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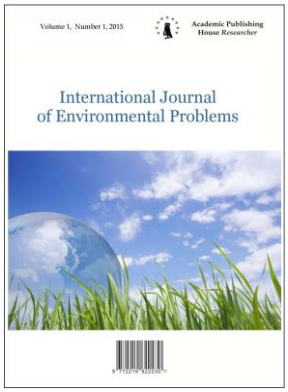

Application of GIS Technique for Mapping Suspended Sediment Concentration in Surface Water of the Day River, Northern Vietnam

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Abstract

Monitoring of suspended sediment is important to maintain water quality and geomorphologic balance. Traditional methods based on field surveys only solve the problem on a small scale. This article presents the results of mapping suspended sediment concentrations in surface water of the Day River, northern Vietnam using GIS technique. The inverse distance weighting (IDW) interpolation method was applied to map suspended sediment concentration using data obtained from 11 sampling stations. The results which are obtained in this study can be used to evaluate surface water quality.

Keywords: GIS, suspended sediment, interpolation, IDW, surface water, Vietnam.

1. Introduction

Suspended sediment has long been recognized as an important contaminant affecting surface water resources. Besides its direct role in determining water clarity, suspended sediment has the potential to transport chemical pollutants, including nutrients, trace metals and numerous pesticides into lotic systems. For the above reasons, monitoring suspended sediment in surface water is important. Traditional methods of data collection and analysis, including water sampling, filtering and measuring dry weight, are time consuming, labor intensive and provide only point data (Lodhi and Rundquist, 1998).

Geographical information system (GIS) is the most efficient tool for mapping the suspended particle concentrations and observing seasonal movements of turbidity in surface water. Spatial interpolation methods are frequently used to estimate values of physical or chemical constituents in locations where they are not measured. To monitor and map suspended sediment distribution, many researchers have determined the suspended sediment concentration and assessed water pollution by using spatial interpolation methods, such as Inverse distance weighted (IDW), Kriging, Spline, Trend, Natural Neighbor...methods (Meratnia et al, 2000; Bilhimer, 2012; Alaguraja et al, 2010; Narany et al, 2014; Nas, 2009; Tahoora Sheikhy Narany et al, 2014; Li et al, 2006).

This paper is focused on mapping suspended sediment distribution in surface water of the Day River, northern Vietnam using GIS technique based on IDW interpolation method and in situ data collected from five observations in March, May, July, September and November 2015.

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2. Materials and Method

2.1. Study area

The Day River is a large river and one of the five longest rivers in Northern Vietnam. The river is a distributary of the Red River, draining into the Gulf of Tonkin. The river has a length of 240 km and has a drainage basin of more than 7 500 km², flowing through 5 provinces (Figure 1). The study area was selected as the Day River through Ha Nam, Nam Dinh and Ninh Binh provinces.

