

Compounded Ecological Ditch used for Improving Fishpond Water

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Abstract: In order to guarantee a good water quality for freshwater aquaculture in fishpond, compounded ecological was constructed around the fishpond and an experimental study was made that it improves fishpond water quality. A compounded ecological ditch based on the simple transformation of general ditch, has a regular cross-section of isosceles trapezoid, with a lining of permeable brick where ceramsite stroma etc were filled in the grids of the permeable bricks and some hydrophytes were grown in the ditch, including spatterdock, *Myriophyllum verticillatum*, *Vallisneria natans* (Lour.) Hara etc. According to the study, after aquaculture wastewater treated by the compounded ecological ditch, the water quality will be improved obviously; the important sign is an increase for DO and apparent decrease for TN, TP, NO_3^- -N, NH_4^+ -N and COD_{Mn} . The removal rate (R_m) of the main substances is significantly relative to their initial Concentration (C_0) and the distance of them carried by flowing water (D_f). When compounded ecological ditch is used to purify fishpond water, besides slow velocity of the flow (6-9 m/h), the ditch must have a certain length which is suggested to be more than 100 m. On the other hand, a good effect will be procured in fishpond water purification only if an initial concentration exceeds 2.0 mg/L for TN, 0.6 mg/L for NO_3^- -N and 8.0 mg/L for COD_{Mn} .

Keywords: Aquaculture water, compounded ecological ditch, freshwater pond, water environment, water quality

INTRODUCTION

In freshwater aquaculture of China, pond farming has an important position which provides a great deal of aquatic products accounting for 68.5% of the total of the freshwater aquaculture (Xu *et al.*, 2009). In the southern plain, fishponds are excavated or consolidated by manpower, the individual pond generally has a small area (1 hm^2 or so), where water is static and without flow. In current practice, a popular technological mode is that aquaculture in freshwater pond is high density and high investment of bait, which wide extension can produce a great increase in aquatic product yield and economic benefit, meanwhile it also brings some serious problems, such as deterioration of pond environment, water loss and water pollution due to pond wastewater discharging to water body around the ponds, as well as quality safety of aquatic product. It is reported that in the process of fish breeding, 70 to 80% of the fish food are in form of particles or dissolved substances into the water environment, about 51% of nitrogen and 64% of phosphorus in fish fodders finally become offal (Song *et al.*, 2008). This will not only affect the growth of fish and increase fish disease rate, reduce the aquaculture output and quality, influence the

overall economic benefit of aquaculture, but also lead to discharge a great deal of aquaculture wastewater and thereby quicken an eutrophication of the rivers and lakes that surround the fishponds. As a water treatment technology, artificial wetland has been widely used, its purification way including filter, adsorption, precipitation, ion exchange, plants absorb and microbial metabolism, through the synergy of physical, chemical and biological effectively to remove suspended solid, organic matter, nitrogen, phosphorus and heavy metal and so on Kivaisi (2001) and Volodymyr and Sirajuddin Viktor (2007). At present, some scholars have used artificial wetland to purify pond aquaculture wastewater and obtained some achievements. An artificial wetland constructed by Tilley *et al.* (2002) etc can improve water quality of the aquaculture wastewater from shrimp breeding; degrade TP, TSS and ISS separately by 31, 65 and 76%, respectively. Yue *et al.* (2004) developed a technology to purify low concentration aquaculture wastewater, in which the purification is realized by a circulation of aquaculture wastewater through vertical flow of compounded wetland, through this technology water quality in fishpond can maintain in good condition in the case of no metathesis for pond water. A compounded

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ecological system consisting of fishpond and artificial wetland, constructed in Jingzhou, Hubei province (Li *et al.*, 2006), has successfully realized a recycle of aquiculture water. Considering the actuality of fish breeding in freshwater pond, in order to lower productive cost in improving pond water, it is an effective way to construct ecological ditch around the fishpond, for a wide extension of this technology, an experiment was made that an ecological ditch was used for purifying fishpond water and the study is reported as following.

