Pollution Load Estimation Based on Characteristic Section Load Method

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Abstract. Weihe River Watershed above Linjiacun Section is taken as the research objective in this paper and COD is chosen as the water quality parameter. According to the discharge characteristics of point source pollutions and non-point source pollutions, a new method to estimate pollution loads-Characteristic Section Load Method(CSLM) is proposed and point source pollution and non-point source pollution loads of Weihe River Watershed above Linjiacun Section are calculated in the rainy, normal and dry season in the year 2007. The results show that the monthly point source pollution loads of Weihe River Watershed above Linjiacun Section are discharged stably, the monthly non-point source pollution loads of Weihe River Watershed above Linjiacun Section change greatly, the non-point source pollution load proportions of total pollution load of COD are gradually decreased in the rainy, normal and wet periods.

1. Introduction
With the point source pollution gradually brought under control, non-point source pollution problem of river basin is increasingly prominent. The occurrences and sources of non-point source pollution are random, and pollution load vary widely in time and space, those bring much difficulty to the calculation of non-point source pollution load. Although there are many relatively comprehensive, advanced methods can be used to estimate non-point source pollution load, such as Runoff segmentation method(Cai Ming 2004), the output coefficient method(Johns P J et al. 1996), water quality & quantity method(Hong Xiaokang et al. 2000), Rainfall deduction method(Cai Ming et al. 2005), Mean concentration method(Li Huaien et al. 2000), etc. But these parameters are numerous and some parameters measurement and obtain is difficulty. In this paper, According to the characteristics of point source pollution and non-point source pollution, a new method- Characteristic Section Load Method is proposed. A simple and practical method to estimate COD of non-point source pollution load(Zhu Lei et al. 2013,2015). Taking Weihe River Watershed above Linjiacun Section as research object, the point source and non-point source pollution loads in the year 2007 are calculated. Linjiacun Section is the first hydrological and water quality monitoring section of Weihe River, the quantitative count of pollutant loads is the basis of research on environmental problems such as corresponding relationship water quality and water quantity, improving water quality and so on.

2. Research Area
Weihe River originates in Weiyuan County, Gansu Province Bird Mouse Mountain, from DONGGOU
Gap enter Shaanxi, to Tongguan into the Yellow River. The total length is 818 km (316 km in Gansu, 502 km in Shaanxi). Weihe River upstream through Gansu Weiyuan County, Longxi County, Wushan County, Gangu County, and Tianshui, then the river flows from west to east through Xianyang, Xi’an, Weinan, Hua County. The point source pollution, in Weihe River Watershed above Linjiacun Section, mainly includes the fixed discharge of city life sewage and industrial wastewater pollution. The non-point source pollution is the pollution that without a reasonable disposal, comes mainly from agricultural production and residents produced during daily life in rural area beside the basin, which in returns to pollute water, soil, air and products. Water quality is good in Gansu. Six monitoring sections such as North bridge, Cattle of Tianshui and so on, achieved matching its functional area, in 5 consecutive years (2006 - 2010). Shaanxi Section of weihe is the core economic development zone, and it is also a water shortage area of the northern China. Water resources of per capita is 357.5 m$^3$/a in this area, 25.5% of it in Shanxi. The amount of water shortage even reach to 1.43 x 10$^9$ m$^3$, shortage rate is 21% in the year 2000. With groundwater exploitation expanding, the cumulative amount of over-exploitation reaches 6.96 x 10$^9$ m$^3$ from 1986 to 2000, resulting in environmental problems, such as subsidence and ground fissure. Eco-environmental water guarantee rate is extremely low. For the development of production, the local municipalities seize the ecological environment water, which aggravates the water resources pollution levels. With the further increase of regional socio-economic development and urban population, even if under the condition of strengthening water saving, if no increase in water supply amount, the contradiction between supply and demand will be further intensified. Since such contradiction and the unreasonable way to exploit and develop water resources, the problems that ecological environment degradation and destruction gradually exposed, water pollution and deterioration has become a bottleneck restricting the society sustainable development.

3. Research Method

Since monitoring non-point source pollution is difficult and high cost, there is almost no continuous monitoring data in our country. Therefore, how to estimate the amount of non-point source pollution load based on limited information, has become an important basis for the prediction of water quality and water quality planning. Characteristic Section Load Method proposed in this paper is a new method to estimate annual pollutant emissions, which based on the characteristics of the point source pollution and non-point source pollution. Non-point source pollutants enter the earth's surface and groundwater in a form of wide-area dispersion and trace. such pollution load is very huge, with a great randomness, uncertainty and complexity, and influenced by the external climate to a large extent, hydrological conditions in a large extent. Point source pollution is the pollution that mainly includes the fixed outfall discharge of city life sewage and industrial wastewater. In a particular year, under the premise of no significant changes in the urban population, and the monthly emissions of pollutants in urban living is relatively stable, while industrial waste water amount changes a little during the year, the point source pollutant discharge is relatively stable. Since the non-point source pollution load vary large in a year, and calculate the total pollution load is relatively easy and simple, so the non-point source pollution load estimation can be obtained indirectly in the way that the total pollution load minus the watershed point source pollution load. Due to rainfall runoff is the main reason for the watershed non-point source pollution, when in dry season, the basin is little rain, so the pollutants load is mainly point source pollution load. So above the river characteristic sections, the basin point pollution monthly load $L_{ppm}$ can be determined by the minimum value of the average concentration $C_i$ multiplied the average flow $W_i$ in dry season.

