Geospatial water quality assessment system for the Sg. Buloh river basin in Malaysia

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Abstract: Assessment of pollution risk requires the assimilation of spatio-temporally variable data on water quality parameters. This paper describes a GIS user-interface program coupled with a water quality index (WQI) model that was developed and built to assess water quality in the Sg. Buloh river basin. Fifty-two water sampling stations were selected for this study, and the WQI model considers parameters such as pH, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total suspended solids and ammonia nitrogen, as used by the Department of Environment in Malaysia. The spatial pattern of each parameter was analysed, and WQI values were calculated, ranging from 4.48 to 76.8 on a scale with 100 representing the highest pristine quality. A map of WQI is provided, which will help planners and decision makers to develop water pollution control strategies, and the model is capable of extension with further data to address pollution risk.

Keywords: assessment; water quality; GIS user-interface; interactive system.

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1 Introduction

Assessment of the possible risks of pollution in rivers for different uses as well as for aquatic animals and plants is essential. A powerful geographical information system (GIS) tool is capable of integrating and analysing the information from various sources for assessing spatial information. The term pollution refers to changes caused by humans and their actions that result in water quality conditions that negatively impact on the integrity of the water for beneficial purposes, including natural ecosystem integrity. Determining the extent of pollution is difficult, given the wide range of constituent measures that characterise water quality. Water quality management practices are guided by established criteria and standards typically expressed as constituent concentrations, or narrative statements describing water quality levels that support particular uses. A broad range of environmental and administrative data is required for water quality assessment. Water is a natural resource which can be used for different purposes, namely for drinking, domestic, irrigation and industrial use, mainly depending on its intrinsic quality, hence it is a prime importance to have prior information on water quality resources available in the region, while planning developmental projects (Cheremisinoff, 1993; Rajankar et al., 2009). Water quality refers to the physical and biological characteristics of water (Helmer and Hespanhol, 1997; Ali et al., 2009). Rivers are among the most vulnerable water bodies to pollution because of their role in carrying municipal and industrial waste and run-off from agricultural lands in their vast drainage basins. Detailed hydro-chemical research is needed to evaluate the different processes and mechanisms involved in polluting water (Helena et al., 1999).

Development of environmental decision support systems (EDSS) is rapidly progressing (Matthies et al., 2007). Future developments appear directed towards better representation of reality in models and improving user-friendliness for decision making. Geographic information systems (GIS) have become increasingly important for understanding and dealing with the pressing problems of water and related resources management in our world. Unique aspects of water resource management problems require a special approach to development of spatial and temporal data structures. Many challenges are associated with the integration of GIS with models in specific application (McKinney and Cai, 2002). The GIS capability has made itself appropriate to decision-making (Bradley, 1993).

Modelling the impact of non-point source pollution in catchments is a complex problem. Pollution loads from land sources and their impact on the receiving waters can be predicted by using land-use and surface water quality models, respectively. A watershed is a complex ecosystem and assessment of watershed condition entails consideration of numerous issues and factors (Dai et al., 2004). Mathematical models alone are not satisfactory tools in the process of decision-making (Maidment, 1993). To analyse the spatial variability of water quality in the basin, the modern GIS-integrated user-friendly tool coupled with water quality model is worthwhile since the temporal and spatial dimensions could be studied at once. The object-oriented approach, data, models and users interfaces are integrated in the GIS environment, which creates great flexibility for modelling and analysis. Different strategies for linking a catchment model with GIS and tighter integration between generic sub-models for physical landscape processes and GIS is essential (McKinney and Cai, 2002). GIS-based procedures for predicting chemical distribution are reported in the literature (Schowanek et al., 2004; Verro et al., 2002). GIS is one of the most important tools for integrating and analysing spatial information from different sources (Mohd et al., 2000; Shamsi, 2005).

Malaysia enjoys a relative abundance of water that is becoming less due to growing water demands, insufficient investment in water resources development and deterioration of water quality (Assaf and Saadeh, 2008). Rapid development has contributed a negative impact to the environment, especially on river water quality (Ali et al., 2009). This issue has become sensitive and affects human health and also the entire environment, particularly aquatic life. Inappropriate treatment and effluent discharge results in downstream pollution from urbanisation and agricultural development (Salmah, 2007). Rivers, streams, lakes and reservoirs are the most important resources for water. The possible causes of water quality pollution are due to lack of efficient treatments for untreated effluents from domestic and industrial activities, deforestation, sewage wastewater from residential area, industrial wastes from nearby industrial areas, lack of cooperation and coordination among private and government sectors. Due to temporal and spatial changes of point and non-point source pollutants, frequent water sampling at various sites is mandatory for monitoring a large number of physicochemical parameters.

Therefore, a knowledge-based system is necessary to enhance the performance of an assessment operation and develop better water resource planning and management.

Surface water quality may be deteriorated due to both natural processes such as sewage discharge and anthropogenic activities, and many others. Water pollution has become a growing threat to human society and natural ecosystems in recent decades, increasing the need to understand better the spatial and temporal variability of pollutants (Hongmei et al., 2010). Information on water quality and pollution sources is important for the implementation of sustainable water-use management strategies (Sarkar et al., 2007; Zhou et al., 2007). Chang (2008) stated that urban land cover is positively associated with increases in water pollution and included as the most important explanatory variable for BOD, TP, and TN in South Korea. Topography and soil factors are the major determinants of the spatial variations in temperature, pH, and DO. The process of river water quality pollution requires the assimilation of data that are spatially and temporarily variable in nature, making GIS an ideal tool for such assessments. Currently, there is no such tool available that can help water managers, planners and decision-makers identify the risks associated with contamination of water in river networks. Hence it is anticipated that a GIS-based water quality assessment tool can usefully be developed for the spatial water quality assessment system to assess pollution levels for the different potential uses. In this study, the Sg. Buloh river basin was selected for water quality evaluation as it reflects typical drainage patterns in urban areas. Incorporating spatial dimensions into water assessment enhances the understanding of patterns and processes in water quality. Therefore, the objective of this study was to reveal the spatial variability in water quality and identify the possible pollution risk.

