International Proceedings of Chemical, Biological and Environmental Engineering, V0l. 93 (2016)
DOI: 10.7763/IPCBEE. 2016. V93. 12

Prospect of Application of EM Technology in the Water Ditch of Paddy Field

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Abstract. Agricultural non-point source pollution has become an important source of China's river basin water pollution, and drainage from paddy field is a kind of important non-point source pollution. Exploring the EM effect on TP and TN absorption characteristics in ditch sediments of paddy field drainage and screening for proper proportion as well as unique fermentation process is an important means of biotechnology to solve the problem of non-point source pollution from paddy fields, which also can promote ecological environment sustainable development in irrigation area.

Keywords: EM technology, paddy field drainage, ditch system, agricultural non-point source pollution, ecological environment

1. Preface

According to the Gazette on the first national census of pollution sources [1], agricultural source pollution of TP and TN emissions is accounted for 38% and 59% of the country's total emissions, and agricultural non-point source pollution has become an important source of China's river basin water pollution. Paddy's rice production is a typical hydrological process, and the drainage from paddy field is a kind of important surface source pollution. A lot of nitrogen and phosphorus not full used are lost to the surrounding water environment with the paddy field drainage, resulting in eutrophication of rivers, lakes and even oceans; according to statistics, the rate of the drainage contributing to the water eutrophication in rivers and lakes is 27% [2]. The ditch system for paddy field drainage is important water conservancy facilities, which can collect water and save water, and the channel for water flowing past; moreover it is the key place for intercepting and transforming agricultural non point source pollutants. In the ditch system, ditch sediments is an important part of the environment; it is also the important material source and storage of overlying water,which plays an considerable role in the migration of the material cycle.On the one hand, the ditch sediment will absorb the nitrogen and phosphorus, and then deposite and transform them; on the other hand, the surface of the ditch sediment attaches to a large number of microorganisms, which can nitrate and denitrate nitrogen,and so on. At the same time, with the transferring of the sediment interstitial water, the phosphorus on the surface of the sediment will be transferred to the inside of the mud, which will be removed by mineralization and plant absorption. The interception of nitrogen and phosphorus in ditch sediments is related to many factors, such as temperature, pH, DO, velocity of flow and influent concentration, and so on [3].

Due to the complexity of non-point source pollution, source reduction and process truncation is better than terminal repair. In the source reduction and process truncation, the measures which are based on the ecological environment and artificially assisted by microbial enhancement, can achieve a multiplier effect and prevent pollution efficiency maximization. In the process of intercepting lost nitrogen, phosphorus and other pollutants , the main microorganisms in the rhizosphere (mycorrhizal fungi and rhizosphere promoting

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endophytic bacteria, etc.), can expand the buffer function area the period of buffer function, improve buffer soil characteristics, and give full play to the limited land the interception and net function . The sustainable development of microbial technology will create update, stronger and more stable method for the agricultural water pollution prevention control and repair, and will bring the strong driving force for the development of agricultural modernization.

EM (effective microorganisms) technology development and application is particularly important for the sustainable development of facility agriculture in China. It plays an important role in improving and maintaining soil fertility, transforming nutrient, improving fertilizer use rate, promoting crop growth, antagonizing soil borne diseases, purifying environmental, balancing the ecological system and other aspects [4], [5]. EM bacteria have a certain role of nitrogen and phosphorus removal, and can change the influent concentration; at the same time, it can be as the nutrient base of the sediment to further change the adsorption characteristics of nitrogen and phosphorus when draining away water from paddy field. In ditch sediments of paddy field drainage and screening for proper proportion as well as unique fermentation process exploring the EM effect on TP and TN absorption characteristics is an important means of biotechnology to solve the problem of non-point source pollution from paddy fields, which also can promote ecological environment sustainable development in irrigation area.

2. Research Process at Home and Abroad

Series of dynamic and static experiments were performed to study the effects of ditch sediments on the fate of N and P at acidic [6], basic and neutral pH (5, 7 and 9), the pH effect on the N and P retention in the sediments, and the mass transfer at the sediment-water interface. The adsorption capacity of the sediments for NH^{+}_{4}-N, nitrification to produce NO^{-}_{2}-N and retention of TN all increased with increasing pH, which also enhanced the sediments 'adsorption capacity for TDP and increased the retention of TP during the first 5 days. The transfer of N species at the sediment-water interface was affected due to the pH' s effect on the microbial activities and that the transfer of P species at the interface was affected due to pH' s effect on absorption and ionic exclusion. Knowing the effects of pH on N and P retention in ditch sediments will help to understand the transfer and transformation of N and P species in agriculture drainage ditch, which is important for effective control of agricultural non-point source pollution.