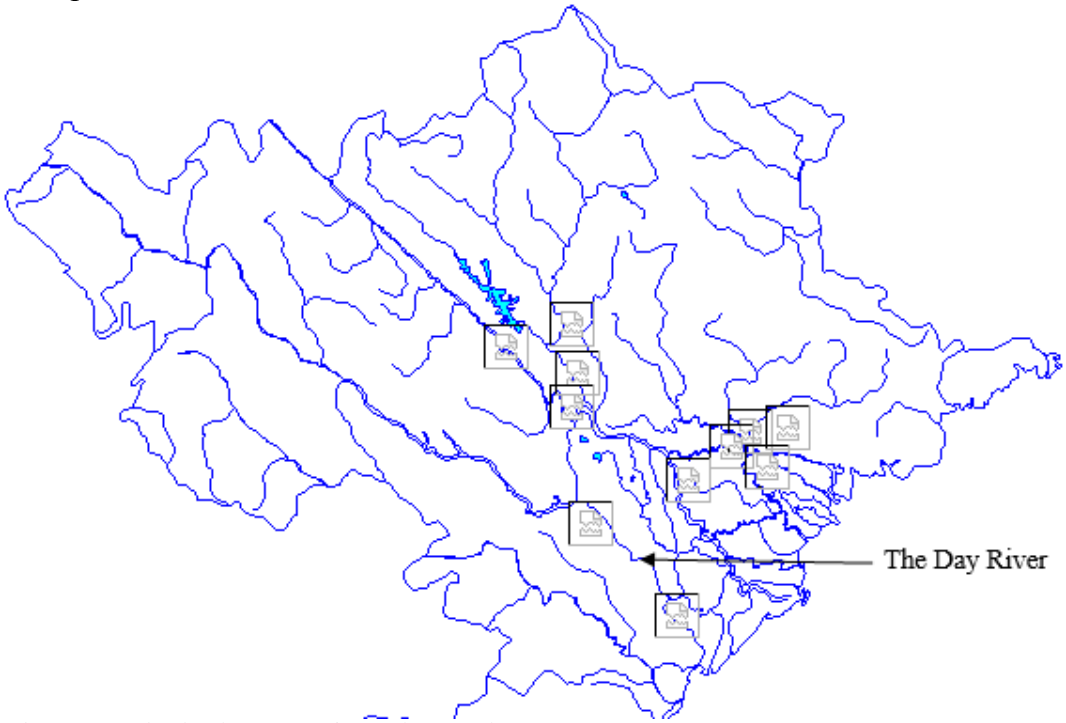


Fig. 1. Hydrologic map of northern Vietnam

2.2. Surface water sampling

A total of 11 field measurements of suspended sediment concentration were carried out in the Day River. All in situ data were collected during research cruises in March, May, July, September and November 2015 in a set of stations distributed along the Day River (Figure 1). In table 1, it can be seen that the highest concentrations of suspended sediment were found at the sampling stations No. 6, 7, 8, 9, 10 and 11 in March 2015, and at sampling stations No. 1, 2, 3, 4, and 5 in May 2015.

Table 1. In situ measurements of TSS in 2015

No.	Coordinates		TSS (mg/l)				
	Latitude	Longitude	March 2015	May 2015	July 2015	September 2015	November 2015
1	105°48.27'	20°36.47'	23	59.4	31	18	20
2	105°52.4'	20°34.2'	20	48.3	15	22	16
3	105°53.6'	20°34.1'	15	54.6	15	22	24
4	105°55.5'	20°31.4'	27	62.2	15	22	32
5	105°54.6'	20°30.5'	33	41.2	35	24	15
6	105°54.2'	20°26.4'	148	61.2	26	26	15
7	105°55.4'	20°22.4'	203	39.9	15	15	19
8	105°55.5'	20°22.8'	69	39.3	27	21	55
9	105°56.3'	20°19.5'	70	30	15	43	21
10	106°01.8'	20°14.8'	74	48.2	15	32	38
11	106°03.1'	20°15.1'	102	55	21	16	39

