD were analyzed and the results were shown in (Table 3 and 4). In the present study, COD concentrations were higher during wet season, associated with the increase of urbanization and agricultural activities. During 2000, the highest COD value during wet season was 22.50 mg/L (St. 11) and 15.00 mg/L. (St. 6) during dry season. The 2013 COD values during wet season varied from a maximum of 33.00 mg/L. (St. 11) to a minimum of 13.5 mg/L (St. 6) during dry season (Fig. 10(a)-(d)). A deterioration in water quality is frequently associated with high concentrations of COD, while low concentrations are indicative of good conditions [47]. The COD level considered to reflect unpolluted and good water condition is generally less than 25 mg/L [48, 49]. Such levels were found in the downstream sections of the river, indicating no heavy organic or inorganic pollutants in these areas. However, COD values were high in total upstream slightly higher compared to downstream due to the presence of extensive agricultural practices (palm oil plantations) in the sub-watershed. Finally, the total mean value COD of the Nerus River was classified as Class II according to the NWQS classification [40].

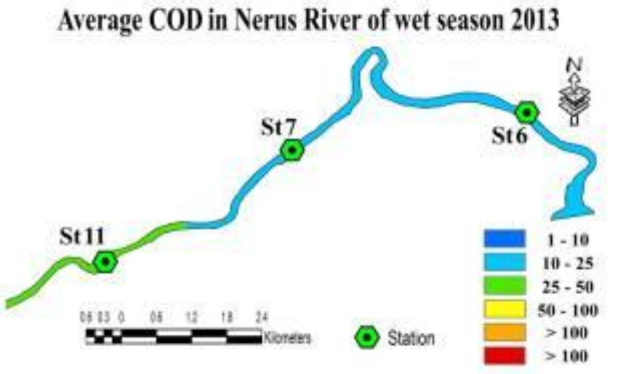


(a)

(b)

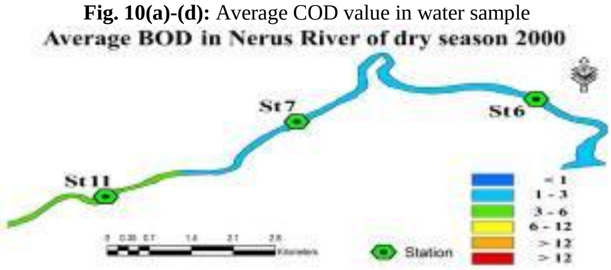


(c)



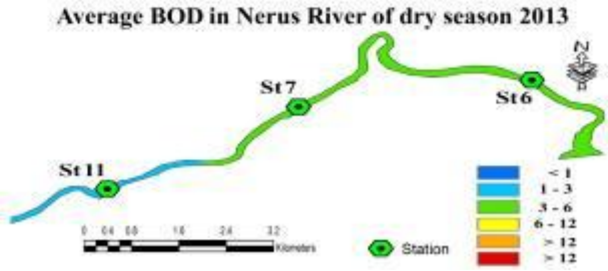
(d)

Fig. 10(a)-(d): Average COD value in water sample

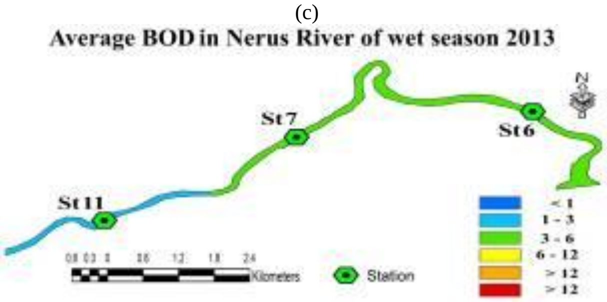


(a)

(b)



(c)



(d)