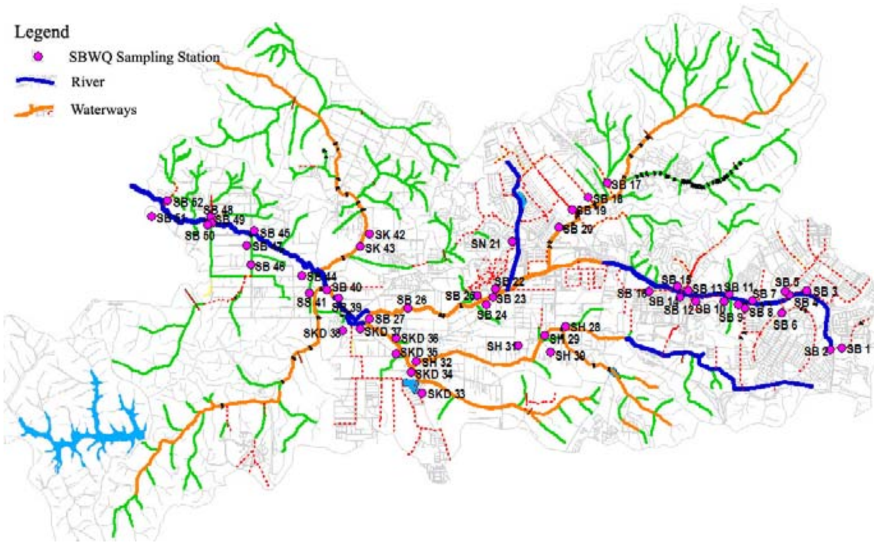
2 System framework for water quality assessment

The system framework illustrates how the spatial water quality data and model coupled with GIS-interface can enhance the assessment of pollution risks and the identification of possible patterns of pollution from various sources.

2.1 Water sampling sites

The study area is located at a sub-district of Petaling District bordering with Gombak District in the state of Selangor. According to Department of Irrigation and Drainage (DID, 2009a, 2009b), Sg. Buloh is the main river flowing westerly from Bandar Sri Damansara through Desa Moccis before heading towards Malacca Straits. The Upper Sg. Buloh catchment consists of seven (7) tributaries, namely Sg. Gasi, Sg. Hampar, Sg. Kedondong, Sg. Kembit, Sg. Pelong, Sg. Cemubung, and Sg. Subang shown in Figure 1. The steeper areas are extended to the north-east of the study boundary and the terrain falls steeply southwards before flattening out at the plains in a westerly direction where Sg. Buloh Town is located. The elevation varies from 20 m to 600 m above mean sea level. The uppermost area of Sg. Buloh catchment is characterised by undulating terrain with slopes from 5% to 10%. The middle reach tends to be of milder slopes from 0.5% to 1%. Fifty two sampling stations were chosen to represent the water quality of the river systems as shown in Figure 1.

Figure 1 Water sampling stations for assessing water quality in Sg. Buloh river basin (see online version for colours)



2.2 Data preparation

There are 52 water quality sampling stations selected for this study. These sampling stations were located using a global positioning system (GPS) and were overlaid on the topographical map of Sg. Buloh river basin for the processing of the water quality assessment program. The water quality parameters from the Department of Environment (DOE), Malaysia and map features of the Sg. Buloh river basin were collected from the Department of Survey and Mapping Malaysia (JUPEM, 2004).

2.3 WQI model

The water quality index (WQI) formula is recommended by Department of Environment (DOE) in Malaysia. It consists of six parameters namely dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), ammonia nitrogen (AN) and pH. The formula is expressed as follows:

$$WQI = 0.22SI_{DO} + 0.19SI_{BOD} + 0.16SI_{COD} + 0.16SI_{TSS} + 0.15SI_{AN} + 0.12SI_{pH} \quad (1)$$

where

SI_{DO} sub index DO

SI_{BOD} sub index BOD

SI_{COD} sub index COD

SI_{AN} sub index NH3-N

SI_{TSS} sub index TSS

SI_{pH} sub index pH

$0 \leq WQI \leq 100$

Sub-index for DO (in % saturation):

$$
\begin{aligned}
SI_{DO} &= 0 \text{ for DO} < 8 \\
&= 100 \text{ for DO} > 92 \\
&= -0.395 + 0.030DO^2 - 0.00020DO^3 \quad \text{for } 8 < DO < 92
\end{aligned}
$$

Sub-index for BOD (in mg/l):

$$
\begin{aligned}
SI_{BOD} &= 100.4 - 4.23BOD && \text{for BOD} < 5 \\
&= 108e - (0.055BOD) - 0.1BOD && \text{for BOD} > 5
\end{aligned}
$$

Sub-index for COD (in mg/l):

$$
\begin{aligned}
SI_{COD} &= -1.33COD + 99.1 && \text{for COD} < 20 \\
&= 103e - (0.0157COD) - 0.04COD && \text{for COD} > 20
\end{aligned}
$$

Sub-index for AN (in mg/l):

$$
\begin{aligned}
SI_{AN} &= 100.5 - 105AN && \text{for AN} < 0.3 \\
&= 94e - (0.573AN) - 5.5\ AN - 2.5 && \text{for } 0.3 < AN < 4 \\
&= 0 \text{ for AN} > 4
\end{aligned}
$$

Sub-index for SS (in mg/l):

$$
\begin{aligned}
SI_{TSS} &= 97.5e - (0.00676SS) + 0.05SS && \text{for SS} < 100 \\
&= 71e - (0.0016SS) - 0.015SS && \text{for } 100 < SS < 1{,}000 \\
&= 0 \text{ for SS} > 1000
\end{aligned}
$$

Sub-index for pH:

$$
\begin{aligned}
SI_{pH} &= 17.02 - 17.2pH + 5.02pH^2 && \text{for pH} < 5.5 \\
&= -242 + 95.5pH - 6.67pH^2 && \text{for } 5.5 < pH < 7.0 \\
&= -181 + 82.4pH - 6.05pH^2 && \text{for } 7 < pH < 8.75 \\
&= 536 - 77.0pH + 2.76pH^2 && \text{for pH} > 8.75
\end{aligned}
$$

