Research on variation of non-point source pollutant of field in Qingtongxia Irrigation District

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Abstract: An experiment was conducted to research the non-point source pollutant of field in qingtongxia irrigation area, and its variation features was also analyzed. The results showed that the rate of pollutants’ concentration in water of the paddy field during the crop growing season was in the order of $TP > NO_3^- > N > NH_4^+ > TN > salinity$, in agricultural ditch of the paddy field which is in the order of $NH_4^+ > NO_3^- > N > TP > TN > salinity$, and in agricultural ditch of the dry field which is in the order of $NO_3^- > N > NH_4^+ > N > TP > salinity > TN$. The salinity concentration in field changes greatly. The content and loss quantity of $TP$ are rarely small. The nitrogen loss is mainly $NO_3^-$. The variation process of pollutants’ concentration in field was closely related to fertilization, irrigation process, the crop growing season and so on.

1. Introduction
The Qingtongxia Irrigation Area is located in Ningxia Hui Autonomous Region Yongning County, with an area of 45 hm², belonging to the typical continental climate. In this area the annual average precipitation is 200 mm, the annual average evaporation is 1225 mm, and the Annual average temperature is 8.5℃.

The paddy-upland crop rotation is mainly used in the irrigation area, of which the primary crops are rice, wheat and corn. Dry fields generally irrigate 6 times and paddy fields irrigate 22-25 times during the crop growing season, and farmland fertilization such as urea, carbon ammonia, ammonium phosphate are commonly used. In this article, based on variation process for monitoring pollutants from field ditch import through the field irrigation and leakage, then entering into the agricultural ditch and moving to the end of the ditch, variation of non-point source pollutant of field in the Qingtongxia Irrigation District was researched.

1.1 Materials and methods
In the experiment, the test period was from May to September 2016, and open drainage was selected, besides, stripe field was equal interval parallel arranged with a length of 600 m. On the one hand, there were four lines in the field ditch of paddy field, and two lines in dry field, on the other hand, agricultural ditch set six lines where average control area was 6 hm². Furthermore, sampling time was set as follows. Import sampling of field ditch was once a month, sampling in water of paddy field was ten to fifteen days at a time, besides, sample was taken every five days in the agriculture ditch of paddy field.
Sampling in the agriculture ditch of dry field was combined with irrigation recession flow process. The volume of each sample was 1000 ml, salinity, $TP, TN, NH_4^+ - N$ and $NO_3^-- N$ was immediately analyzed and tested in the lab when sampling was finished.

2. Results and analysis

2.1 The variation characteristics of pollutants

The information referring to statistical characteristics of pollutant on the paddy and dry field in crop growth period were shown in Table 1. It could be seen that the biggest change of salinity was in the end of agriculture ditch of dry field, where variation was in the range of 316-1472 mg·L⁻¹, whereas the variation monitored in water of the paddy field was in the range of 550-1226 mg·L⁻¹ and in the end of agriculture ditch of paddy field was in the range of 468-1344 mg·L⁻¹. In addition, the standard deviation of salinity was largest, resulting from the salinity which were in water of the paddy field, the end of agriculture ditch on paddy field and the end of agriculture ditch on dry field respectively were 233.58 mg·L⁻¹, 256.11 mg·L⁻¹, 312.4 mg·L⁻¹.

To sum up, the mean and the standard deviation of salinity both are biggest, while coefficient of variation was minimum, which in water of the paddy field, in the end of agriculture ditch of paddy field and dry field respectively were 0.27, 0.29, 0.31, thus, the results indicated that the salinity variation of pollutant was smallest, especially in water of the paddy field. The next was $TN$ whose the coefficient of variation in the water of paddy field, in the end of agriculture ditches of paddy field and dry field were 0.59, 0.48, 0.30, respectively.

During the crop growth period, $TP$ was the biggest pollutant change in water of the paddy field, where showed a trend of $TP > NO_3^-- N > NH_4^+ - N > TN > salinity$; whereas $NH_4^+ - N$ was the biggest pollutant change in the end of agriculture ditch of paddy field, showing a trend of $NH_4^+ - N > NO_3^-- N > TP > TN > salinity$; and $NO_3^-- N$ was the biggest pollutant change in the end of agriculture ditch of dry field, where showed a trend of $NO_3^-- N > NH_4^+ - N > TP > salinity > TN$.

| Position                      | Index  | Range /mg·L⁻¹ | Mean /mg·L⁻¹ | Standard Deviation /mg·L⁻¹ | Coefficient of variation |
|-------------------------------|--------|---------------|--------------|----------------------------|--------------------------|
| The water of the paddy field  | Salinity | 550-1226     | 850.86       | 233.58                     | 0.27                     |
|                               | $TP$   | 0.091-5.529  | 1.42         | 1.9                        | 1.34                     |
|                               | $TN$   | 1.656-11.181 | 5.8          | 3.43                       | 0.59                     |
|                               | $NO_3^-- N$ | 0.02-1.22  | 0.3          | 0.39                       | 1.3                      |
|                               | $NH_4^+ - N$ | 0.214-4.159 | 1.13         | 1.25                       | 1.11                     |
| Agriculture ditch of the dry field | Salinity | 468-1344     | 898          | 256.11                     | 0.29                     |
|                               | $TP$   | 0.031-0.749  | 0.21         | 0.21                       | 0.99                     |
|                               | $TN$   | 1.214-9.736  | 5.59         | 2.66                       | 0.48                     |
|                               | $NO_3^-- N$ | 0.02-16.32  | 3.93         | 4.28                       | 1.09                     |
|                               | $NH_4^+ - N$ | 0.092-3.603 | 0.84         | 0.93                       | 1.11                     |
| Agriculture ditch             | Salinity | 316-1472     | 1013.78      | 312.4                      | 0.31                     |
2.2 Process of pollutant variation

According to the experimental monitoring situation, the study respectively drew figures about the variation of pollutant concentration during the crop growth period in field ditch import, in water of the paddy field and the end of field ditch of paddy and dry field, analyzing variation characteristics of pollutant under certain fertilization and irrigation condition.