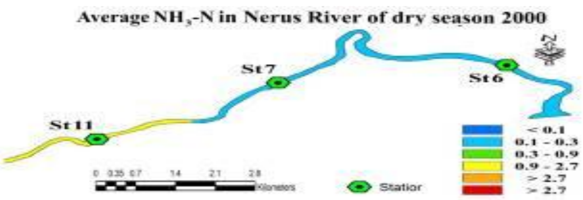
Fig. 11(a)-(d): Average, BOD value in different seasons and years in water sample

The BOD values of water samples ranged from 1.00 mg/L at (St. 7) during dry season and a maximum of 5.50 mg/l at (St. 11) during dry season in 2000, whereas in 2013, the values of BOD ranged from a minimum of 2.50 mg/L (St. 7) during wet season and a maximum of 4.00 mg/L (St. 6) during dry season (Fig. 11 (a)-(d)). The highest concentrations of BOD are found in the upstream and downstream sections of the river. The combination of clear water and forest yielded the highest concentration of BOD in upstream sections. High BOD concentrations in areas of horticultural land use (villages) may be attributed to faulty sewer systems and non-point source pollution discharges [15].

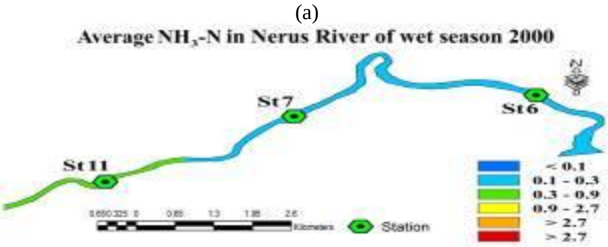
Concentrations of BOD is a tendency to increase when the presence of organic content, which encourages the growth of microbacteria. Sources of organic contamination include leaky sewer pipes, combined sewer overflows and livestock waste in adjacent areas, as well as agricultural runoff [50]. Such anthropogenic disturbances introduce suspended materials into the river system, thereby augmenting the amount of organic matter [46]. Moreover, (St. 6, 7 and 11) were classified under Class II and III which according to the classification of NWQS [40].

3.6. NH_3-N

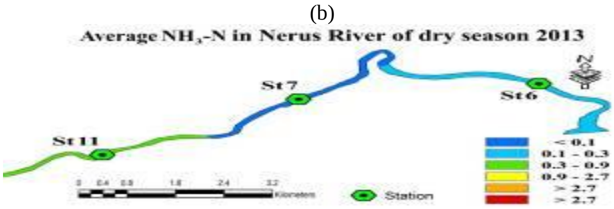
Urbanization and cultivated lands primarily are located along the river, since then their pollutants impact in river bodies was started. Water quality degradation due to ammoniacal nitrogen releases is crucial to environmental and concern worldwide, it can cause eutrophication [50]. NH_3-N concentrations increased at (St. 11) in dry seasons 2000 to a maximum of 0.99 mg/l and to a minimum of 0.01 mg/l at (St. 6) during wet seasons in 2000. On the other hand, in 2013 the value of NH_3-N to a maximum of 0.36 mg/L at (St. 11) in dry seasons to a minimum of 0.06 mg/L at (St. 7) also in dry seasons (Table 3-4 and Fig. 12 (a)-(d)). Increase in the NH_3-N at upstream derived from possible diffuse sources of pollution such as agricultural activities. Indeed, the widespread usage of fertilizers and the improper management of farming activity waste in the region may lead to considerable diffuse NH_3-N pollution triggered by rainwater running toward the rivers, at due to the greater influence of agriculture in these areas. Moreover, Potential point sources of NH_3-N pollution include intensive urban activities such as sewage treatment, as well as industrial effluent. Also, the other reason related to an increase in the NH_3-N at upstream, such as pollutants from animal manure applications and farming activities, released into the rivers have contributed to the high content of ammonia nitrogen. Generally, the high NH_3-N value was due to human and farming activities. Also, the lowest NH_3-N value 0.01mg/l was recorded at (St. 6) during dry and rainy seasons 2000. Therefore, sometimes, heavy rain and runoff have a dilution effect on the nutrients resulting in a decrease in the ammonia content towards downstream [51]. Finally, NH_3-N concentrations at (St. 6, 7) downstream in river within class II, except at (St. 11) upstream in dry seasons 2000 in river within class III based on the NWQS classification.