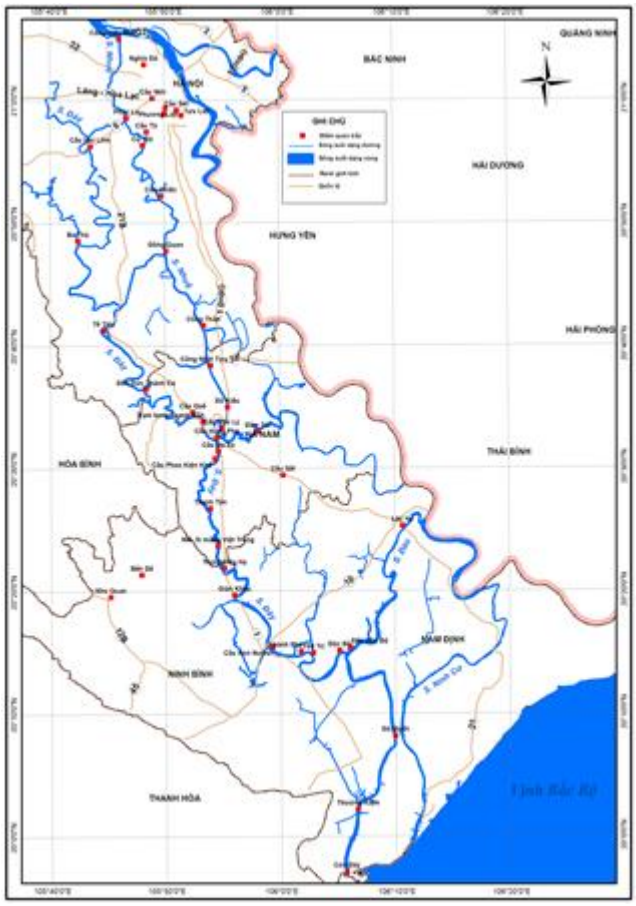


Fig. 2. Suspended sediment sampling locations in the Day River

2.3. Methodology

Four interpolation methods were evaluated, including Inverse Distance Weighting (IDW), Spline, Ordinary Kriging (OK) and Indicator Kriging (IK) for selecting the most efficient and accurate interpolation method for mapping of suspended sediment in surface water of the Day River. The interpolation method accuracy was evaluated on the basis of the root mean square error (RMSE) for cross-validation. In this study, the IDW interpolation method was selected due to the smallest root mean square error (RMSE).

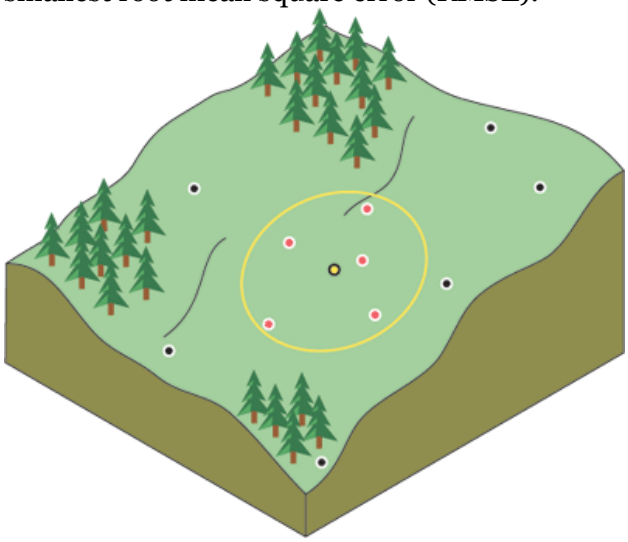


Fig. 3. IDW interpolation method (http://esri.com)

Inverse Distance Weighted (IDW) is a method of interpolation that estimates cell values by averaging the values of sample data points in the neighborhood of each processing cell. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process (http://esri.com).

3. Results and Discussion

In this study, the suspended sediment distribution map is prepared by employing an Inverse Distance Weightage *(*IDW) interpolation method in ArcGIS. The suspended sediment distribution maps area displays the different zone of suspended sediment concentration. The density sliced image shows five suspended sediment concentration zones that represents greater than 100, 50 – 100, 30 – 50, 20 – 30 and less than 20 mg/l respectively, in which areas of highest suspended sediment concentration colored in black. These maps were created using Vietnam National Technical Regulation on Surface Water Quality (QCVN 08-MT: 2015/BTNMT).

Table 2. National technical regulation on surface water quality (QCVN 08-MT: 2015/BTNMT)

No.	Parameter	Units	Limiting value of TSS			
			A		B	
			A1	A2	B1	B2
1	Total suspended sediment	mg/l	20	30	50	100

The classification of A1, A2, B1, B2 for surface water sources to assess and control water quality the various purposes of water use, sorted by descending quality level (National technical regulation on surface water quality (QCVN 08-MT: 2015/BTNMT)).