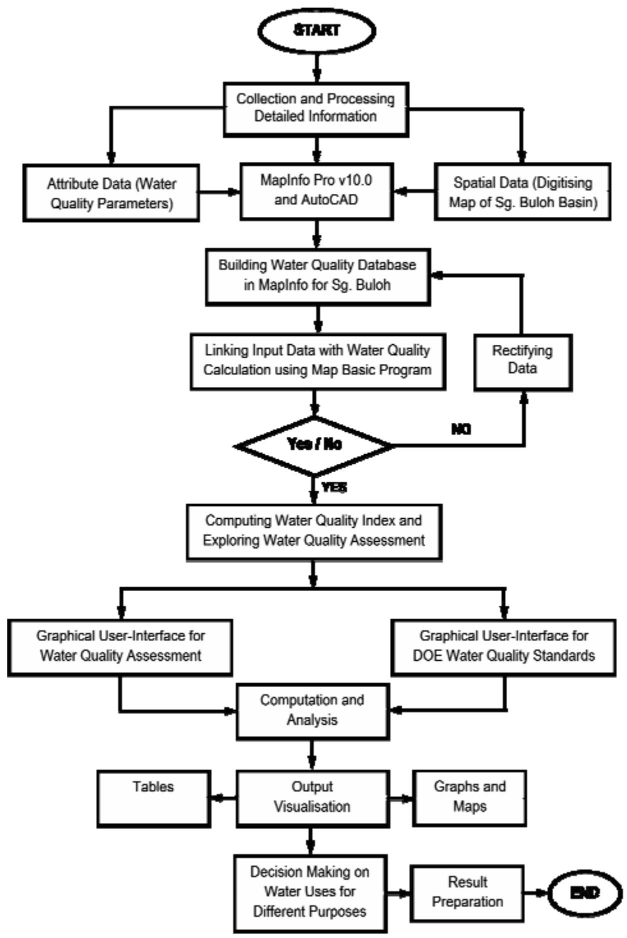
The WQI introduced by the Department of Environment (DOE) has been used in practice in Malaysia for about 25 years (DID, 2007; DOE, 1994). The Malaysian WQI considers six parameters. A panel of experts was consulted on the choice of the parameters and the weighting assigned to each parameter. Based on the Malaysian WQI, water quality is classified according to one of the following categories shown in the Table 1.

Table 1 WQI classes in Malaysia

Parameters	*Class*				
	I	*II*	*III*	*IV*	*V*
AN (mg/l)	<0.1	0.1–0.3	0.3–0.9	0.9–2.7	>2.7
BOD (mg/l)	<1	1–3	3–6	6–12	>12
COD (mg/l)	<10	10–25	25–50	50–100	>100
DO (mg/l)	>7	5–7	3–5	1–3	<1
pH	>7	6–7	5–6	<5	<5
TSS (mg/l)	<25	25–50	50–150	150–300	>300
WQI	>92.7	76.5–92.7	51.9–76.5	31.0–51.9	<31

Source: Salmah (2007)

Figure 2 Schematic flowchart of GIS user-interface for water quality assessment



2.4 GIS user-interface development

The flowchart shown in Figure 2 illustrates the components and operation strategies for the assessment of water quality of Sg. Buloh river basin. The GIS software MapInfo Pro 10.0 for windows and MapBasic 7.0 Programming Language were used for the developing of the interactive user-interface.

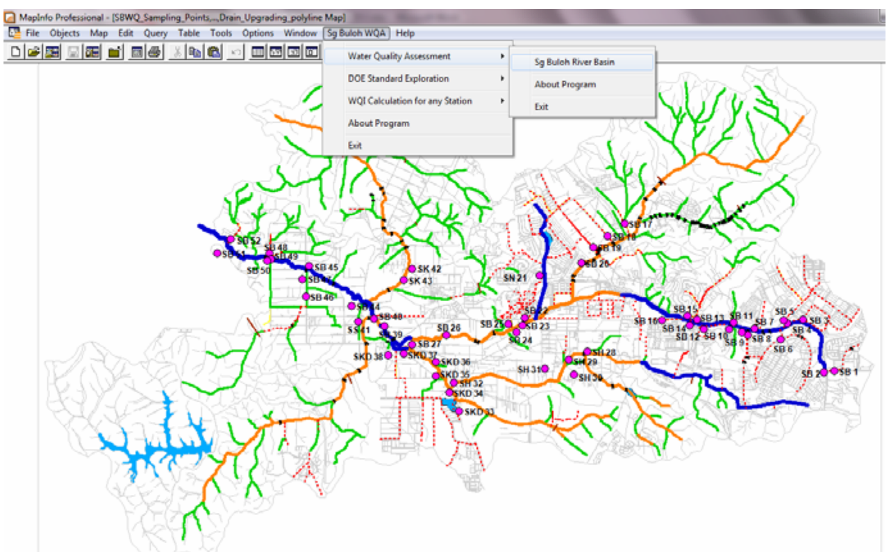
By running the MapBasic program for water quality assessment, the main menu 'Sg. Buloh WQA' appears on the menu bar of MapInfo Window as shown in Figure 3. Water quality monitoring program is consist of two major submodules, namely

1 water quality assessment for Sg Buloh

2 exploring DOE water quality standard, as shown in Figure 3.

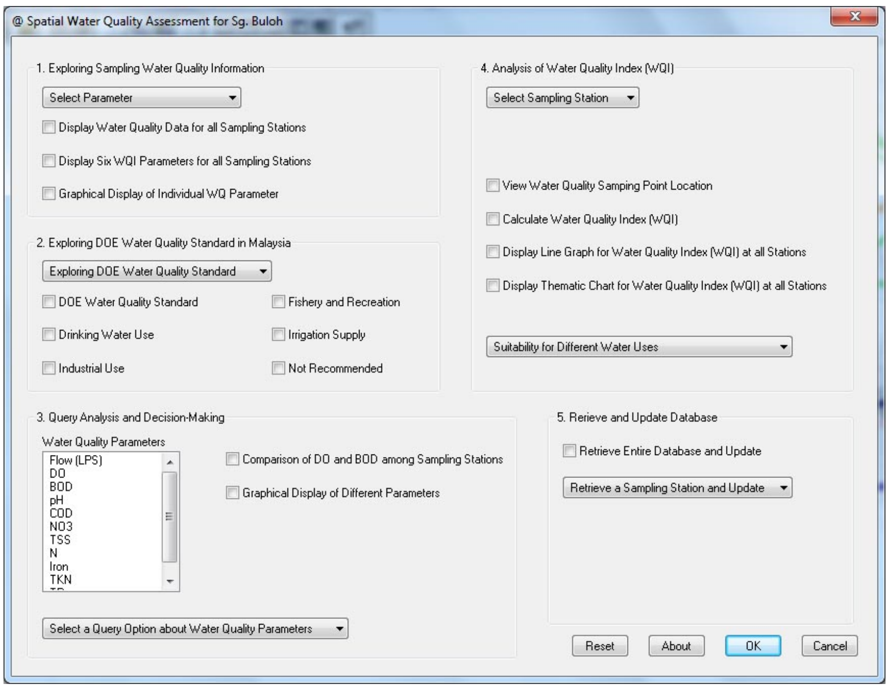
Spatial and relational databases and risk indices were integrated into GIS to produce maps of exposure, effect and risk at watershed scale. A GIS database model consisting of a set of vector data layers and related attribute data was constructed. The water quality standards recommended by DOE of Malaysia were used to assess the water quality at the Sg. Buloh river basin.

