Study on Transfer and Transformation of Nitrogen and Phosphorus in Agriculture Ditch under Rainfall Runoff

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Abstract: TN and TP in agriculture ditch are measured and analyzed under rainfall runoff in this paper, and in order to intercept and wipe off effectively nitrogen and phosphorus from agricultural soil, the transfer and transformation and the space-time distributing of nitrogen and phosphorus are also studied. The result shows that, the agriculture ditch changes as outside condition (rainfall), otherwise it has the ability of anti-jamming and restoration and can restore the transfer and transformation of nitrogen and phosphorus. Because of this characteristic, TN concentration variation along cross section was according to the cubic equation and TP concentration variation is on the whole the descending variation of the exponential curve along cross section, and the concentration variations of both TN and TP are the cubic equation with time. [The Journal of American Science. 2006;2(3):58-65].

Keyword: nitrogen and phosphorus; agriculture ditch; transfer and transformation; rainfall runoff

Introduction

Nitrogen and phosphorus are important life elements, and main component which is not substituted for life support system, and also the fundamental element which advances sustainable development of agriculture (Yan, 1999). The use of nitrogen and phosphorus fertilizer is one of effective measures which comes true increase of Chinese foodstuff. However, the over-fertilization with nitrogen and phosphor also brings non-point source pollution. The recent research shows that, the pollution load of nitrogen and phosphorus has accounted for over 50% of that in water body and seriously affects water body (Canter, 1986). Because of the influence of non-point source pollution, 63.6% of lakes in China have suffered eutrophication, and the concentration of TN and TP in lakes such as Tai Lake, Chao Lake, Dianchi Lake and so on where existed some agriculture high yield areas is about ten times as high as that in 1980s and over 50% of nitrogen and phosphorus pollution load comes from agriculture non-point source pollution (Coote, 1982). To be the channels by which nitrogen and phosphorus enter into water body, some researches have been carried out in agriculture ditch, however, only a few attempts have been made to study on the intercept mechanism and the transfer and transformation of nitrogen and phosphorous (Jorgensen, 1983; Tiessen, 1995). Therefore, it is very important to study the transfer and transformation of Nitrogen and Phosphorus in agriculture ditch to control agriculture non-point source pollution. This paper chooses Jiaxing town in Zhejiang province in southeast of China as the study area and the variation of TN and TP in rainfall are mainly studied.

1. Materials and Methods

1.1 Site description

The Shuangqiao farm which was founded in Nov. 1949 in Jiaxing town in Zhejiang province of China is chosen as research area. The farm is also agriculture demonstrate garden in Zhejiang province. The area, in which field is agglomerate and ditch system is reticulate and ditch gradient is smaller than 0.2%, locates in the plain of Hangjia Lake. The ditch keeps perennially some water and is dry in December to next March. The period of July to October when the rainfall is more typical and rainfall is between 50mm to 100mm is chosen as the research period. This rainfall is about 85mm, maximal rainfall intensity is about 40mm/h and typical rainfall time is about two hours in the area and is used in this paper.

1.2 Methods

The distribution of ditch is showed in Figure 1. The cross sections are set per 30m along the stream direction and the space between the last two sections (the 5th and 6th section) is 100m. The total length of Ditch Two is 350m. After rainfall, the water was sampled daily and the velocity and quantity of flow of five days were measured which are showed in Table1. The samples were collected with 200ml PVC bottle , kept in 4℃and was measured the next day. Concentration of TN and TP are analyzed using standard methods (SEPAC, 2002).

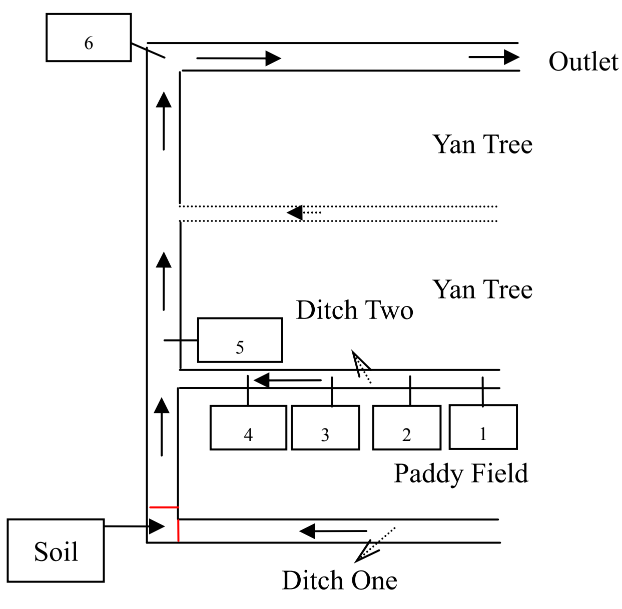

Figure 1. Distribution of cross section in ditch

Table 1. Velocity and quantity of flow in five days after rainfall

time	1st day	2nd day	3rd day	4th day	5th day
V/(cm·min^{-1})	2.5	1.6	0.8	0.3	0.2
Q/(L·min^{-1})	0.625	0.4	0.2	0.075	0.05