In order to discuss the effects of drying and wetting conditions on the capability of ditch sediments purifying nitrogen, different drying and wetting conditions of the simulation tests were performed to study the purification capacity of sediments [7]. The results showed that the purification efficiency of ditch sediments was improved with drying time increasing. At the same time, the concentration of nitrate reached to the peak and then decreased. Finally, the removal rate of total nitrogen under conditions of continuous wetting (CW), drying for four days and then wetting (DFW) and drying for eight days and then wetting (DEW)was 84.5%,90.2% and 93.3%, respectively. Dried ditch sediments may increase the removal efficiency of ammonia nitrogen in water, and promote the ability of denitrification. While the concentration of total nitrogen was close to 10mg/L, it was useful for the nitrogen removal to dry ditch sediments for eight days. Adsorption of sediments and microbial absorption were the main reasons of total nitrogen reduction in the first few days.

To investigate the removal effects of ditch system in a farmland-wetland on nitrogen and phosphorus, a simulation experiment was carried out [8], [9] to study the kinetic characteristics of nitrogen and phosphorus adsorptions on the sediment of the agricultural ditch system in Caohai Wetlands. Results showed that the retention rates of the everglade farmland ditch system for TP, TN and NH^{+}_{4}-N were 66.7%~79.7%, 66.0~76.4% and 82.8~89.3%, respectively. The equilibrium time of adsorption on nitrogen and phosphorus were long, comparing with the sediments from Taihu and Dianchi. With the increasing concentrations of the salinity, $SO^{2-}_{4}$and NO^{-}_{3}, the sorption ability of PO^{3-}_{4}-P and NH^{+}_{4}-N on the sediment declined, respectively. However, the influence of Ca^{2+}on PO^{3-}_{4}-P sorption might be divided into two patterns：Restraining at low concentration and promoting at high concentration, and $Ca^{2+}$was found to have a significant restraining effect onNH^{+}_{4}-N adsorption, with the minimum adsorption value at the Ca^{2+}concentration of 5 mg • L^{-1}.

Static adsorption experiments were performed [10], [11] to investigate the transformation mechanisms of nitrogen and phosphor in open few channel. The experiments show that the ammonium and phosphate are

mainly adsorbed on the sediment within 0 - 5 h with maximum adsorption rates of ammonium and phosphate in the channel sediment of 160 mg/(kg • h) for ammonium and 300mg/(kg • h) for phosphate. The adsorption isotherms for the ammonium and phosphate are linear on the tested range. The measurements show that waters, N and P do not accumulate much in ditches. Effects of pH on the adsorption of ammonium and phosphat were observed. When the pH altered from 5 to 9, the adsorption ability of ammonium was bigger than that in acidic condition. While the adsorption ability of phosphate declined gradually with the increasing pH.

Adsorption behavior of sediments on ammonia and nitrogen is an important part of nitrogen transformation process of ditch-ecosystem in estuary. Adsorption kinetics experiment, isothermal adsorption experiment and the influencing factors of the adsorption behavior of sediments on ammonia and nitrogen were studied by simulation tests [12]-[15]. The results showed that: the process of ammonium adsorption by sediments mainly had two stages which were fast stage and slow stage, the fast stage could complete within 2 h, and the slow stage could complete within 6 h, the adsorption behavior reached balance after 6 h; isothermal adsorption of ammonia nitrogen by sediments showed a good linear relation, the fitting results of Langmuir model was good. Thus it could be seen, the adsorption ability of trunk canal sediments on ammonia nitrogen was higher than that of agriculture ditch; organic matter, iron and manganese could affect the adsorption behavior in different degrees, and the adsorbing capacity increased with the increase of organic matter, iron and manganese.

In order to discuss the adsorption capacity of nitrogen and phosphorus for slag, 70% slag with 30% ditch sediment and ditch sediments, the isothermal adsorption and kinetics experiments were conducted at the comprehensive experimental field of the Sanjiang Mire Wetland Experimental Station(47° 35′ N, 133° 31′ E), Chinese Academy of Sciences [16]. Meanwhile, the experimental data were fitted by the Langmuir isothermal adsorption equation. The maximum ammonium nitrogen adsorption amounts for slag, 70% slag with 30% ditch sediment, and ditch sediments were 0.49, 1.03and 1.75mg/g, respectively; the maximum phosphate adsorption amounts were 0.99, 2.33and 1.88mg/g, respectively; the adsorption rates of ammonium nitrogen were 0.10, 0.11and 0.54mg/(g • h) during 0~4h; the adsorption rates of phosphate were 0.048, 0.051, 0.096mg/(g • h) during 0~2h. Slag was used as matrix dam fill since ditch sediments were loose and easy to run off. The hydraulic retention time of ditch water in drainage ditches was extended with matrix dams as well as mitigating the flow velocity of ditch water.