It could be seen from Figure 1 that the variation of salinity concentration in import of field ditch was higher, changing from 400 mg·L⁻¹ in early May to 1200 mg·L⁻¹ in middle and late June to 400 mg·L⁻¹ in August. As the extension of crop growth cycle, salinity concentration showed a decreased trend in water of the paddy field, the end of agriculture ditch of paddy field and dry field. On account of the beginning of the irrigation, impacted on evaporation from phreatic water for a long time after the end of last winter irrigation, salt content accumulated in soil surface and reached the highest standard about 1400 mg·L⁻¹ in the dry field drainage. With number of crop irrigation times increasing, and infiltration, leaching, flushing, soil salinity concentration decreased. Influenced by groundwater table, irrigation water volume, fertilization cycle, salinity concentration variation showed a decreased trend like zigzag.

The concentration of TP in import of field ditch was smaller. In agriculture ditch of dry field, the concentration of TP was basically at a low level, which was less than 0.1 mg·L⁻¹. Conversely, the concentration of TP changed greatly. Compared with agriculture ditch of dry field, the water of paddy field was more obvious. With the gradual loss of phosphate fertilizer, the concentration of TP in water of paddy field and agriculture ditch of paddy field gradually decreased before June. With the rice entering the critical growth period, the topdressing phosphate was conducted in paddy field to enhance the plant vitality. At this time, paddy field surface have covered 10-15 cm water layer, causing the concentration of TP in water and agriculture ditch of paddy field increased from early June to mid to late July, and respectively reached to 5.53 mg·L⁻¹ and 0.80 mg·L⁻¹, thereafter gradually decreased, until the end of the crop growth period. Phosphorus in the soil was insoluble and soluble, where insoluble phosphorus accounted for about 95%, demonstrating that phosphorus was mainly in the form of adsorbed state. Therefore, the phosphorus outflow in granular form through sediment adsorption was the main migration method. Furthermore, leakage runoff as the main drainage method in paddy field, adsorption of phosphorus was difficult to enter the agriculture ditch, resulting in the concentration in agriculture ditch and water of paddy field had a big difference.

Similarly, it can be seen that the nitrogen concentration in water of the paddy field, agriculture ditch of paddy and dry field gradually decreased, influenced by nitrogen application rate. Because of twice topdressing in green-up date to tillering stage and jointing to heading stage, the concentration of NO₃⁻ − N in agriculture ditch of paddy field showed a trend of bimodal pattern where the peak respectively was 16.32 mg·L⁻¹, 13.53 mg·L⁻¹. Topdressing for corn after wheat harvest, the concentration of NO₃⁻ − N was up to 29.82 mg·L⁻¹ in middle June. The loss of NO₃⁻ − N was larger and became the main loss type of nitrogen in field crop. The concentration of NO₃⁻ − N in paddy field and agriculture ditch of dry field was far above NH₄⁺ − N, and the reason was that NO₃⁻ − N was water-soluble in soil solution after applying nitrogen fertilizer, besides, NO₃⁻ − N adsorption to soil was weak due to soil with negative charge, which was easy to wash away on the condition of runoff leaching. Ammonium on NH₄⁺ − N with positive charge absorbed in soil particle surface in the state

| Pollutant | Concentration (mg·L⁻¹) | Mean | SD | CV |
|-----------|------------------------|------|----|----|
| TP        | 0.034-0.214            | 0.08 | 0.04 | 0.53 |
| TN        | 3.896-13.063           | 9.08 | 2.73 | 0.3 |
| NO₃⁻ − N  | 0.04-29.82             | 9.15 | 8.44 | 0.92 |
| NH₄⁺ − N  | 0.054-0.782            | 0.36 | 0.21 | 0.59 |
of absorbed state, and soil colloid had a strong adsorption effect on $NH_4^+ - N$, so the amount of its loss was small. The trend of nitrogen change in field drainage was greatly affected by fertilization process, where nitrogen loss was mainly $NO_3^- - N$. The process of translocation and transformation of nitrogen in field soil and the water of field during crop growth period need further study.

3. Conclusion
(1) The rate of pollutants’ concentration in water of the paddy field during the crop growing season was in the order of $TP > NO_3^- - N > NH_4^+ - N > TN > salinity$, in agricultural ditch of the paddy field which is in the order of $NH_4^+ - N > NO_3^- - N > TP > TN > salinity$, and in agricultural ditch of the dry field which is in the order of $NO_3^- - N > NH_4^+ - N > TP > salinity > TN$.

(2) The salinity concentration in field changes greatly. The content and loss quantity of $TP$ are rarely small. The nitrogen loss is mainly $NO_3^- - N$.

(3) The variation process of pollutants’ concentration in field was closely related to fertilization, irrigation process, the crop growing season, and so on.

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