Figure 3 Customised menu 'Sg. Buloh WQA' for water quality assessment program in MapInfo Pro window (see online version for colours)

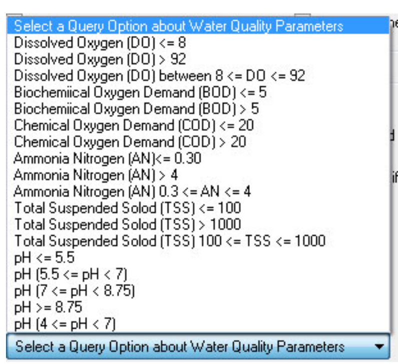


On activation within the MapInfo environment, the 'Sg. Buloh WQA' main menu appears directly within the menu bar. Clicking on this menu item activates a drop-down menu which allows the user to select any one of the two major sub-module for appropriate action. By selection of the menu item 'water quality assessment', the program allows to view the dialog wizard of the spatial water quality assessment as shown in Figures 3 and 4. With each major sub-module, further selection of an individual module can be displayed. The program allows to calculate the WQI of each station and to carry out the spatial analysis for the entire basin instantly after the selection of a particular option related to water quality from the dialog wizard/window (Figure 4). Menu item ‘water quality index for any station’ allows user to determine WQI instantly for any station of river in Malaysia. It allows to make comparison with other river networks in Malaysia.

Figure 4 Illustrated dialog window for water quality assessment at Sg. Buloh Basin (a) dialogue window with command buttons (b) SQL for water quality parameters in drop-down ListBox (c) 52 sampling stations in drop-down ListBox (d) suitability of water uses in drop-down ListBox (see online version for colours)

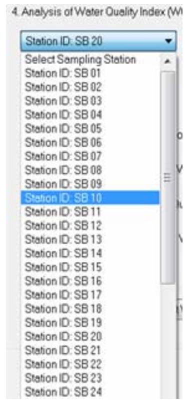


(a)

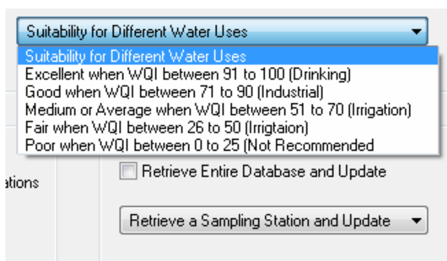


(b)

Figure 4 Illustrated dialog window for water quality assessment at Sg. Buloh Basin (a) dialogue window with command buttons (b) SQL for water quality parameters in drop-down ListBox (c) 52 sampling stations in drop-down ListBox (d) suitability of water uses in drop-down ListBox (continued) (see online version for colours)



(c)



(d)

The ControlBox 'selecting a query option about water quality parameter' under GroupBox 'query analysis and decision making' activates a drop-down list [Figure 4(b)], which allows the user to select different parameters and to identify their spatial variation and environmental impacts. The selection of a particular station in the drop-down list menu 'analysis of water quality index (WQI)' in Figure 4 allows instantly to calculate the WQI for a particular station. In the main dialog window, by clicking the menu 'DOE water quality standard' followed by 'Sg. Buloh WQA', which allows further selection of individual sub-modules for detailed exploring of water quality information.

3 Results and discussion

3.1 Impact analysis for varying water quality parameters

The physicochemical and bacteriological parameters of the water of Sg. Buloh River are presented in Table 2. The fluctuating physical and chemical characteristics of water and their interactions bear an effect on the biological features of aquatic ecosystems of rivers.

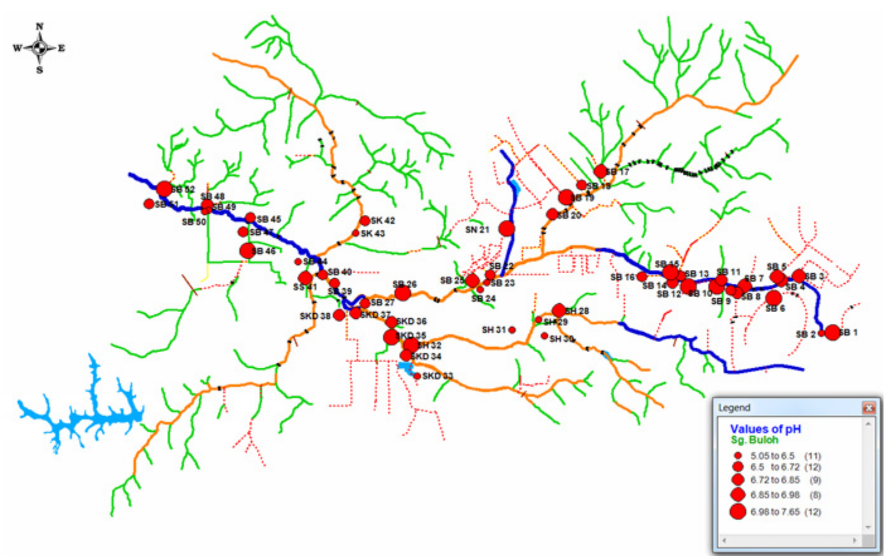
This GIS-based interactive information system could be potentially used as a powerful tool to assess regional riverine water quality, allowing risk comparison between different chemicals and different effluent patterns in river water.