Agricultural non-point source pollution has become the largest source of China's total non-point source pollution, and water pollution is the most important content of agricultural non-point source pollution. Due to the complexity of non-point source pollution, between prevention and control of agricultural water pollution, prevention is better than rule. With the rapid development of science and technology in recent decades, microbial technology plays an increasingly important role in the prevention and control of agricultural water pollution. Microbial technology is an engineering technology which can reduce or eliminate pollutants, purify environment or product useful materials by directly or indirectly using biological or biological, to reduce the discharge of pollutants to the surrounding water and to contribute to the sustainable development of the agricultural ecological environment by reducing the agricultural source pollution and intercepting the agricultural process pollution [17].

EM is composed of photosynthetic bacteria, lactic acid bacteria, yeast, actinomycetes, filamentous bacteria and other 5 species of 10 genera and 80 species of microorganisms. It is a mixture of aerobic and anaerobic microbial microorganisms through the proper proportion and a unique fermentation process. The microbial generated useful substances and secretion of substances in the growth process, which become their or mutual growth of matrix material. Through the mutual symbiosis increased colonization relationship a biological bacteria group with a variety of microbial communities is formed which has stable structure and wide function. The biological bacteria group plays a synergistic role, who makes the microorganism and animal body and external environment maintain a balance, and let the body in the best condition. EM can improve soil structure, physical and chemical status and microbial status, accelerate the decomposition and transformation of soil organic matter, and increase the organic nutrients and fertility in soil. Walnut mandshurica seedlings experiment was carried out in the greenhouse by using EM technology, which found that EM can improve the nutrient content of soil organic matter, available nitrogen and available phosphorus.

Put EM fermentation liquid, EM Fermented Rice Bran into the mud, and make it as big as a tennis ball ,then place it in fermentation, until its surface is covered with white mycelium, then devote it into a polluted ditches, rivers and ponds every two month launch , and EM fermentation liquid used together, which can achieve better treatment effect [18]. EM fermentation liquid flows with water, and all the place connected waterways can get EM fermentation liquid and was purified. Purification of EM fermentation sludge is stationed in the dumplings in the sludge on the site as EM nutrient medium, constantly releasing EM bacterium, which can quickly remove the odor and sewage sludge. The test results showed that the EM bacterium put into the water has obvious effect on reducing water chlorophyll, suspended solid sand organic pollution index, improving dissolved oxygen, transparency and bactericidal deodorant, and has certain removal effect of nitrogen and phosphorus removal. In addition, the safety monitoring of EM and the water body results show that there is no negative impact.

EM technology is widely used in many countries, and EM technology has promoted the development of international agriculture, organic agriculture and green environmental agriculture [19]-[22]. EM technology is not only applied in agriculture, animal husbandry and aquaculture, but also extends to the field of environmental protection and medical treatment. Although EM technology has been applied in more than 60 countries, it is necessary to further develop the new field of EM technology; in particular, it is necessary to further study the mechanism of its role in agriculture and environmental protection. In the upcoming Chinese"13th Five-Year" period, it is necessary to study further application of effective microorganisms to develop efficient water purification agent, soil conditioner, biological organic fertilizer and other products, which will make contributions to soil and water environment restoration and the agricultural product quality and safety.

3. Epilogue

In the study of the interception characteristics of TN and TP, the influence of temperature, pH, DO, influent concentration and velocity of flow on the interception characteristics of the sediment in paddy field was considered, but the effect like EM or other added substances is less considered. In the process of intercepting lost nitrogen, phosphorus and other pollutants, the main microorganisms in the rhizosphere (mycorrhiza fungi and rhizosphere promoting endophytic bacteria, etc.), can expand the buffer function area the period of buffer function, improve buffer soil characteristics, and give full play to the limited land the interception and net function .Under the effect of EM technology the adsorption characteristics of nitrogen and phosphorus are not clear.

4. Acknowledgements

Thanks very much for Professor Shao Xiaohou who provide a lot of help so that the research can be carried out smoothly.

5. References

[1] Environmental Protection Department of the people's Republic of China, the people's Republic of China National Bureau of statistics, Ministry of agriculture of the people's Republic of China. The first national pollution source census bulletin [EB / OL]. / content ['s] *http: / /www. Gov. cn/jrzg/2010-02 / Content_1532174. HTM*.