$$L_{ppm} = \min(C_iW_i) \quad (1)$$

The monthly river basin pollution total load $L_{tm}$ is determined by the water quality concentration $C_i$ multiplied the average flow $W_i$ in the characteristic section.

$$L_{tm} = C_iW_i \quad (2)$$

The monthly river basin non-point source pollution load $L_{ppm}$ equals the monthly total watershed
pollution load $L_{tm}$ minus the basin point source pollution load $L_{ppm}$

$$L_{ppm} = L_{tm} - L_{ppm}$$  \hspace{1cm} (3)

The basin yearly point source load $L_{ppy}$ can be counted by

$$L_{ppy} = 12 \times \text{Min}(C_i \times W_i)$$  \hspace{1cm} (4)

The basin yearly point source total load $L_{ty}$ can be computed by

$$L_{ty} = \sum_{i=1}^{12} C_i \times W_i$$  \hspace{1cm} (5)

The basin yearly non-point source load $L_{nppy}$ can be calculated by

$$L_{nppy} = L_{ty} - L_{ppy}$$  \hspace{1cm} (6)

The above all kinds, $i=1,2,...12$. refers to month.

Characteristic Section Load Method is applied to estimate the pollution load of Weihe River Basin above Linjiacun Section. COD is the water quality parameter. 2007 is selected as the current year. The water phase is divided as follows: 7, 8, 9, 10 month is wet period, 4, 5, 6, 11 month is flat water period, 1, 2, 3, 12 month is dry season.

The river flow changes of Linjiacun Section in 2007 are shown in figure 1.

![Flow changes of Linjiacun Section in 2007](image)

**Figure 1.** Flow changes of Linjiacun Section in 2007

As can be seen from Figure 1, the flow of Linjiacun Section begins to increase from January, keeps increasing still to August, after a slight decline in September, the flow reaches to maximum in October, and then gradually reduce. January's average flow is 15.9 m³/s, 55.84 m³/s in August, 107.4 m³/s in October, and 24.66 m³/s in December.
The COD concentration changes of Weihe River Watershed above Linjiacun Section in 2007 are shown in figure 2. As can be seen from Figure 2, the COD concentration is relatively small in January and February and the minimum is 10 mg/L. The maximum concentration is 17 mg/L and the annual average concentration is about 13.2 mg/L.

4. Results

Characteristic Section Load Method’s equations (1) to (6) are used to calculate the COD point source and non-point source pollution load. The results are shown in Figure 3 and Figure 4.
As can be seen from Figure 3 and Figure 4, the total annual COD discharge is 14969.95 t. Among them, the point source emissions is 4824.84 t accounting for 32.23% of the total annual emissions, the non-point source is 10145.11 t accounting for 67.77%. Above Linjiacun section of Weihe River basin, the COD point source pollution load stabilize emission in each month and the monthly average load is 402.07 t. Non-point source pollution load emission changes largely in each month, the monthly average pollution load is 845.43 t. The COD non-point source pollution load is larger in the wet period, the total emissions is 7147.82 t accounting for 70.5% of the annual total emissions. Followed is the normal period, total emissions is 2254.53 t accounting for 22.2% of the total annual emissions. Minimum is in dry season, the total emissions is 742.76 t accounting for 7.3% of the total annual emissions. The COD non-point source pollution average monthly load is 1786.96 t in the wet period, 563.63 t and 185.69 t in normal and dry season. Because rainfall is low in the dry season, resulting in a corresponding reduction of surface runoff and non-point source pollution load. In the wet season, the rain increased and the pollutions via surface runoff, irrigation and drainage, underground seepage and other ways into the Weihe River. At the same time, the dry and wet atmosphere depositions are also the pollution sources.

5. Conclusions

This paper established a new method-Characteristic Section Load Method (CSLM) to estimate non-point source pollution loads. The COD pollution load above Linjiacun Section of Weihe River Basin is estimated in 2007. The conclusions are following:

1) The point source pollution load stabilize emissions each month throughout the year above Linjiacun Section of Weihe River Basin. COD monthly average load is 8.95 t, and its annual average load is 4824.84 t.

2) The non-point source pollution emissions vary widely each month throughout the year above Linjiacun Section of Weihe River Watershed. The average monthly non-point source pollution load of COD is 845.43 t and its annual load is 10145.11 t.

3) In rainy, flat and dry season, non-point source pollution load of COD proportion accounted for the total pollution load is 70.5%, 22.2% and 7.3%.

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