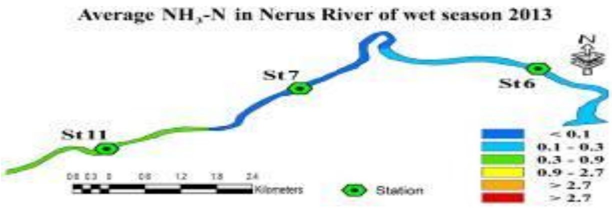
(a)



(b)



(c)



(d)

Fig. 12(a)-(d): Average NH_3-N value in different seasons and years in water sample

3.7. NO_3

There is a positive relationship between NO_3 with NH_3-N due to the NO_3 being the final oxidation as a product of nitrogen [52]. The nitrate values varied from a maximum of 0.58 mg/L (St. 7) during the wet season in 2013 to a minimum of 0.05 mg/L (St. 6) during the dry season in 2013. In contrast, the NO_3 values varied from a minimum of 0.05 mg/l at sampling (St. 11) during the wet season in 2000 to a maximum of 0.28 mg/l at sampling (St. 7) during the wet season in 2000 (Table 3-4 and Fig. 13). The high values of nitrate during the rainy periods are closely related to the higher fertilizer content of oil palm plantation along the river from (St. 11) to (St. 6) as well as agricultural runoff from the farms at the two banks of the river, which is the main source of nitrate.

Furthermore, in the primary rainy periods, the NO_3 value also was affected by the surface runoff from the urban area at (St. 7 and 6). Also, that the low concentrations of NO_3 might be caused by human activities, which were determined by some agricultural lands that use nitrate as fertilizer. According to the NWQS, the mean concentrations of NO_3 were in the natural range. In addition, the high values of NO_3 during the rainy season are closely related to the higher fertilizer of the oil palm plantation along the river in (St. 7) as well as agricultural runoff from the farms at the river banks. Furthermore, during rainy season, the NO_3 value also was affected by the surface runoff from the urban and agricultural, different effluents including sewage, domestic wastewater and industrial wastes. The N03 content in this study was within the minimum permissible limit (natural level). Based on the acceptable level of NWQS of [16], the values of NO_3 were in the natural range and placed at (St. 6, 7 and 11) under Class I.

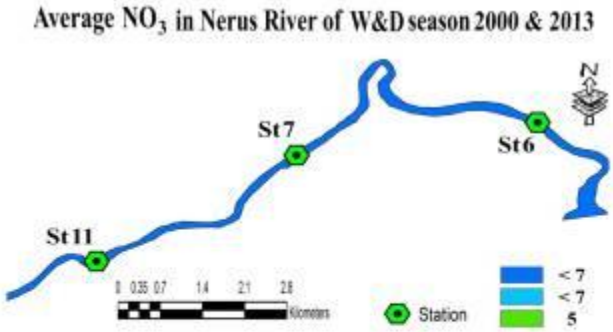


Fig. 13: Average NO_3value in different seasons and years in water sample

3.8. E.Coli

E.coli, and total coliform The *E.coli* population in the Nerus River ranged from 350 to 3900 CFU/100ml. The minimum value was recorded at (St. 6, 7) during dry season in 2000 and the maximum was observed at (St. 11) during dry season in 2000. In addition, the *E.coli* population in 2013 ranged from 200 to 1025 CFU/100 ml. The minimum value was recorded at (St. 6) during dry season 2013 and the maximum was observed at (St. 6) during wet season 2013 (Table 3-4. Fig. 14). The values of *E.coli* and total coliform of the different stations at all periods are within the permissible threshold limits for NWQS [52]. In addition, the increasing of *E.coli* and total coliform at (St. 11) was attributed to land use

