Effect of Land Use Planning for Water Quality in Kelani River, Sri Lanka

Liyanage CHAMARA P[1], Bandara DUMINDA N[2] and Marasinghe ASHU[3]

[1]Doctoral Student,Dept. of Information and Management for System Engineering,Nagaoka University of Technology
(1603-1, Kamitomioka Nagaoka, Niigata 940-2188, Japan)
E-mail: s125080@stn.nagaokaut.ac.jp
[2] Master Student,Dept. of Information and Management for System Engineering,Nagaoka University of Technology
(1603-1, Kamitomioka Nagaoka, Niigata 940-2188, Japan)
E-mail: s155035@stn.nagaokaut.ac.jp
[3] Associate Professor Dept of Information and Management for System Engineering,
Nagaoka University of Technology
(1603-1, Kamitomioka Nagaoka, Niigata 940-2188, Japan)
E-mail: ashu@kjs.nagaokaut.ac.jp

Kelani River is one of the most important surface water source in Sri Lanka as it supplies potable water to the commercial capital Colombo and suburbs However, it is one of the severely polluted river in Sri Lanka due to anthropogenic activities during past few decades. The water quality of river basin is dependent on many factors but analyzing the environmental sensitivity index (ESI) in river basin is not enough to examine the all factors. Generally raw water samples are collected from 12 locations and tested for a range of physical, chemical and biological water quality parameters according to the Sri Lankan Standards (SLS) by the Central Environment Authority (CEA). Even though this existing monitoring system analyze the variation of those parameters, it is inadequate to recognize pollution pattern and identify the sources of contamination due to lack of data sources. This paper discusses the applicability of geospatial analysis to improve the efficiency of existing water quality monitoring system in Kelani River. According to existing data sources, in the lower region of the Kelani River is selected as the study and about 25 km along the from the river mouth to landward side aiming to evaluate the existing water quality variation of parameters. As result of preliminary investigation determined the significance of trends in fecal coliform concentration with population. When consider other parameters, there are no significant trends according to value of quantity but show increasing or decreasing trends with geospatial changes. Due to that in here discuss comprehensive assessment to identify the hydrologic effects of land use at watershed and regional scale. The geospatial information systems (GIS) is used for measure the land use changes rates between 8 years period. Statistical and spatial analyses are employed to examine the correlation of land use and the water quality in Kelani River.

Key Words : *correlation, water quality, land use,Kelani river*

1. INTRODUCTION

The providing safer water has begun to a major problem due to the current water quality issues happened in Sri Lanka. By using available resources a comprehensive ICT based water quality system is essential to address the present priorities as well as the future requirements. As an initial step the Kelani River was selected as the study site of this research. It is one of the most polluted river in Sri Lanka due to rapid growth of industries located in close vicinity of the river and passes through most populated cities in the country. Further considerable number of industries along with two major Export Promotional Zones are located in the lower region of the river bank affect considerably to this precious water body. Many extensive researches have been carried out for most of the locations in the Kelani River due to the rapid deterioration and degradation of water ecosystem in the river(1). The existing system is not sophisticated to address current requirement such as recognize pollution pattern and identify the sources of contamination. Furthermore monitor the non-point pollution sources are highly essential. As a solution for this issue, will be increased the number of monitoring points is quite reasonable but it's a costly procedure and when consider the resources available in CEA not supported to extend the numbers of monitoring sites(2). As a cost effective factor of this research is used currently existing geospatial data from CEA, survey department, and census and statistics department in Sri Lanka.

(1) Objective of the study

To improve the efficiency of existing water quality monitoring system in Kelani River, through the applying geospatial data to identify the variation of water quality. Due to that identification of the relationship between water quality and land use of the main target of this approach. As a benefit of this research, the cost effective pollution prevention methods will be found for the design proper land-use planning to protect water quality.