[2] Wang Chao, Wang Peifang, Hou Jun et al. Main contents and key technologies of ecological water saving irrigation district construction. *Water resources protection*, 2015 (11): 1-7.

[3] Li Haibo, Lv Xuedong, Wang Hong et al. An overview on the strengthening measures of nitrogen and phosphorus removal from paddy fields in paddy field and its application. *Hubei agricultural scienc*e, 2015 (10): 4985-4989.

[4] Li Bai, Li Jun. microbial technology in the prevention and control of agricultural non-point source pollution. *Biotechnology bulletin* 2015, 31 (10):99-104.

[5] Zhao Qinrui, Chang Tingting, Wang Chunfang, et al. Application and Prospect of effective microbial technology in agriculture. *Jiangsu Agricultural Sciences*, 2012, 40 (8): 6 - 8

[6] Xi Bei Dou, Xu Hongdeng, Zhai Lihua, et al. Study on the effect of pH on nitrogen and phosphorus in Ditch Sediment interception of farmland drainage ditch. *Environmental pollution control*, 2007 (7): 490-495.

[7] Zhang Yan, Yan Baixing. P wet and dry conditions in ditch sediments purifying nitrogen influence study. *Journal of soil and water conservation*, 2011, (6): 113-116.

[8] Xue Fei. Kinetics and influencing factors nitrogen and phosphorus adsorption in ditch sediment of Guizhou Caohai Wetland Farmland [J]. *Journal of agro environment science*, 2012, 31(10):1999-2005.

[9] B. J. Peterson, W. M. Wollheim, P. J. Mulholland, et al. Control of nitrogen export from watershed by headwater streams. *Science*, 2001, 292: 86-90.

[10] Zhai Lihua, Liu Hongliang, Xi Bei Dou, et al. Study on adsorption characteristics of nitrogen and phosphorus in ditch sediments from agricultural source ditches. *Journal of agro environmental science*, 2008, 27 (4) 1359-1363.

[11] Wang Yan, Wang Jianguo, Li Wei, et al. A preliminary study on the mechanism of nitrogen and phosphorus removal from farmland drainage by ecological ditches. *Journal of ecology and rural environment*, 2010, 26 (6): 586-590.

[12] Ji Xianchao, Li Haibo, Yu Yanyan, et al. The adsorption behavior of ammonia nitrogen in the ditch sediments after the drainage from paddy field in the estuary area [J]. *China Agricultural bulletin*, 2015, 31 (32): 148-153.

[13] T. V. N. Parmesan, K. Vijayaraghavana, G. Sekaranb, et al. Batch and column studies on biosorption of acid dyes on fresh water macroalga Akola filiculoides.*Journal of Hazardous Materials*, 2005,125(1-3):121-129.

[14] S. Riga, P. Tatum, T. D. Astard, et al. Effects of salinity on NH_4^+adsorption capacity nitrification and gentrification in Danish estuary sediments. *Estuaries*, 1999, 22:21-30.

[15] B. H. Zhang, D. Y. Wu, C. Wang, et al. Simultaneous removal of ammonium and phosphate by zeolite synthesized fromcoal fly ash as influenced by acid treatment. *Journal of Environmental Science*s-China, 2007, 19 (1):540-545.

[16] Zhang Yan, Zhu Hui, Yan Baixing. Drainage ditch slag and sediment on water and nitrogen, phosphorus retention effect [J]. *Chinese Environmental Scienc*e 2013, 33 (6):1005~1010.

[17] Study on effective microorganisms. EM use case set. *Technology*: EM Japan Research Institute, 2004

[18] Shao Xiaohou. Agricultural environment science. Nanjing: Hohai University press, 2005

[19] Shao Xiaohou, Chang Tingting, Wu Qijin. Research and application of effective microorganisms in sustainable agriculture. *Nanjing: Publishing House of Hohai University*, 2015

[20] Cheng Jin. Study on the application of effective microorganisms in ecological agriculture. *Nanjing: Hohai* University, 2008

[21] E. J. Dunne, N. Culleton, G. O'Donovan, et al. Phosphorus retention and sorption by constructed wetland soils in Southeast Ireland. *Water Research*, 2005, 39(18) : 4355-4362.

[22] A. M. Zhou, H. X. Tang, D. S. Wang, Phosphorus adsorption onnatural sediments: modeling and effects of p H and sediment composition. *Water Research*, 2005, 39 (7) : 1245-1254.