change associated with the untreated sewage from the residential area and directly discharges sewage into the river as well as the palm plantations that use the animal manure as fertilizer. Furthermore, the effect by the livestock husbandry (farms the animal), the domestic effluent of settlements, agricultural activities (plantations and farms). Also, the livestock waste contains high concentrations of coliform bacteria which enter the waterways as results of the drainage of livestock farms and the applications of livestock manure in the agricultural activities as fertilizer that is carried to the rivers during the stormwater runoff. Overall, in this study, the *E.coli* and total coliform were increased during dry periods compared to the rainy periods affected by the direct discharges of untreated sewage, domestic wastewater and livestock wastewater.
in addition to, this was consistent with the results of many researchers in their studies areas who found that the coliform bacteria in dry period is more than rainy period affected by the direct effluent from anthropogenic pollutants [53, 54]. These results indicated that the river can be used for irrigation, agriculture, home use and is class II.

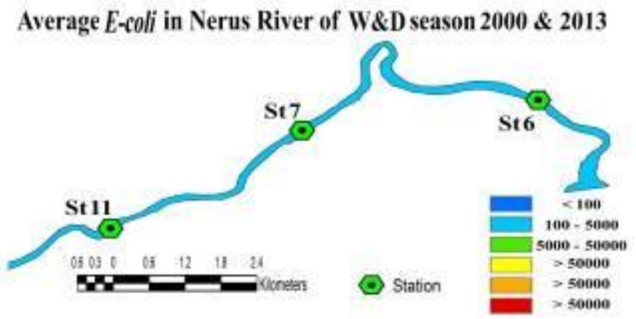


Fig. 14: Average *E.coli* value in different seasons and years in water sample

4. Conclusion

Evaluation of the relationship between water quality and land use characteristics in the Nerus River basin. In addition, the detailed dynamic characterization of pollution sources of a particular importance to identify and control new pollution sources. The relationship between land use and water quality in the dry and rainy Seasons events is based on data from three sampling stations each along the Nerus River. The multivariate statistical techniques could provide and GIS, the relationship between land use and water quality, showing that forested land use was negatively associated with nutrients and organic parameters, the relationship between land use and water quality shows that urbanization was a key factor affecting the river water quality, followed by horticultural anthropogenic activities (rural area) which are often in the vicinity of rivers, due to higher urbanization and agricultural activities. GIS showed greater significance for the sampling site groups (land-use activities) than for the sampling event. The topographical map was first rectified to provide a baseline estimation of Nerus River. Changes of line and polygon were detected by superimposing the maps of segment and raster. This technique provided the distortion of the base map and overlay maps. Digital scanning plus tablet and on-screen digitizing techniques were applied to all the maps. The procedure is summarized in three stages: Stage one: Scanning and downloading of images. The Topographic and land use maps of 2000 and 2013 were scanned using a Digital Scanner and saved in a *jpg file [55]. This indicates that the sources of pollution were there during the dry and rainy sampling events and were clearly marked by variations in the concentration of the following parameters: TEMP, pH, DO, EC, SAL, TUR, TDS, TSS, COD, BOD, NH_3-N, NO_3 and *E.Coli* in the Nerus River water was colored slightly suitable for agriculture, irrigation and home use according to INWQS levels by the Malaysian DOE being classified as Class III.