MATERIALS AND METHODS

The experimental plots were constructed in Yaowan testing ground of the Yangtze River fisheries research institute (in Jingzhou, Hubei, China) where a compound ecosystem has been established which is composed of freshwater ponds and compounded ecological ditch. The ditch has a regular cross-section of isosceles trapezoid, with a lining of permeable brick where ceramic stroma etc., were filled in the grids of the permeable bricks, after lining the effective section size is 0.65 m for bottom width, 2.47 m for top width and 0.7 m for its depth. Some hydrophytes were grown in the ditch, including spatterdock, *Myriophyllum verticillatum*, *Vallisneria natans* (Lour.) Hara etc., because the above characteristics of the ditch it is called compounded ecological ditch.

The experiment was made in summer (Jun to Aug) in 2010 and 2011. During the trial, the ditch kept a slow flow with a discharge of 60-70 L/min and a velocity of 10-14 cm/min, from its head to end some monitored points were set up each 30 m for monitoring water quality. Through observation of water quality varying with flow, the purposes is to understand an effect of wastewater purified when it tardily flow in the ecological ditch, to analyze the influence of initial concentration and flow path on water purification. In the experiment, DO was determined by portable dissolved oxygen analyzer (Profiline Oxi 1970i) in the spot and clean polyethylene bottle were used to sample, after water samples done, then labeling the bottles, taking them back to the laboratory immediately and mensurating TN, TP, NO_3^- -N, NH_4^+ -N and COD_{Mn} etc. The specific methods are $\text{K}_2\text{S}_2\text{O}_8$ -spectrophotometric-ultraviolet spectrophotometry for TN, molybdenum-antimony anti-spectrophotometry for TP, spectrophotometry with phenol disulfonic acid for NO_3^- -N, Nessler's reagent spectrophotometric method for NH_4^+ -N, potassium permanganate method for COD_{Mn} . Specific steps and methods can be found in literature (MEP, 2002). For each water quality index, three parallel determinations were done and then their average was adopted.

RESULTS AND DISCUSSION

Analysis of water quality variation: Figure 1 showed that, DO increases with the distance of the water flowing in the ecological ditch. The main reason is that photosynthesis of hydrophytes in the ditch produces oxygen for DO increase. In addition, the water from fish pond flows slowly when it is pumped into the ecological ditch and has enough time to contact air, so that cause DO increase. From Fig. 1 an important cognition can be obtained that ecological ditch has an ability to increase DO when aquiculture water from fishpond flows slowly in it, but this ability is limited, in the experimental condition DO cannot any longer increase when aquiculture water flows about 150 m along the ditch.

According to our observation, Fig. 2 to 6 gives the trends of water quality variation in the ditch. Obviously, in the conditions of the study, water quality indices such as TN, TP, NO_3^- -N, NH_4^+ -N and COD_{Mn} etc., decline slowly, which mainly because when fishpond water was pumped into the ditch and tardily flowed in it, some factors play an important role in water environmental improvement, which are:

- Hydrophyte absorption, decomposition, assimilation
- Adsorption of stroma (ceramic particles etc.)
- Metabolism of microbe, algae and protozoans etc., which reduces the concentration of nutrients in the aquiculture water

In addition, in view of water quality index variation along the ditch, water purification effect will be obvious only if an initial concentration exceeds 2.0 mg/L for TN, 0.6 mg/L for NO_3^- -N and 8.0 mg/L