Table 2 Physicochemical and bacteriological parameters for 52 stations

Parameters	*Unit*	*Maximum*	*Average*	*Minimum*
pH		7.63	6.69	5.05
DO	mg/l	7.32	4.16	1.00
BOD	mg/l	583.00	39.09	2.00
COD	mg/l	598.00	70.36	2.00
TSS	mg/l	1,705.00	56.2	2.00
Fe	mg/l	8.45	1.54	0.07
AN-N	mg/l	15.60	3.89	0.10
NO_3	mg/l	21.60	2.77	0.10
TKN	mg/l	27.40	7.34	0.40
TP	mg/l	33.33	2.11	0.10

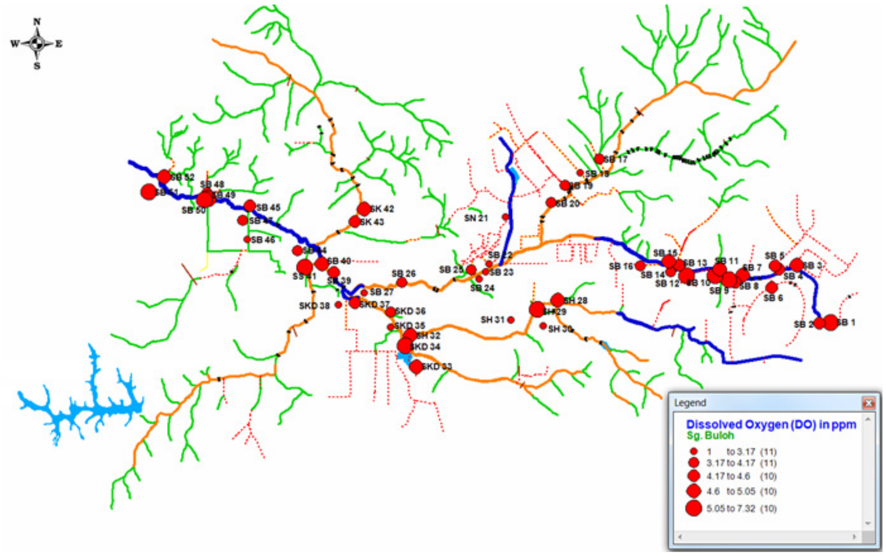
Physical and bacteriological parameters were provided by DID Malaysia for the 52 stations. The maximum, average and minimum values of important parameters are shown in Table 2. At first, a particular parameter from ListBox 'select parameter' is selected under the GroupBox of 'exploring DOE water quality standard in Malaysia' from Figure 4. Then by simply clicking on the CheckBox 'graphical display of individual WQ parameter', spatial variability graph for pH, DO, COD, BOD, AN and TSS at Sg. Buloh river basin can be generated instantly, which are illustrated in Figure 5.

Figure 5 Extent of water pollution in the Sg. Buloh River basin (a) pH (b) DO (c) COD (d) BOD) (e) AN (f) TSS (see online version for colours)

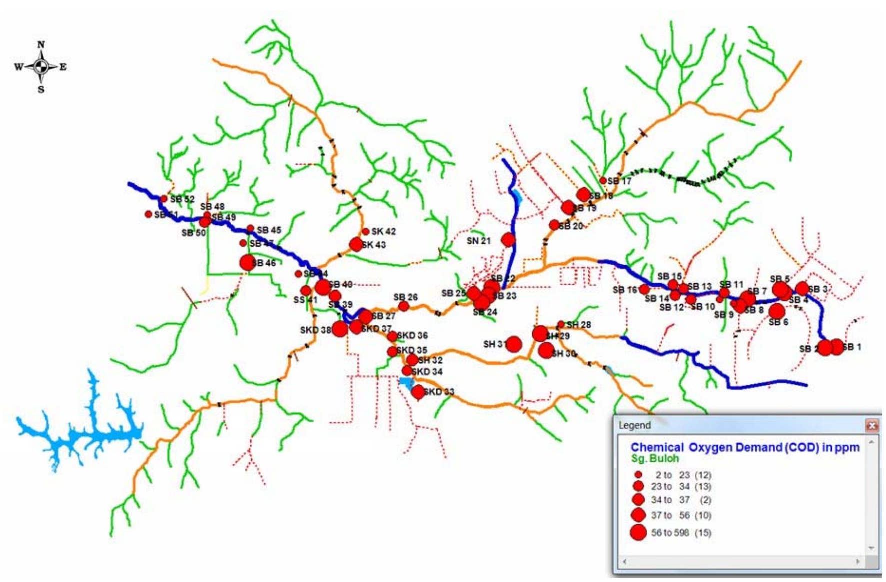


(a)

Figure 5 Extent of water pollution in the Sg. Buloh River basin (a) pH (b) DO (c) COD (d) BOD) (e) AN (f) TSS (continued) (see online version for colours)

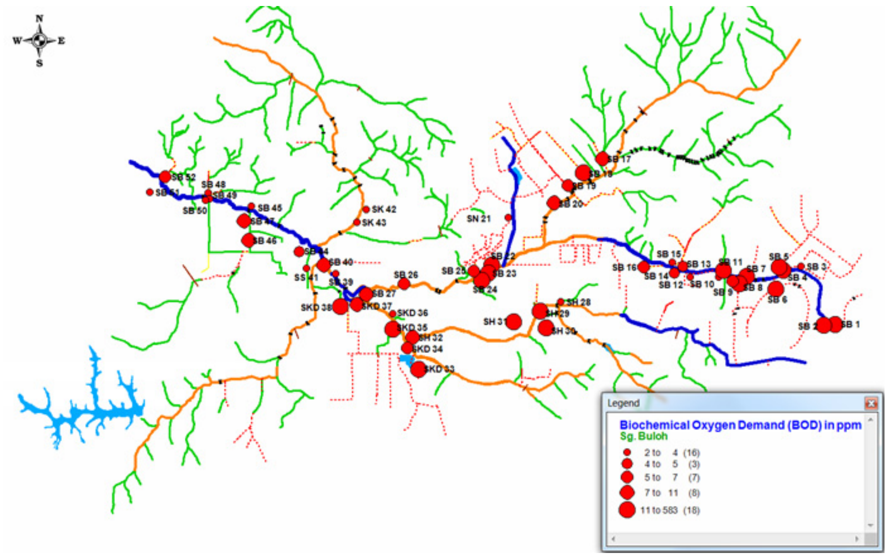


(b)