Acknowledgement

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References

[1] Das, J. & Acharya, B. C. 2003. Hydrology and assessment of lotic water quality in Cuttack city, India. *Water, Air, Soil Pollution* 150: 163-175.
[2] Al-badaii, F., M.B. Gasim, M. Mokhtar, M.E. Toriman and S.A. Rahim, 2012. Water-Pollution Study Based on the Physico-chemical and Microbiological Parameters of the Semenyih River, Selangor, Malaysia. The Arab World Geographer, 15(4): 318-334.
[3] Suarez, J. & Puertas, J. 2005. Determination of COD, BOD, and suspended solids loads during combined sewer overflow (CSO) events in some combined catchments in Spain. *Ecological Engineering* 24: 201-219.
[4] Khalil, B., Ouarda, T. B. M. J. & St-Hilaire, A. 2011. Estimation of water quality characteristics at ungauged sites using artificial neural networks and canonical correlation analysis. Journal of Hydro logy 405: 277-287
[5] O. M. A. Laila, M. B. Gasim, M. E. Toriman and M. A. A. Hassan. 2018. The assessment of physico-chemical and biological water quality characteristics of the Ibai River between wet and dry seasons, Kuala Terengganu, Malaysia. Journal of Fundamental and Applied Sciences. 10(1S), 396-411.
[6] Gazzaz, N., Yusoff, M. K., Aris, A. Z., Juahir, H. & Ramli, M. F. 2012. Artificial neural network modeling of the water quality index for Kinta River (Malaysia) using water quality variables as predictors. Marine Pollution Bulletin 64: 2409-2420.
[7] O. Altansukh and G. Davaa, "Application of Index Analysis to Evaluate the Water Quality of the Tuul River in Mongolia," Journal of Water Resources and Protection, Vol. 3, No. 6, 2011, pp. 398-414.
[8] Najafpour, S., S.M.V. Farabi, M. Yousefian, F.M.A. Alkarkhi and A.G. Khenary, 2010. The determination of organochlorine pesticide residues in Chalus River water by multivariate analysis. Iranica Journal of Energy and Environment, 1(3): 222-227.
[9] V. P. Singh and M. Fiorentino, "Geographic Information System in Hydrology," Kluwer Academic Publishers, Dordrecht, 1996.
[10] Poh, S. C., Suratman, S., Chew, C. K., Shazili, N. A. M., & Tahir, N. M. (2008). Metal geochemistry of Nerus River, Terengganu. Malaysian Journal of Analytical Sciences, 12(3), 593-599.
[11] Alssgeer, H. M. A., Gasim, M. B., Azid, A., & Alabyad, L. O. M. (2017). The Evaluation of Physico-Chemical And Biological Characteristics of Water Quality between Wet and Dry Seasons of Nerus River, Kuala Terengganu, Malaysia. *Journal of Fundamental and Applied Sciences*, *9*(2s), 563-582.
[12] Shazili N.A.M., Sharipudin H., M.Tahir. N. and Yunus K. 2004. Dissolved Cd, Cu, Pb and Zn concentration in Nerus River, Terengganu. Malaysian Journal of Analytical Sciences 8, pp.112-117.
[13] Y. Saeedrashed and A. Guven, "Estimation of Geomorphological Parameters of Lower Zab River-Basin by Using GIS-Based Remotely Sensed Image," Water Resources Management, Vol. 27, No. 1, 2013, pp. 209-219.
[14] V. P. Singh and M. Fiorentino, "Geographic Information System in Hydrology," Kluwer Academic Publishers, Dordrecht, 1996.
[15] USEPA. 2012. *Water Quality Criteria Copper, Aquatic Life Criteria*. Washington, DC. United State Environmental Protection Agency.
[16] DOE. 2011. *Malaysia Environmental Quality Report*. Department of Environment. Ministry of Science, Technology and Environment Malaysia.
[17] Huang, J., Li, Q., Pontius, R. G., Klemas, V., & Hong, H. (2013). Detecting the dynamic linkage between landscape characteristics and water quality in a subtropical coastal watershed, Southeast China. *Environmental management*, *51*(1), 32-44.
[18] Sliva, L., & Williams, D. D. (2001). Buffer zone versus whole catchment approaches to studying land use impact on river water quality. *Water research*, *35*(14), 3462-3472.