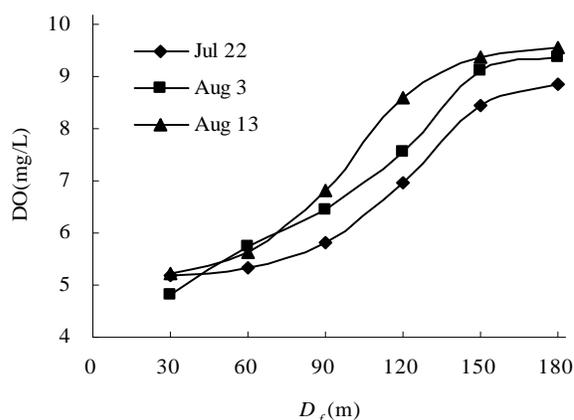


Fig. 1: Variation of the DO in ecological ditch

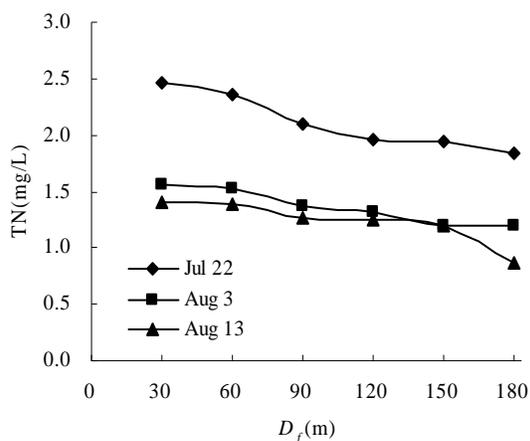


Fig. 2: Variation of TN in ecological ditch

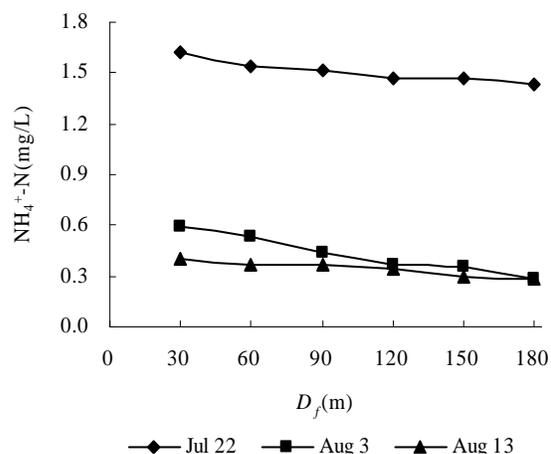


Fig. 5: Variation of NH₄⁺-N in ecological ditch

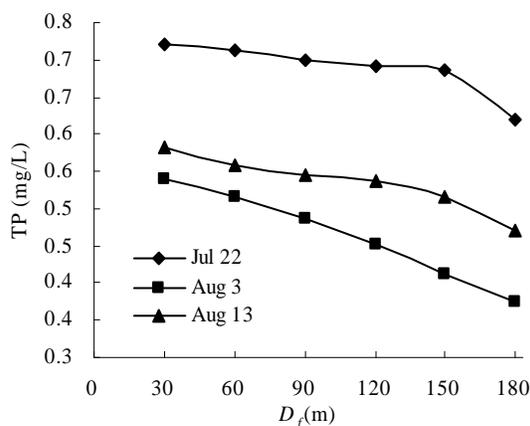


Fig. 3: Variation of TP in ecological ditch

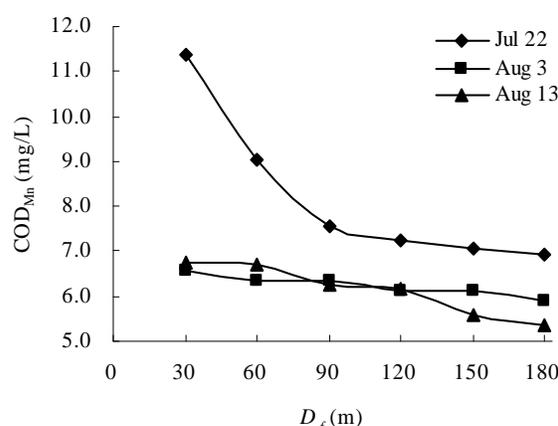


Fig. 6: Variation of COD_{Mn} in ecological ditch

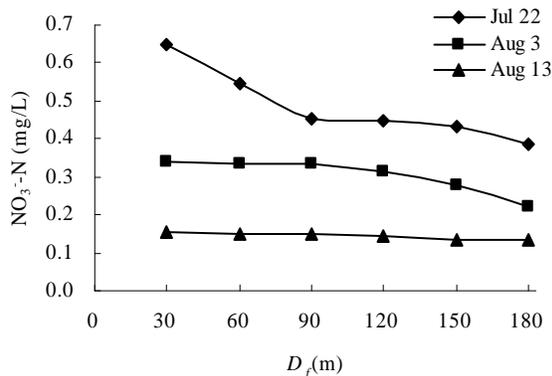


Fig. 4: Variation of NO₃⁻-N in ecological ditch

for COD_{Mn}, which illustrates that the removal rate of main substances is relative to both the distance of them carried by flowing water but also their initial concentration. In light of Fig. 2 to 6, another fact is that the compounded ecological ditch must have a certain

length, which more than 90 or 100 m is needed besides it with a slow velocity of the flow (6-9 m/h).