2. Results and Discussions

2.1 Variation of TN and TP concentration along ditch section

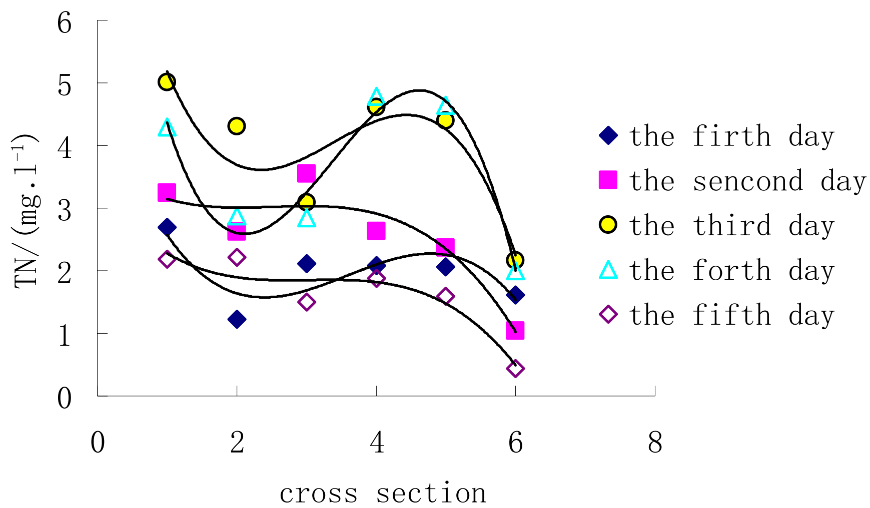

Figure 2. Variation and its simulation of TN concentration along cross section

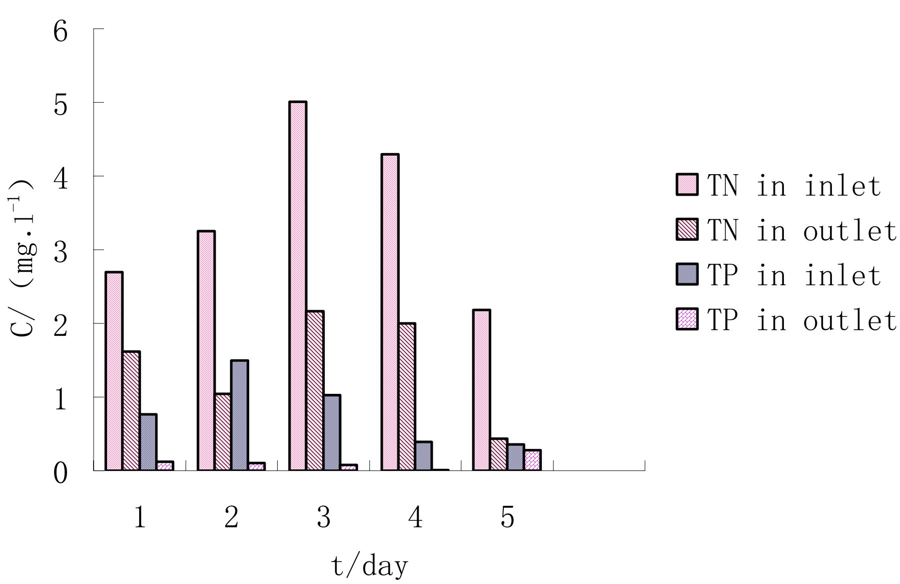

Figure 3. Contrast of TN and TP concentration in inlet and outlet

The transfer and transformation of nitrogen and phosphorus is very intricate especially in rainfall and its intercept mechanism is hardly studied, therefore, the variation of TN and TP concentration may be help to open out the transfer and transformation of nitrogen and phosphorus along the ditch. From the Figure 2, the TN concentration in inlet and outlet were between 2 to 5mg·l^{-1} and between 1 to 3.5 mg·l^{-1} respectively. From Figure 2 and Table 2, the simulation result of TN along the ditch indicated that TN concentration variation along cross section was according to the cubic equation and the correlation coefficient is about 0.6-0.9. By comparing TN concentration in inlet with that in outlet (Figure 3), TN concentration decreased at a rate of 40 to 70% which indicated that the agriculture ditch can intercept nitrogen even if under the condition of rainfall. In rainfall, TN concentration variation was not simple beeline but cubic equation. TN concentration along cross section was not degressive, inversely, it increased a little especially at the 5th section. This may be that there is a big branch ditch. In short time, the runoff was large which caused large loss of nitrogen, so the TN concentration in main ditch increased.