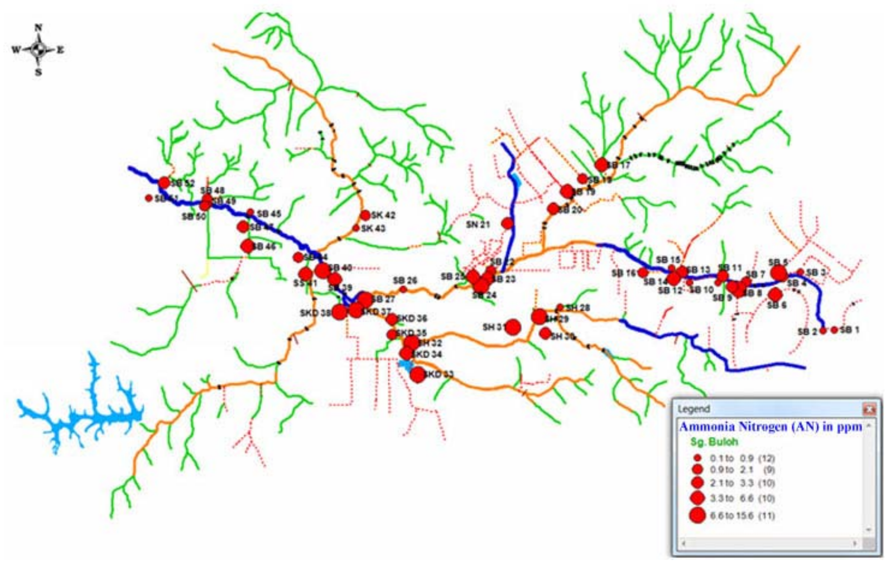


(c)

Figure 5 Extent of water pollution in the Sg. Buloh River basin (a) pH (b) DO (c) COD (d) BOD) (e) AN (f) TSS (continued) (see online version for colours)

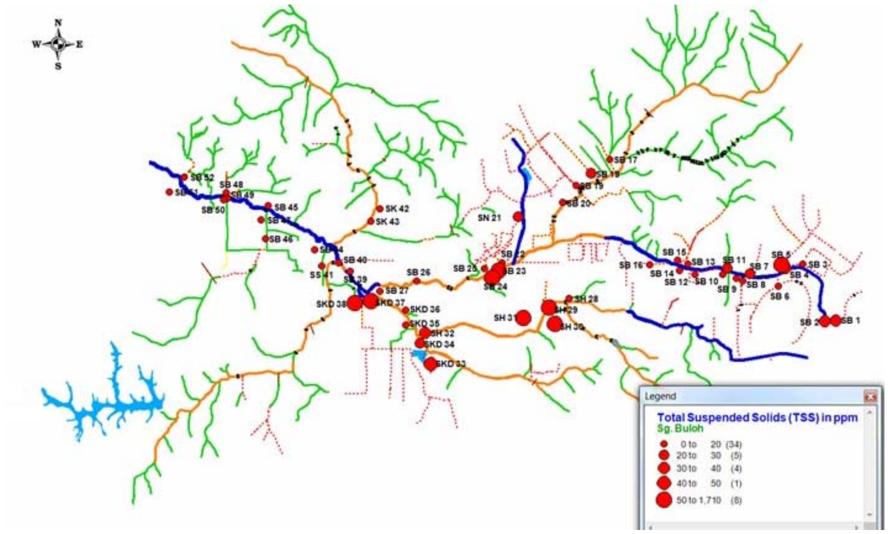


(d)



(e)

Figure 5 Extent of water pollution in the Sg. Buloh River basin (a) pH (b) DO (c) COD (d) BOD) (e) AN (f) TSS (continued) (see online version for colours)



(f)

The temperatures of the sampling points were approximately constant ranging from 25.5 to 30°C. The variation is mainly due to the time of sampling rather than any real difference between the sampling stations. The pH of all the sampling sites ranged from 5.05 to 7.63, with a mean of 6.69 and standard deviation of 0.43 as illustrated in Figure 5(a). This satisfies the requirement for Class II water quality. The range of pH values is suitable for aquatic life within the basin. Generally, toxic limits are pH values <4.8 and >9.2. Variability of pH from upstream to downstream is noticeable, and value of pH decreases along the main river from upstream to downstream. Higher pH values were obtained at tributaries as shown in Figure 5(a). This scenario indicates possible introduction of basic substances during the sampling time at these points. This is supported by the fact that the pH subsequently decreased from upstream to downstream. The pH affects the availability of certain chemicals or nutrients in water for uptake by plants. The pH of water directly affects fish and other aquatic life.

DO concentration represents the status of the water system at particular point and time of sampling. DO of all the sampling sites ranged from 1.0 to 7.32 mg/l, with a mean of 4.16 mg/l, and standard deviation of 1.37 mg/l as shown in Figure 5(b). The inverse relationship between temperature and DO is a natural process because warmer water becomes more easily saturated with oxygen and it can hold less DO. In this study, temporal data were not used in the assessment program. There are 10 sampling sites that satisfy DO criteria for Class I and Class II type water, and the remaining sampling stations were found to be either class III, Class IV or highly polluted water as shown in Figure 5(b). There are many industries which contribute to the increase in pollution load in the basin. Beside these, there are also a number of other small industries and several wet markets along the river. Industrial effluents are discharged into tributaries and/or drainage systems that might be the possible causes of low DO especially in the upstream areas of the basin. The water level in the river is mainly shallow and turbulent due to the steep slope, allowing ample aeration in some sampling sites. Under normal conditions, DO exists in very low concentrations. Natural levels of oxygen in aquatic systems are always somewhat depleted by normal levels of aerobic bacterial activity. In most cases, if the DO concentrations drop below 5 mg/l (ppm), fish will be unable to live for very long. All clean water species will die below this level and even low oxygen fish such as catfish and carp will be at risk below 5 ppm. The amount of DO often determines the number and types of organisms living in that body of water. This is the most common cause of fish kills, especially in summer months when warm water holds less oxygen. The quality of natural water as habitat for aquatic species is strongly related to the amount of oxygen available in water. This tool provides important information for aquatic organisms whether survive with lower oxygen concentration or higher concentration. Fish especially kills are the result of variation of DO concentration as some species require higher concentration.