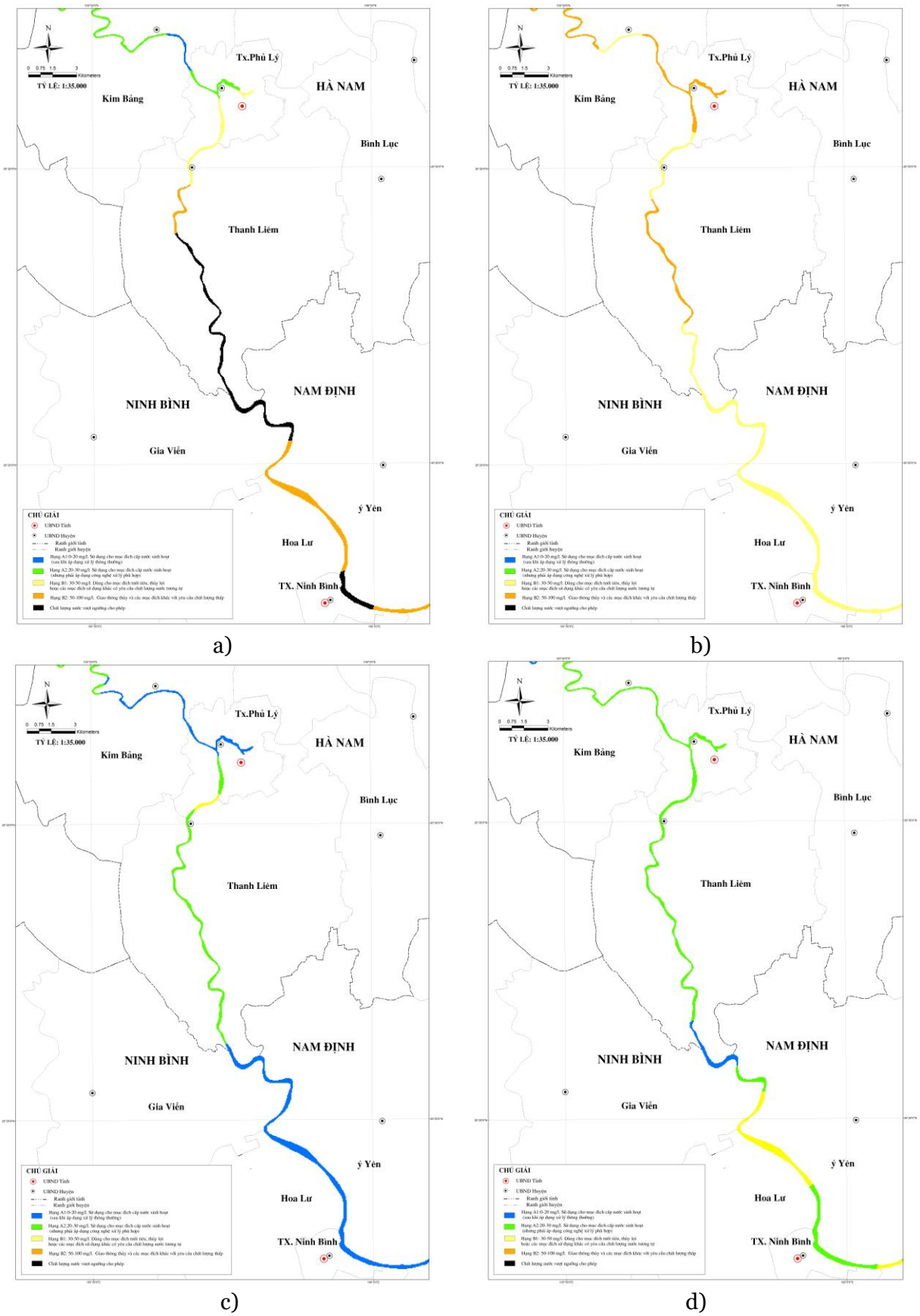
A1 – Use for domestic water supply purposes (after applying conventional treatment), conservation of aquatic plants and for other purposes such as type A2, B1 and B2.