Figure 4 showed the variation and its simulation results of TP concentration along cross section. From Figure 4, the TP concentration in inlet was 0.3-1.5 mg·$l^{-1}$and that in outlet was 0.01-0.3 mg·l^{-1}, and the variation of TP concentration along cross section was degressive. Combined with Table 2, the simulation result indicated that TP concentration had the descending variation of the exponential curve on the whole. Comparing the TP concentration in inlet with that in outlet in Figure 2, we can find that the agriculture ditch can intercept effectively phosphorus element and the phosphorus decreased at the rate of 20%-80%. The TP concentration variations along cross section at different time were alike which indicated that TP concentration variation along cross section was very regular, what's more, the change was the descending variation of exponential cure on the whole, but it had a little change as time gone.

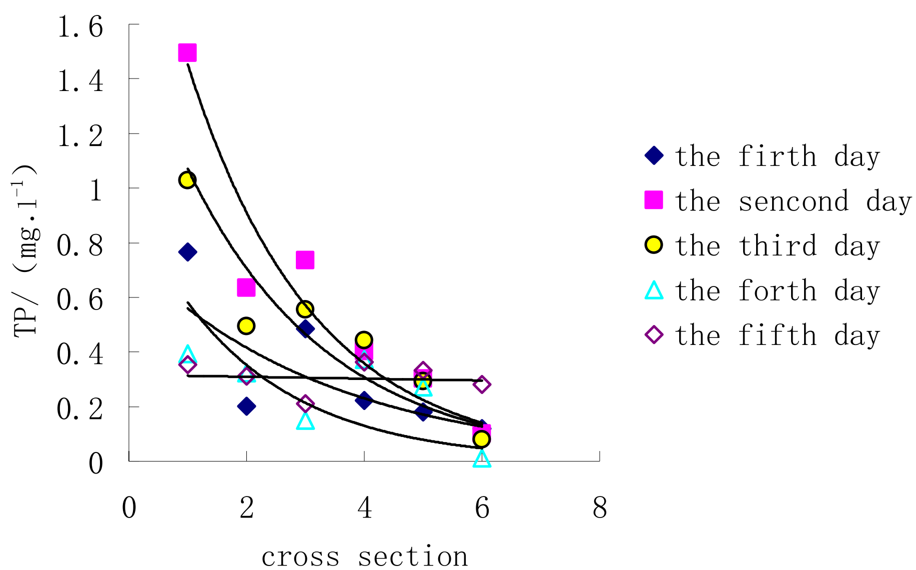

Figure 4. Variation and its simulation of TP concentration along cross section

Table 2. Simulation result of TN and TP concentration along cross section

time	TN		TP	
	Simulation equation	R^2	Simulation equation	R^2
1st day	$y = -0.1031x^3 + 1.1099x^2 - 3.5416x + 5.1067$	0.6714	$y = 0.7514e^{-0.2959x}$	0.6472
2nd day	$y = -0.0509x^3 + 0.3865x^2 - 0.9413x + 3.7536$	0.867	$y = 2.3173e^{-0.4669x}$	0.9023
3rd day	$y = -0.1938x^3 + 1.9696x^2 - 6.0427x + 9.4496$	0.8278	$y = 1.6241e^{-0.4164x}$	0.8144
4th day	$y = -0.293x^3 + 2.9582x^2 - 8.5826x + 10.281$	0.9541	$y = 0.9568e^{-0.4996x}$	0.4618
5th day	$y = -0.008x^3 + 0.0987x^2 - 0.5048x + 2.6615$	0.6768	$y = 0.3163e^{-0.0111x}$	0.0109