[19] Dodds, W. K., & Oakes, R. M. (2008). Headwater influences on downstream water quality. *Environmental management*, *41*(3), 367-377.
[20] V. P. Singh and M. Fiorentino, "Geographic Information System in Hydrology," Kluwer Academic Publishers, Dordrecht, 1996.
[21] Y. Saeedrashed and A. Guven, "Estimation of Geomorphological Parameters of Lower Zab River-Basin by Using GIS-Based Remotely Sensed Image," *Water Resources Management*, Vol. 27, No. 1, 2013, pp. 209-219.
[22] C. Childs, "Interpolation Surfaces in ArcGIS Spatial Analyst," ESRI Education Services, 2004. www.seri.com.
[23] Berry, J. K., Delgado, J. A., Pierce, F. J., &Khosla, R. (2005). Applying spatial analysis forprecision conservation across the landscape. *Journal of Soil and Water Conservation*, *60*(6), 363-370.
[24] Johnson, L.; Richards, C.; Host, G.; Arthur, J. (1997). Landscape influences on water chemistry in midwestern stream ecosystems. *Freshwater Biol.*, *37*, 193–208.
[25] Petry, J., Soulsby, C., Malcolm, I. A., & Youngson, A. F. (2002). Hydrological controls on nutrient concentrations and fluxes in agricultural catchments. *Science of the Total Environment*, *294*(1), 95-110
[26] Yates, A. G., Brua, R. B., Corriveau, J., Culp, J. M., & Chambers, P. A. (2014). Seasonally driven variation in spatial relationships between agricultural land use and in-stream nutrient concentrations. *River research and applications*, *30*(4), 476-493.
[27] Kang, J. H., Lee, S. W., Cho, K. H., Ki, S. J., Cha, S. M., & Kim, J. H. (2010). Linking land-use type and stream water quality using spatial data of fecal indicator bacteria and heavy metals in the Yeongsan river basin. *Water research*, *44*(14), 4143-4157.
[28] Mouri, G., Takizawa, S., & Oki, T. (2011). Spatial and temporal variation in nutrient parameters in stream water in a rural-urban catchment, Shikoku, Japan: Effects of land cover and human impact. *Journal of Environmental Management*, *92*(7), 1837-1848.
[29] Woli, K. P., Nagumo, T., Kuramochi, K., & Hatano, R. (2004). Evaluating river water quality through land use analysis and N budget approaches in livestock farming areas. *Science of the Total Environment*, *329*(1), 61-74.
[30] Vega, M., Pardo, R., Barrado, E., & Debán, L. (1998). Assessment of seasonal and polluting effects on the quality of river water by exploratory data analysis. *Water research*, *32*(12), 3581-3592
[31] Dudgeon, D. (1992). Endangered ecosystems: a review of the conservation status of tropical Asian rivers. *Hydrobiologia*, *248*(3), 167-191
[32] J. Yisa and T. Jimoh, "Analytical Studies on Water Quality Index of River Landzu," *American Journal of Applied Sciences*, Vol. 7, No. 4, 2010, pp. 453-458.
[33] Canadian Council of Ministries of the Environment (CCME), "Scientific Criteria Document for the Development of the Canadian Water Quality Guidelines for the Protection of Aquatic Life," 2012. http://ceqg-rcqe.ccme
[34] S. Gandaseca, N. Rosli, J. Ngayop, and C. I. Arianto, "Status of water quality based on the physico-chemical assessment on river water at wildlife sanctuary Sibuti Mangrove forest, Miri Sarawak," *American Journal of Environmental Sciences*, vol. 7, no. 3, pp. 269–275, 2011.
[35] DOE, *Water Quality Index. Department of Environment. Ministry of Science*, Technology and Environment Malaysia, Kuala Lumpur, Malaysia, 2006.
[36] N. Rosli, S. Gandaseca, J. Ismail, and M. I. Jailan, "Comparative study of water quality at different peat swamp forest of Batang Igan, Sibu Sarawak," *American Journal of Environmental Sciences*, vol. 6, no. 5, pp. 416–421, 2010.