(2) Approach

According to paper review, there is a possibility of applying cost effective integrated geospatial analyzing and GIS for Kelani river in Sri Lanka. Remotely sensed data has been supplementary utilized to develop the spatial data (3). There have been various kind of application that tried to study the linkage between geospatial data and water management. Some of them are can be listed as follow. investigation of the morphological features of watersheds, the analysis of the watershed scale, identification of the effect on nonpoint source pollution, and land use can be simply defined as the spatial pattern of anthropogenic activates(4).

Other than that the spatial and temporal information sensed through satellite imagery related to water quality in the river could be identified and classified by categorizing mainly under two indices. These two can be listed as Development Pressure Index (DPI) and Environmental Sensitivity Index (ESI). According available data of Kelani River, land use data are used evaluate the DPI index against to ESI index.

2. STUDY AREA

Kelani River is used for hydropower production in Sri Lanka. It supplies approximately 80% of the water used in Colombo and it is an important source of drinking water for the Colombo District. There is a water supply intake point at Ambatale, 14 km from the river mouth.In addition, the river is used for transport, irrigation, fisheries, and sewage disposal, and sand is extracted from its bed. In these ways, many people depend on the river for their daily life.

Kelani River passes through the country through most cities. Most of them cities are located near to capital and administrative city of Sri Lanka. Other than that many industries were established in these areas. The development of the agricultural sector enhanced the application of agrochemicals and fertilizers and contributed largely to water pollution [Sri Lanka Water, State of the Environment Report, Regional Resource Centre for Asia and the Pacific, 2001]. The central region is used to farm the commercial crops like tea, coffee, cocoa and staple foods like potatoes and vegetables and these farms have led to large scale use of fertilizers and pesticides. As a result of that, toxic chemicals enter the country’s water system and spread delivered to other part of country because of the central region is the source of all major rivers. According to that the degradation of watershed resources began with the large-scale clearing of the central highlands for plantation crops in the latter part of the 1990 decade. Removal of forest cover and the associated soil erosion is also one of main problem for main water resources (5).

Industrial development also has led to pollution of aquatic water bodies due to lack of adequate infrastructure for wastewater disposal and disposal of solid wastes. According to disposal of solid wastes, untreated domestic wastewater and industrial wastewater are also cases for other inland fresh surface waters (6). Further more than 30 factories are identified by CEA which are used chemical and other material that are not good for disposal direct to environment. Manmade developments such as roads, highways, Building were formulated only considering economic factors. These approaches have now proven to be unsustainable even infrastructures requirements for industry development.

3. METHODOLOGY

The preliminary assessment is consist with two criterions.

(1) Comparison of urbanization factor over water quality parameters

This section analyzed the population in each water quality monitoring site to observe anthropogenic activities. The population within a 10 km radius of the monitoring sites were selected. The water quality monitoring sampling sites ate shown in Fig.1.

The buffer tool of QGIS application, Google Classical Map, Sri Lanka Political Map, and statistical data of population in 2010 in Sri Lanka are used for this process. The monitoring sites are named with a to l.

Fig 1Water quality monitoring sampling sites

The population is used for as an urbanization factor of this research and then compare with the value of fecal coliform concentration and other main components such as pH, and BOD in each site.

(2) Comparison of land use change over water quality parameters

Comparison of Land use change over water quality parameters is conducted under this step. In here we consider three main regions to evaluate land use change over water quality parameters in 2002 and 2010. Fig. 2 shows the land use distribution of each region. From left side to right side in the map region a, region B and region C are shown in correspondingly. Each region containes at least three monitoring sites.

