Journal of **Kim Il Sung** University Vol. 4 No. 1
(Natural Science) Juche104(2015)

The Method of Eutrophic Assessment for the River Area by Remote Sensing

O Nam Chol

Abstract We performed the eutrophic assessment using remote sensing which is one of the essential problems in the water environmental management of water area and made a base that can process scientifically the environmental management. As the result of the study, we assessed trophic state of study area using trophic state index as high accuracy and made a picture of distribution field.
Key words remote sensing, eutrophication

Introduction

The great leader Comrade **Kim Il Sung** said.

"**The most important aspect of environmental protection is to completely prevent environmental pollution**"("**KIM IL SUNG** WORKS" Vol. 39 P. 349)

There is an urgent need to assess eutrophic phenomenon in solving a number of important environmental problems.

This paper deals with the process, how to determine eutrophic phenomenon level using remote sensing.

Eutrophic assessment by trophic state index (TSI) is easy to control and it has a relative high accuracy. It can rapidly process eutrophic assessment of wide water area with a visual education and can apply to other rivers.

1. Theoretical Basis for Eutrophic Assessment

In terms of water environmental assessment and conservation, the eutrophic problem is very important.

If it becomes eutrophicaton some water area because of any reason, this one gets rapidly several algae involving green algae and indigo algae, and so it is occurred lack phenomena of DO, finally water quality becomes bad.

The cause of eutrophic phenomena for water area can explain with several methods, but main factor is contributed to chlorophyll, nitrogen, phosphorus [1－9].

Nitrogen, phosphorus which cause eutrophication is generated by a decomposition process of organic and inorganic compound in many cases.

However, eutrophication phenomenon, mostly in two ways, that is caused by natural action and artificial action by economic action of human.

Because sewage and wastewater include a large mount of N and P etc.

According to data, generally 90～95% of total nitrogen involving in waste water is ammoniac nitrogen.

2. The Method of Eutrophic Assessment by Trophic State Index (TIS)

We assessed the eutrophic state of study area using TSI.

The TIS method is one, which selects a few main water quality index and converts its concentration to TIS, and assesses by dividing trophic status (oligo to eutropic) into continuous value within 0 to 100. As the water quality index used in eutrophic assessment, we selected $\mathrm{Chl-a}$, $\mathrm{NH_3-N}$, organ phosphorus (OP) and its relative importance is $\mathrm{Chl-a} > \mathrm{NH_3-N}$ >OP.

Chlorophyll is comparatively stable a range of it in algae. chlorophyll concentration in water is a main index of algae distribution and plays very important role in assessing aquatic plants and eutrophication.

Generally, remote sensing of chlorophyll is contributed to two ways.

First, it is to decide chlorophyll concentration in accordance with a reflex peak's position around 700nm of chlorophyll.

Second, it is to establish the method of chlorophyll concentration calculation using a reflex peak's position around 700nm of chlorophyll and reflex ratio of 675nm (or 560nm) ravine.

A researcher suggested the following models by analyzing relations between $\mathrm{Chl-a}$ and TM bands [4].

$$\left.\begin{aligned}
\mathrm{Chl-a_1} &= 0.035\ 013(TM3\times TM4) - 0.366\ 984 \\
\mathrm{Chl-a_2} &= 0.130\ 428\left[\frac{TM3\times TM4}{\ln(TM1+TM2)}\right] - 0.382\ 138 \\
\mathrm{Chl-a_3} &= 0.213\ 500\left[\frac{TM3\times TM4}{\ln(TM1+TM2)}\right] - 0.405\ 492 \\
\mathrm{Chl-a_4} &= 0.114\ 975\left[\frac{TM3\times TM4}{\ln(TM1)}\right] - 0.387\ 292 \\
\mathrm{Chl-a_5} &= 0.099\ 423\left[\frac{TM3\times TM4}{\ln(TM2)}\right] - 0.437\ 805
\end{aligned}\right\} \qquad (1)$$

The average relative error of the model of equation (1) is 9.8～11.2% and criterion deflection is 6.7%, so it has comparatively high accuracy.

In the paper, I got concentration of $\mathrm{Chl-a}$ from the amount of plankton using $p = 0.052\ 1 + 0.378\ 3\cdot \mathrm{Chl-a}$ and selected a fitting model by comparison with $\mathrm{Chl-a}$ concentration obtained by equation (1) [2, 4].

The result of model selection is same as table 1.

Table 1. Comparison analysis result(μg/L)

No.	Observation value	Calculation value				
	$\mathrm{Chl-a}$	$\mathrm{Chl-a_1}$	$\mathrm{Chl-a_2}$	$\mathrm{Chl-a_3}$	$\mathrm{Chl-a_4}$	$\mathrm{Chl-a_5}$
1	23.11	27.01	11.81	19.55	20.07	19.14
2	23.21	27.35	11.92	19.73	20.28	19.31
3	27.52	32.88	14.16	23.42	24.13	22.82
4	25.31	30.51	12.94	21.41	22.21	21.16
5	21.76	34.64	14.85	24.53	25.36	23.84

As seen in table 1, $\mathrm{Chl-a_4}$ is the best suitable as 13.37% of average relative error.