[37] Parihar S.S., Kumar A., Kumar A., Gupta R.N., Pathak M. Shrivastav A. and Pandey A.C., Physico-Chemical and Microbiological Analysis of Underground Water in and Around Gwalior City, MP, India, *Res. J. Recent Sci.*, 1(6), 62-65, (2012).
[38] Latiff, A. A. 2011. *Water Pollution: the Never Ending Story*. Universiti Tun Hussein Onn, Malaysia.
[39] Chapman, D. V. 1996. *Water Quality Assessments: A Guide to the Use of Biota, Sediments and Water in Environmental Monitoring.* London: E and Fn Spon.
[40] Department of Environment, Interim National Water Quality Standards for Malaysia. DOE, Kuala Lumpur, Malaysia (2008).
[41] Weiner, E. R. 2000. Applications of Environmental Chemistry: A practical Guide for Environmental Professionals. Boca Raton, Florida: CRC Press LLC.
[42] Gasim, M. B. 2003. *Watershed Analysis of the Semenyih River Basin, Selangor, Malaysia* .PhD. dissertation (Unpublished), Universiti Putra Malaysia.
[43] Gordon, N. D., McMahon, T. A., Finlayson, B. L., Gippel, C. J. & Nathan, R. J. 2013. Stream Hydrology: An Introduction for Ecologists. J44] Varol, M. & Şen, B. 2012. Assessment of nutrient and heavy metal contamination in surface water and sediments of the upper Tigris River, Turkey. *Catena* 92: 1-10.
[44] Daphne, L. H. X., Utomo, H. D. & Kenneth, L. Z. H. 2011. Correlation between turbidity and total suspended solids in Singapore Rivers. *Journal of Water Sustainability* 1(3): 313-322.
[45] Novotny, V. 2003. *Water Quality: Diffuse Pollution and Watershed Management*. John Wiley and Sons.
[46] Department of Environment DOE. 2009. Water Quality (River) Monitoring System/Programme and Pollution Control. Hashim Daud. Ministry of Natural Resources and Environment.
[47] Gandaseca, S., Rosli, N., Pazi, A M. M. & Arianto C. I. 2014. Effects of land use on river water quality of Awat-Awat Lawas Mangrove Forest Limbang Sarawak Malaysia. International Journal of Physical Sciences 9: 386-396.
[48] APHA (2005). Standard Methods for the Examination of Water and Wastewater. 21st ed. Washington: American Water Works Association, Water Environment Federation.
[49] Crim, J. F. 2007. *Water Quality Changes across an Urban-Rural Land Use Gradient in Streams of the West Georgia Piedmont.* M.Sc Thesis. Graduate School at Auburn University, United States.
[50] Al-Dhabi, F. M. S. 2011. Physico-chemical Water Quality study of the Rompin River catchment, Pahang, Malaysia. M.Sc. Thesis (Unpublished), Universiti Kebangsaan Malaysia.
[51] Muriithi, Faith K., and Danlin Yu. "Understanding the Impact of Intensive Horticulture Land-Use Practices on Surface Water Quality in Central Kenya." *Environments* 2.4 (2015): 521-545.
[52] Tebutt, T. H.Y. 1983. *Principles of Water Quality Control*. 3rd Edition. Oxford: Pergamon Press.
[53] Krishna, H., Hosmani, S. & Jayashnakar, M. 2012. Physico-chemical and bacteriological parameters of Kaveri river at Talakaveri region: A comparative study. National monthly refereed Journal of Research in Science & Technology 1 (6): 1-15.
[54] Isobe, K. O., Tarao, M., Chiem, N. H., Minh, L. Y. & Takada, H. 2004. Effect of environmental factors on the relationship between concentrations of coprostanol and fecal indicator bacteria in tropical (Mekong Delta) and temperate (Tokyo) freshwaters. Applied and Environmental Microbiology 70(2): 814-821.
[55] Mohd Ekhwan, T. (2003). Channel geometry change response to flow regulation on the Langat River. Proceedings Seminar on Society, Space and Environment in a Globalised World. 29-30April, Penang.