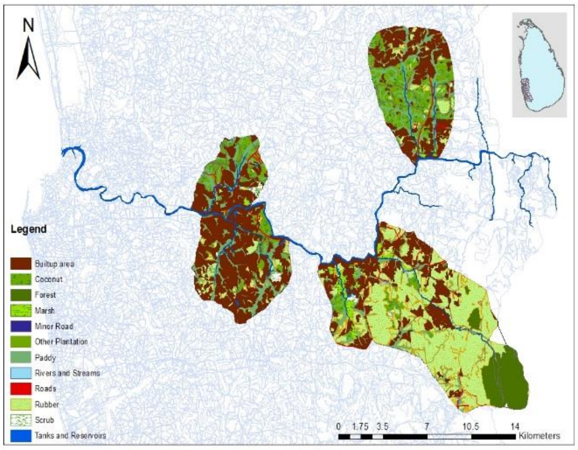

Fig 2a Land use in 2002

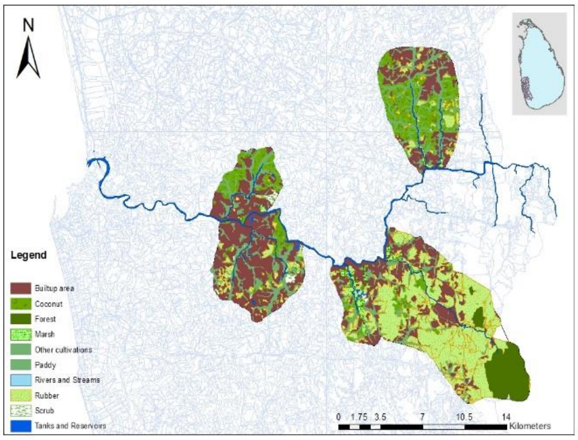

Fig 2b Land use in 2010

4. RESULT

According first criterion Table 1 and Fig 3 explained the result of fecal coliform concentration and population. Rather than the coliform concentration already evaluated for other components also.

Table 1Comparison of Fecal coliform concentration

Ranking No.	Fecal coliform	Population
1	b	b
2	a	a
3	c	c
4	e	f
5	h	e
6	i	h
7	d	k
8	j	i

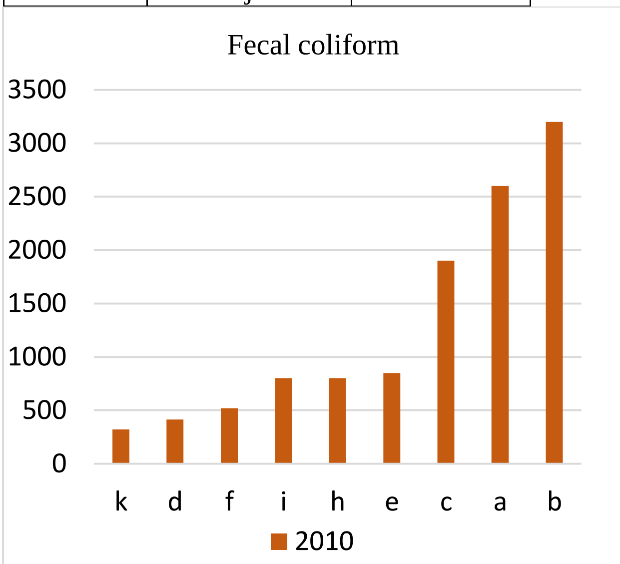

Fig 3: Comparison of Fecal coliform concentration

According to second citation, for each region comp ration was conducted for most essential water quality components such as pH, BOD, COD, NO_3^-.Table 2 explained the land use changers and Fig 4 described the variation of particular components in region A and b, d and e are the monitoring sites in region A.

Table 2 Land use change

Land use	Area (Ha) 2002	Area(Ha) 2010	%
Coconut	1143.6	1350.7	18.11
Built-up area	7010.4	8410.2	19.97

Marsh	30.2	32.1	06.04
Other Plantations	116.9	132.9	13.73
Paddy	1817.2	1837.7	01.12
Roads	3111.5	3111.5	0.0
Rubber	519.7	552.0	06.22
Scrub	142.4	149.1	04.72
Streams	352.4	246.3	-30.09
Tanks and Reservoirs	35.4	35.6	0.74