COD of all the sampling sites ranged from 2.0 to 598 mg/l, with a mean of 70.36 mg/l, and standard deviation of 114.61 mg/l as shown in Figure 5(c). About 30 sampling sites satisfy COD criteria for Class I type water and the remaining sampling stations were either Class III, Class IV or highly polluted water as shown in Figure 5(c). Industrial effluents are likely to cause the higher COD throughout the basin. Bacteria and other organisms in water begin to break down effluents' organic materials to more stable chemical compounds.

BOD of all the sampling sites ranged from 2.0 to 583 mg/l, with a mean of 39.09 mg/l, and standard deviation of 113.42 mg/l as shown in Figure 5(d). About 20 sampling sites were found to have low BOD concentrations that satisfy the Class I type water criterion and 10 sampling sites satisfy Class II type water criterion. The remaining sampling stations in the basin showed higher concentration of BOD. BOD measures the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter. Natural sources of organic matter include plant decay and leaf fall. However, plant growth and decay may be unnaturally accelerated when nutrients and sunlight are overly abundant due to human influence. Urban runoff carries various wastes as points and non-point pollutants, which increase oxygen demand. Oxygen consumed in the decomposition process robs other aquatic organisms of the oxygen they need to live. Most of the bacteria in the water are aerobic. That means that they use oxygen to perform their metabolic activities of decomposition. The level of DO can drop dramatically when abnormally high levels of aerobic bacterial activity takes place due to increasing BOD.

AN of all the sampling sites ranged from 0.10 to 15.60 mg/l, with a mean of 3.89 mg/l, and standard deviation of 3.91 mg/l as shown in Figure 5(e). Ammonia may come from sewage and landfill leachate. It is very toxic to aquatic life. All of the stations were found to have AN more than the 0.10 mg/l limit for Class I.

TSS of all the sampling sites ranged from 2 to 1705 mg/l, with a mean of 56.2 mg/l, and standard deviation of 232.59 mg/l as shown in Figure 5(f). About 36 sampling sites satisfy TSS criteria for Class I type water and 5 sampling stations were identified as Type II water and the remaining sampling stations were either Class III, Class IV or highly polluted water as shown in Figure 5(f). Higher TSS was found at sampling stations nearest to the newly developed urban areas and construction sites.

3.2 WQI assessment

To visualise the water quality of the Sg. Buloh River basin a prototype water quality assessment system was developed which incorporates WQI model and GIS capability. This enables users to interact with water quality variables in order to investigate the spatial complexity in the basin. The user can instantly determine water quality for a particular sampling site as well as spatial variability within the basin. Thus water quality information can be known in the basin and possible remedial measures can be taken to control the pollution. At first, a particular sampling site for example, Station ID: SB 9 from ListBox 'select sampling station' is selected under the GroupBox of 'analysis of water quality index (WQI)' from Figure 4. All stations are listed in this dropdown ListBox. Then by simply clicking on the CheckBox 'calculate water quality index (WQI)', the output window of WQI for Station ID: SB 9 appears on the screen as shown in Figure 6. According to the DOE criteria and recommendations, Class III water was identified in this sampling, with a WQI value of 59.85. The user needs to follow the option for the particular information and analysis. By clicking on a CheckBox 'display line graph for water quality index (WQI) at all stations' will draw a graph for all stations instantly.

Figure 6 WQI for individual sampling site (see online version for colours)

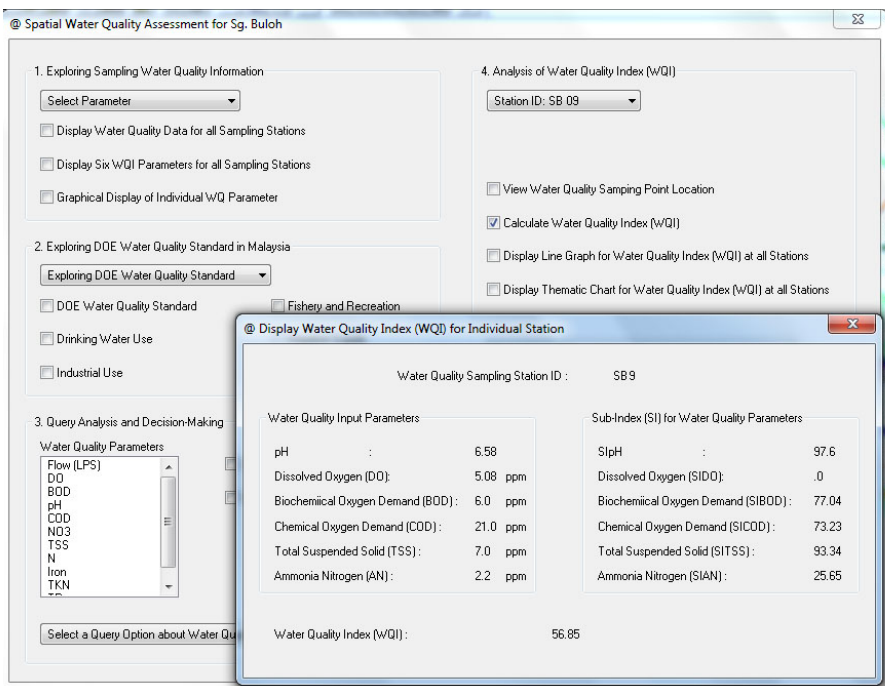


Figure 7 Spatial variation of WQI due to pollutants in the basin (see online version for colours)