Correlation analysis of the removal rate and relevant factors: Based on analysis of the experimental results, some correlation expressions and analysis results can be obtained which are listed in Table 1. As can be seen, the removal rate (R_m) of the main substances is significantly relative to their initial Concentration (C_0) and the distance of them carried by flowing water (D_f). In addition, according to statistics knowledge, we can understand the influence of D_f and C_0 on R_m through comparing absolute values of their standardized coefficient in regression equation, apparently, except the expression relevant to COD_{Mn}, generally an influence of D_f on R_m is more than that of C_0 and for COD_{Mn} it is just reverse. This illustrates that an enough length of the ditch is important to TN, TP, NH₄⁺-N and NO₃⁻-N.

Table 1: The correlation among R_m , D_f and C_0

Item	Correlation equation	Standardized coefficients			
		of D_f	of C_0	Coefficient of determination (R^2)	Coefficient of correlation (r)
TN	$R_m = 0.194 D_f + 3.295 C_0 - 5.29$	0.929	0.124	0.878	0.937**
TP	$R_m = 0.163 D_f + 24.514 C_0 - 14.443$	0.950	0.230	0.955	0.977**
NO_3^- -N	$R_m = 0.182 D_f + 38.652 C_0 - 13.568$	0.655	0.655	0.859	0.927**
NH_4^+ -N	$R_m = 0.122 D_f + 5.125 C_0 - 7.06$	0.801	0.442	0.836	0.914**
COD_{Mn}	$R_m = 0.123 D_f + 4.420 C_0 - 31.371$	0.584	0.705	0.838	0.916**

CONCLUSION

Through the study, the following important cognitions can be acquired:

- After aquaculture wastewater treated by the compounded ecological ditch, the water quality will be improved obviously, the important sign is an increase for DO and apparent decrease for TN, TP, NO_3^- -N, NH_4^+ -N and COD_{Mn} . It must be pointed out that an ability of the compounded ecological ditch to increase DO is limited, which cannot any longer increase when aquaculture water flows along the ditch about 150 m.
- The removal rate of main substances is affected by both the distance of them carried by flowing water but also their initial concentration. When compounded ecological ditch is used to purify fishpond water, besides slow velocity of the flow (6-9 m/h), the ditch must have a certain length which is suggested to be more than 100 m. On the other hand, a good effect will be procured in fishpond water purification only if an initial concentration exceeds 2.0 mg/L for TN, 0.6 mg/L for NO_3^- -N and 8.0 mg/L for COD_{Mn} .
- The removal rate of the main substances (R_m) is significantly relative to their initial Concentration (C_0) and the distance of them carried by flowing water (D_f). D_f and C_0 have a different influence on R_m , except the expression relevant to COD_{Mn} , generally an influence of D_f on R_m is more than that of C_0 and for COD_{Mn} it is just reverse. As can be seen, an enough length of the ditch is important to TN, TP, NH_4^+ -N and NO_3^- -N.
- Despite that compounded ecological ditch has a good effect in improving fishpond water, its maintenance and management must be done well because its function of water purification may be affected by some factors which are rapid development of hydrophytes to reduce the actual cross-section of the ditch after they absorb nutrients in aquaculture water, the suspended solids depositing in it and the accumulation of organic matter. Therefore, it is very necessary for us to

select proper aquatic plants, to remove weeds in the ditch and to regularly put the system in order.

- Compared with traditional pond culture in water quality improvement, compounded ecological ditch is characterized by good purified effect, especially, by which harmful metabolites from fishes may be removed out of the fishpond and adsorbed by soil or matrix in the ditch, transformed by microorganism and assimilated by hydrophytes as fishpond water pumped into the ditch for treatment, so that fishpond water may be improved preferably.

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