A2 – For the purpose of domestic water supply, but must apply appropriate processing technology or the purpose of use as type B1 and B2.

B1 – For irrigated agriculture, irrigation purposes or other purposes which require the same water quality or purposes as type B2.

B2 – Waterway transport and other purposes with low quality water requirements.

Suspended sediment concentration maps in surface water of the Day River, northern Vietnam in March, May, July, September and November 2015 are shown in Figure 4 (a-e). The obtained results showed that surface water of the Day River has high concentration of suspended sediment at most of the sampling stations in first observation (March 2015), with concentration ranging from 15 to 203 mg/l, in which concentrations was higher 100 mg/l in many areas. The mean concentration of suspended sediment is 71.2 mg/l, 49.0 mg/l, 20.9 mg/l, 23.7 mg/l and 26.7 mg/l in observation in March, May, July, September and November 2015 respectively. This can be explained by surface water environment of the Day River basin are subjected to wastewater discharges from municipal, industrial and agricultural sources. The water quality of many segments of the Day River is heavily polluted, especially in the dry season. The concentration of suspended sediment at the measurement stations exceed Vietnam National Technical Regulation on Surface Water Quality (QCVN 08-MT: 2015/BTNMT) type A1 several times.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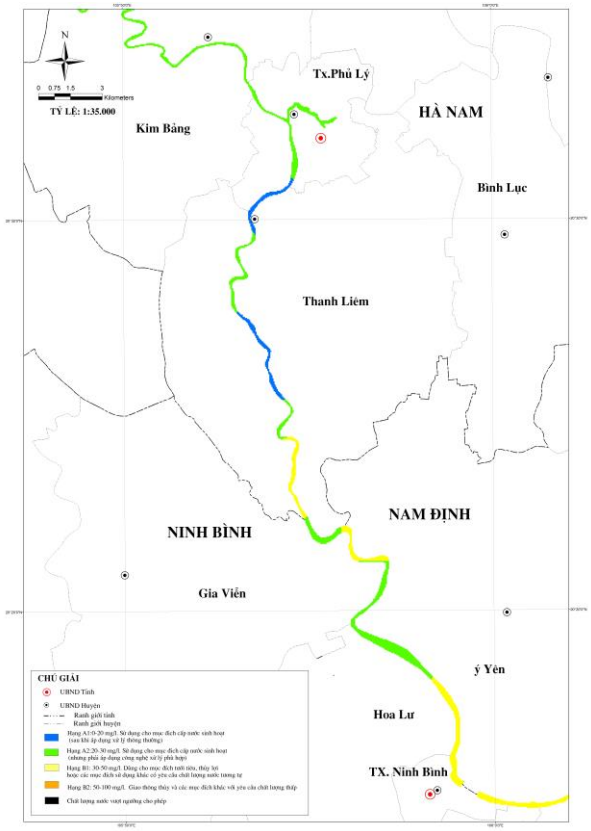
a) b)

c) d)



e)

Fig. 4. Spatial distribution of suspended sediment for the Day River in March (a), May (b), July (c), September (d) and November (e) 2015

4. Conclusion

Nowadays, surface water pollution has become a global issue, directly caused by human populations grow, industrial and agricultural activities and climate change. A simple and operational method is presented to map the suspended sediment concentration in surface water of river using GIS technique based on spatial interpolation method.

The obtained results show that, suspended sediment concentration in first and second observations (March and May 2015) in surface water of the Day River is much higher than Vietnam National Technical Regulation on Surface Water Quality (QCVN 08-MT: 2015/BTNMT). While, suspended sediment concentration decreased in other observation in July, September and November 2015. In these observations, surface water of the Day River can be used for domestic water supply purposes (after applying conventional treatment or appropriate processing technology).

The obtained results in this paper can be used for mapping suspended sediment concentration distribution, in particular and to serve surface water quality, in general.

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