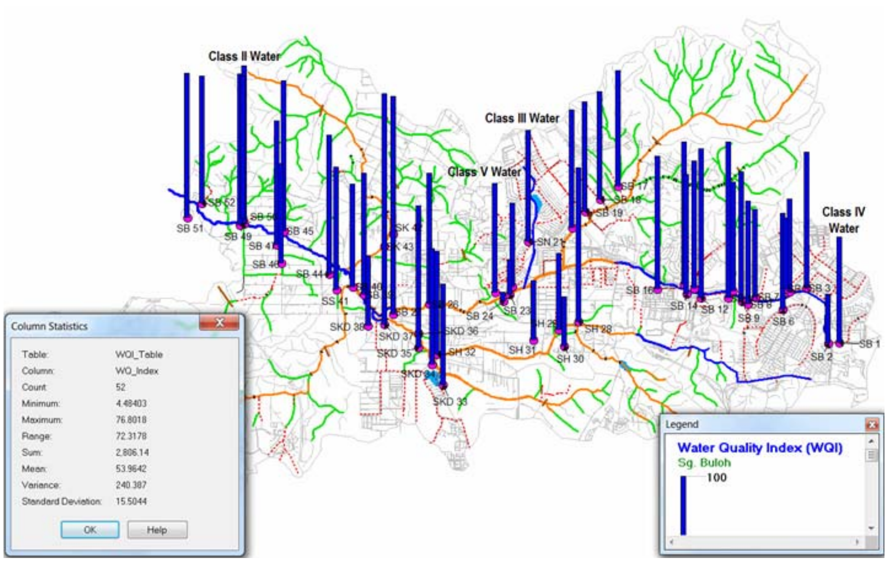
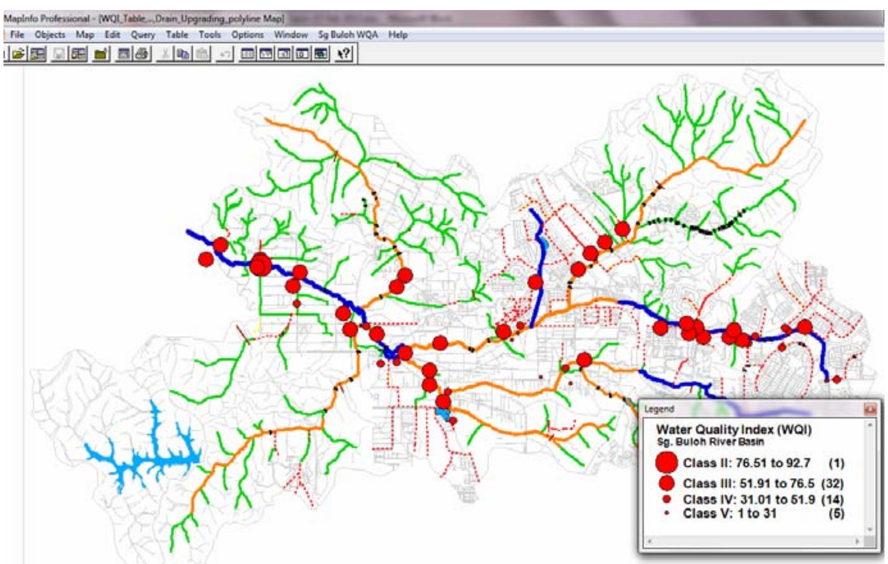


Figure 8 Investigation of WQI using spatial map (see online version for colours)



By clicking on the CheckBox 'display thematic chart for water quality index (WQI) at all stations', spatial variation map for WQI can be generated instantly as shown in Figure 7. WQI for all the sampling sites ranged from 4.48 to 76.80, with a mean of 53.96, and standard deviation of 15.50 as shown in Figure 7. Class I type water was not found anywhere in the basin. 32 sampling sites satisfy criteria for Class III type water, only one station was identified as Class II type water, 14 sampling stations were identified as Type IV water and the remaining 5 sampling stations were identified as having highly polluted water as shown in Figure 8. This tool can correctly and instantly assess the water quality situation, and help to diagnose the many environmental impacts due to water quality deterioration.

4 Conclusions

Spatial analysis of data at different scales plays a vital role of identifying the fundamental spatio-temporal distribution of water quality. In this study, a GIS-aided efficient and cost-effective interactive information system has been developed to identify the spatial variation of water pollution in a rapidly growing urban catchment. The system is very useful for planners and decision makers to identify anthropogenic and natural factors that affect spatial and temporal variations of water quality. The system is coupled with the analytical framework of WQI estimation, which provides meaningful information for water quality management and decision making. The system is employed

1 to estimate spatial variations of pH, DO, COD, BOD, TSS and AN in the basin
2 to provide guidance regarding water quality class in the basin
3 to visualise spatial results
4 to provide necessary scientific information for assessment of short-term and long-term environmental impacts.

The incorporation of spatial dimensions into water quality assessment enhances the understanding of spatial patterns of water quality. Spatial patterns of water quality trends for 52 sites in the Sg. Buloh river basin of Malaysia were investigated for six parameters: pH, DO, BOD, COD, TSS and AN. This study provides spatial variability patterns of in-stream water quality parameter for Sg. Buloh river basin. Overall concentrations of pH, DO, BOD, COD, TSS, and AN showed a wide range of variability within the basin. The results show contaminant levels in the water that are in agreement with observed values, both being below the DOE Class I (drinking) and Class II (industrial) water standard. Spatial variations in water quality may be associated with land development due to urbanisation, point-source pollution and natural factors. Urban land cover is positively associated with increases in water pollution and included as the most important explanatory variable for BOD and TSS. Topography and soil factors may be the major determinants of the spatial variations. The complex spatial patterns illustrate the important of point-source pollution control and other local water quality management practices. Incorporating spatial dimensions into water assessment enhances the understanding of patterns and processes in water quality. This interactive system can be extended and customised for better understanding of spatial water quality information in other areas. Detailed information of the raw water quality at strategic points in the basin enables the proper catchment management activities. The lack of sufficient water quality data in many places hinders the efforts of surface water quality modelling, and therefore affects the process of water quality management. Water quality modelling is, by nature, a problem with spatial aspects. GIS are often used to manage the spatially distributed inputs and to store, manipulate, and display the model outputs. We intend to develop a full-fledged stand-alone system integrated with multi-layered water quality database, development of temperature model, development of DO model, numerical models and GIS interface to compute the areas of pollution hazard and risk frequency within their catchment areas. This can enhance the capability of DOE for better water monitoring for all the river networks in Malaysia. Runoff from many new residential and commercial areas typically contains high amounts of nutrients from lawn fertilisers and animal wastes and other non-point-source pollution. This study suggests the integration of landscape analysis and spatial intensive monitoring to understand the complex dynamics of water quality. Understanding how landscape and natural factors constrain stream water quality at multiple scales and how the relationships change over time is crucial for the improvement of water quality management efforts.

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