$\mathrm{NH_3-N}$ and OP models operated between TM bands and analyzed the observation data and relative relations to obtain a statistical model with the method of least squares [3].

$\mathrm{Chl-a}$, $\mathrm{NH_3-N}$, OP models used in eutrophic assessment are as follows.

$$\left.\begin{aligned} &\mathrm{Chl-a} = 0.114\ 975 \cdot \left[\frac{TM3 \times TM4}{\ln(TM1)}\right] - 0.387\ 292 \\ &\mathrm{NH_3-N} = \exp[2.296 - 2.13 \cdot \ln(TM1 + TM2)] \\ &\mathrm{OP} = \exp\left[-0.44 - 12.53 \cdot \ln\left(\frac{TM2}{TM1}\right)\right] \end{aligned}\right\} \tag{2}$$

The relation between trophic degree and its standard value of each index is same as table 2.

Table 2. Eutrophic assessment indices and its standard value

Trophic degree/%	Index		
	$\mathrm{Chl-a}/(\mu g\cdot L^{-1})$	$\mathrm{OP}/(\mu g\cdot L^{-1})$	$\mathrm{NH_3-N}/(mg\cdot L^{-1})$
0	0.1	0.4	0.010
10	0.2	0.9	0.020
20	0.7	2.0	0.040
30	1.6	4.6	0.079
40	4.1	10.0	0.160
50	10.0	23.0	0.310
60	26.0	50.0	0.650
70	64.0	110.0	1.200
80	160.0	250.0	2.300
90	400.0	555.0	4.600
100	1 000.0	1 230.0	91.000

Eutrophic class of $\mathrm{Chl-a}$, OP is same as table 3.

Table 3. Eutrophic degree of $\mathrm{Chl-a}$, OP ($\mu g/L$)

Index	Very good	Good	Safe	bad	Very bad
$\mathrm{Chl-a}$	<4	<10	<20	20～50	>50
OP	<4	<10	10～35	35～100	>100

According to table 3, the standard value of $\mathrm{Chl-a}$ and OP was settled as follows in order to satisfy the degree of eutrophication “Good”.

$$C_{\mathrm{Chl-a}} = 10\mu g/L,\ C_{\mathrm{OP}} = 10\mu g/L$$

Also, in case of third degree water area, national environment standard value of $\mathrm{NH_3-N}$ is 0.3mg/L.

We estimated a relative expression (TSI) between trophic degree and its standard value of each index based on table 2.

$$TSI = 59.566 + 12.25 \ln p \tag{3}$$

where, $p = \frac{1}{n}\sum_{i=1}^{n} W_i I_i$, $I_i = C_i / C_{i0}$, $p-$pollution index, C_{i0} $-$national environment standard value for $i-$pollutant.

According to relative importance degree, I settled important coefficients of each index as follows.

$$W_{\text{chl-a}} = 0.5,\ W_{\text{NH}_3\text{-N}} = 0.3,\ W_{\text{OP}} = 0.2.$$

We estimated the eutrophication of study water area using expression (3) and Landsat TM/ETM+ image data of June 3rd, 2007.

The assessment result is same as follows (table 4).

Table 4. Eutrophic assessment of study water area

Position	1	2	3	4	5	6
Pixel No.	164, 1543	297, 1285	392, 1282	438, 1005	392, 1282	130, 1384
Trophic degree/%	43	38	42	50	70	54

As seen in table 4, there are some places in eutrophic state. The reason is connected to increase of some kinds of algae in June.

Conclusion

Eutrophic assessment by trophic state index (TSI) is simple to control and it has a high comparability.

It can rapidly process eutrophic assessment of wide water area with a visual education.

References

[1] 조성일; 물환경보호, **김일성**종합대학출판사, 67～70, 주체94(2005).
[2] 김철국; 기상과 수문, 6, 20, 주체92(2003).
[3] 오남철; 국토관리, 2, 28, 주체98(2009).
[4] H. J. Hoogenboom et al.; Remote Sensing of Environment, 65, 333, 1998.
[5] P. Harma; The Science of the Total Environment, 268, 107, 2001.
[6] 陈楚; 环境遥感, 11, 3, 168, 1996.
[7] 余丰宁; 湖泊科学, 8, 3, 201, 1996.
[8] 雷坤; 环境科学学报, 24, 3, 376, 2004.
[9] 尹球 等; 红外与毫米波学报, 24, 3, 198, 2005.