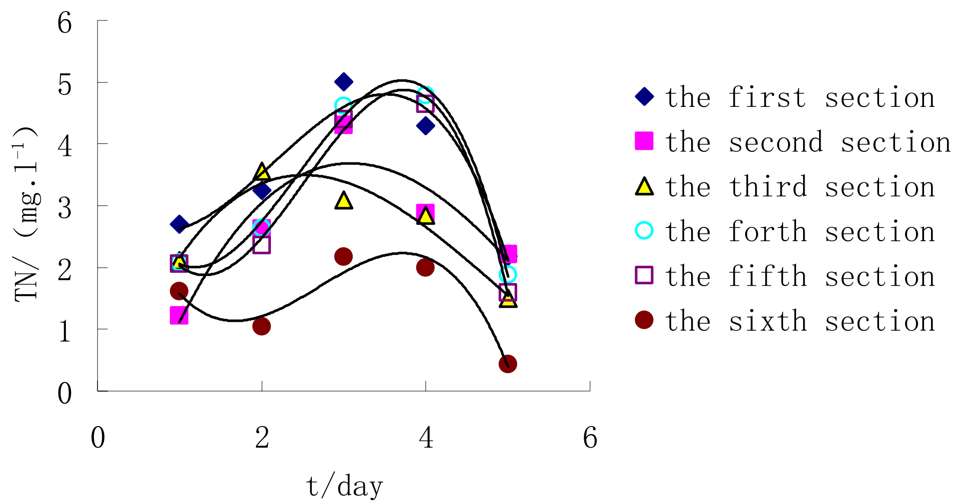

Figure 5. Variation and its simulation of TN concentration with time

2.2 Variation of TN and TP concentration with time

From the Figure 5, TN concentration of every section on the first day was low at 1-3 mg·l^{-1}, increased on the second day, and reached maximum on the third day or forth day, then fell gradually, at last, stabilized at 1-2 mg·l^{-1}. The simulation result indicated that, TN concentration variation with time matched the cubic equation well and the peak value occurred generally on the third day or forth day. The sediment sorption, nitrification-denitrification, macrophyte uptake, infiltration were the main processes by which nitrogen in the agriculture ditch was intercepted (Copal, 1999; Jansson, 1994). After rainfall, a lot of particulate nitrogen (PN) combined with the clay in the process of the transfer and transformation and then deposited, so the sediment can intercept lots of PN. Nitrification-denitrification was the main process that can wipe off nitrogen from water body. The agriculture ditch had the condition of nitrification-denitrification (aerobic area and anaerobic area, enough carbon and nitrogen nutrients, and so on) (Schade, 2002), so nitrogen may be transformed into N_2, NH_3, N_2O and wiped off from water body. In growth season, the emergent microphyte and macrophyte in ditch had a great deal uptake to inorganic nitrogen. Macrophyte root released oxygen at the root zone and the nitrification-denitrification of sediment was strengthened, so nitrogen in ditch was transformed into gas and escaped from water body. But, from Figure 5, TN concentration increased only at the beginning and reached maximum and then fell, which showed that the ditch system was not stable. The convergence of rainfall runoff in short time affected the nitrogen transfer and transformation, but the effect disappeared gradually with time which showed that the ditch system had the ability of anti-jamming and restoration and can gradually restore stable in certain time.

From Figure 5 and Table 3, TN concentration of every section on the whole reached the maximum on the third day or forth day after rainfall. The result provided the optimal control time for control efficiently the loss of nitrogen. The same variation of TN concentration of every section indicated that nitrogen transfer and transformation in the agriculture ditch was not affected by space and location (cross section).