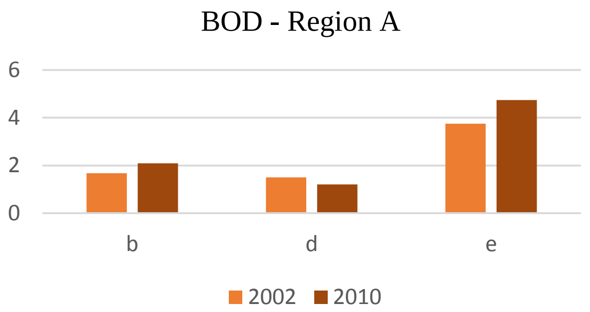

Figure 3a BOD variation in sites of region A.

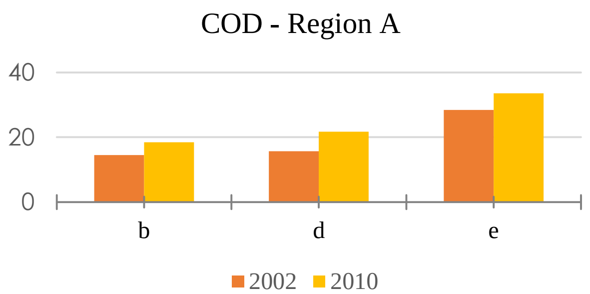

Fig 3b COD variation in sites of region A

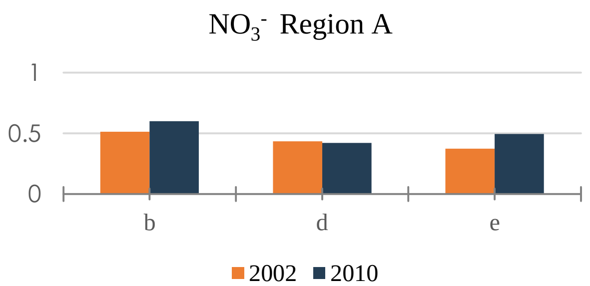

Fig 3c NO_3^- variation in sites of region A

5. CONCLUSION AND WAYFORWARD

Comparison of demographic data over water quality parameters indicated that there is a significant relationship between each other. However the comparison of land use change over water quality parameters was inconclusive, due to, inadequate data bases for both land use change and water quality. Further we couldn't evaluated the effect of industries that specially recognized by CEA. Other than that water quality parameters don't indicate a significant difference, because the volume and the flow rate of the of the river is huge.

Next stage of the research should be planned avoiding the above mentioned mishaps. Further get more accuracy land use data using GIS based spatial overlaying spatial buffer and digital elevation model drive from contour map of survey department in Sri Lanka.

REFERENCES

1) S.W. Athukorala, L.S. Weerasinghe, M. Jayasooria, D. Rajapakshe, L.Fernando, M. Raffeeze, N.P. Miguntanna.: "Ananlysis Of Water Quality Variation In Kelani River, Sri Lanka Using Principal Componet Analysis," SAITM Research Symposium on Engineering Advancements 2013
2) W. Dixon, G.K. Smith and B. Chiswell.: "Optimized Selection of River Smapling Sites," Elsevire, Kidlington,vol.33,pp. 971-978, 1999.
3) Zhi-Yong Y, S.Walcott, B.Kaplan,J Cao, W. Lin, M chen: An analysis of this relationship between spatial patterns of water quality and urban development in Shanghai, China, vol29,pp,197-221 Elservier 2005.
4) D. Chapman, Water Quality Assessments : A Guide to Use of Biota Sediments and Water in Environmental Monitoring, 2nd ed., E&FN Spon, an imprint of Chapman & Hall, UNESCO/WHO/UNEP 1996.
5) E. G. Ranawakage, "Evalution of watershed Management: The Sri Lanka experince," Proceeding of the Asian Regional Workshop on Watershed Management, 2002.
6) T. Wijesinghe, Central Environmental Authority, Sri Lanka, 2010s

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