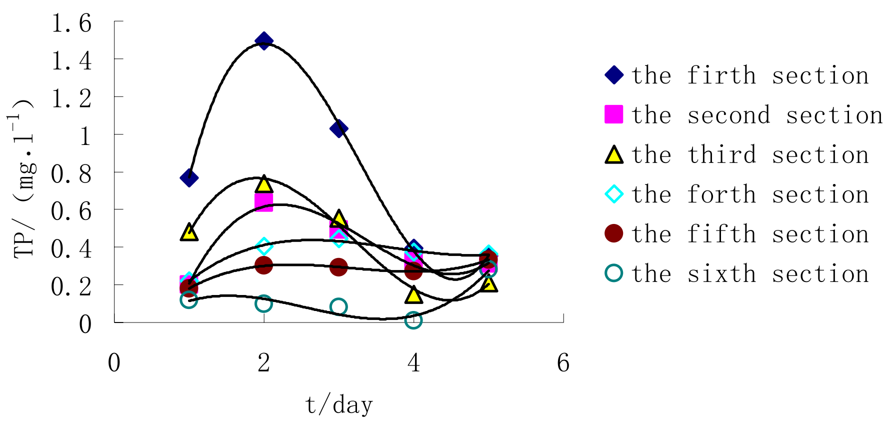

Figure 6. Variation and its simulation of TP concentration with time

Figure 6 describes the variation of TP concentration with time at different sections. On the first day TP concentration of every section was low at 0.1-0.7 mg·l^{-1}, while on the second day increased to maximum and then fell smoothly. From the simulation result of Figure 6 and Table 3, we can see that the variation of TP concentration was the cubic equation with time and the correlation coefficient was great. Contrast to nitrogen, the sorption was the main process of transfer and transformation of phosphorus (Jorgenson, 1996). During rainfall, because of the convergence of rainfall runoff as well as the in-stabilization of ditch, the phosphorus was not clearly transformed and the TP concentration increased and then reached maximum, but the absorption of the particle matter in water body and sediment and the ability of anti-jamming and restoration of the agriculture ditch made the transformation of phosphorus be resumed and the TP concentration reduce. Another reason that phosphorus decreased was that phosphorus decomposed in anaerobic condition and transformed into PH_3 then escaped from water body (Jiang, 2004).

The simulation result of Figure 6 and Table 3 showed that the TP concentration of every section reached the maximum on the second day after rainfall, so the second day after rainfall was the optimal time of controlling efficiently phosphorus loss. The similar TP concentration variation at different sections with time indicated that the agriculture ditch can intercept efficiently phosphorus and the interceptive variation was not affected by the space and location (cross section).

Table 3. Simulation result of TN and TP concentration with time

section	TN		TP	
	Simulation equation	R^2	Simulation equation	R^2
1st section	$y = -0.217x^3 + 1.3956x^2 - 1.7743x + 3.2231$	0.9394	$y = 0.149x^3 - 1.4627x^2 + 4.0544x - 1.9703$	0.999
2nd section	$y = 0.0418x^3 - 0.8926x^2 + 4.3077x - 2.3373$	0.8497	$y = 0.0614x^3 - 0.^{6186x2} + 1.8348x - 1.0714$	0.9848
3rd section	$y = 0.0667x^3 - 0.9847x^2 + 3.6887x - 0.6132$	0.937	$y = 0.0749x^3 - 0.7175x^2 + 1.9144x - 0.7947$	0.9865
4th section	$y = -0.3759x^3 + 2.7597x^2 - 4.9575x + 4.629$	0.9932	$y = 0.0168x^3 - 0.1868x^2 + 0.6346x - 0.2452$	0.9899
5th section	$y = -0.4191x^3 + 3.1642x^2 - 6.1096x + 5.3932$	0.9928	$y = 0.0177x^3 - 0.1685x^2 + 0.5007x - 0.1685$	0.999
6th section	$y = -0.0071x^3 + 0.2583x^2 - 0.8749x + 2.1543$	0.8421	$y = 0.0283x^3 - 0.2169x^2 + 0.4634x - 0.1607$	0.9318

Conclusion

1. The agriculture ditch in itself is instable and will change under the influence of outside conditions (rainfall), but it has the ability of anti-jamming and restoration and can restore the transfer and transformation of nitrogen and phosphorus. This is an important characteristic of agriculture ditch.

2. The agriculture ditch can still intercept efficiently nitrogen and phosphorus in rainfall. Because of the convergence of outlet along cross section, the TN and TP concentration change along the cross section. TN concentration variation along cross section was according to the cubic equation and TP concentration variation is on the whole the descending variation of the exponential curve along cross section.

3. The concentration variation of both TN and TP are the cubic equation with time. The peak vale of TN concentration of every section was on the third day or the forth day. The variation of TP concentration is more relatively stable and the variation trend is on the whole alike. Furthermore, the peak vale of TP concentration was mostly on the second day. Therefore, this indicates that the decomposing process of every section in agriculture ditch has the same trend on the whole and the variation trend will not change a lot by space and location (cross section).

4. The TN and TP concentration variation of every section indicate that TN concentration reached maximum on the third or forth day however the peak vale of TP concentration was on the second day. Therefore, it provides the optimal control time for

controlling efficiently the loss of nitrogen and phosphorus after rainfall, namely, we can control efficiently nitrogen element on the third or forth day and control phosphorus element on the second day after rainfall.

Because of the particularity and complexity of agriculture ditch, each researcher has the different opinion to the interception of nitrogen and phosphorus and takes the different study method and means, but the fact that agriculture ditch can intercept nitrogen and phosphorus has been affirmed. With the continuous research, the transfer and transformation of nitrogen and phosphorus will be further clarified.

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