Experimental Study on Application of A Charging Flocculation Agent for Treatment of Turbidity and Suspended Solid in Catfish Farming Water in Vinh Long Province

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Abstract: The electrically charged flocculation agent Kiyomaru was made on the basis of activating surface sand, clay, volcanic ash and then combined with strong electrical charge on the surface. Thus, it is the flocculant with natural and inorganic origin including 24.7% Na, 11.5% Al, 19.6% Si, 22.5% S, 1.8% K, 19.0% Ca and 0.9% Fe. The experimental results showed that the Kiyomaru is a flocculation agent with ability to treat the turbidity and suspended solid in the catfish farming waters with very high sedimentation rate and removal efficiency. The efficiency of turbidity removal is from 98.7% to 99.1%, while that for TSS removal is from 93.5% to 95.2% using 0.2 mg/L of the flocculation agent. Beside those, the agent can remove the organic matters (BOD, COD) from 21.4% to 26.7%, Total N from 32.4% to 33.9% and Total P from 85.4% to 89.3%. When the concentration of this flocculate agent is 0.2 g/L, turbidity treatment efficiency can range from 98.7% to 99.1%; TSS treatment efficiency can range from 93.5% to 95.2%. Besides, this flocculation agent is also capable of reducing 21.4%-26.7% of the organic matter, 32.4% to 33.9% of Total N and 85.4% to 89.3% of Total P.

Key words: Charging flocculation agent, catfish farming, turbidity, suspended solid, treatment.

1. Introduction

During the process of water and wastewater treatment, coagulation and flocculation are the important phases to reduce turbidity and suspended solid contents [1]. Up to now, there have been many researches on using different kinds of traditional flocculants (such as iron alum, alum, etc.) and polymer [2, 3]. However, some recent researches show that using such flocculants could have negative impacts on the environment, for instance the Alzheimer disease in the elderly persons caused by high level of aluminum residues in domestic water. Therefore, researchers have recently shift interests towards natural flocculation as a measure to partly or fully substitute for chemical coagulation.

With abundant freshwater resources, in the past, the aquaculture farming of Vinh Long province has been constantly growing, in which the total area for intensive catfish farming is 427 ha, with yield up to 112,476 tonnes (2011). Despite its socio-economic interest, the catfish farming discharges a large volume of wastewaters, containing high turbidity, suspended solids, organic matter (BOD, COD), nutrients (N, P), which pollute the freshwater resources. In order to protect the water resources to meet water demands for domestic activities, industrial production, agriculture, aquaculture, tourism and transportation, the wastewater from catfish ponds needs to be treated to meet the technical regulations.

In the last few years, the experts of HALVO Group (Japan) has invented a new kind of flocculants on the basis of activating surface sand, clay, volcanic ash, combined with electrical charge (called as Kiyomaru)

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to thoroughly treat the surface water, ground water, waste water containing large suspended solids content and turbidity (up to 10,000 ppm). This flocculant is considered as an ecological flocculant due to its natural origin, in which it contains no chemical. Besides, this flocculant is also at reasonable price, has big floccules, rapid sedimentation rate (from a few seconds to tens of seconds, much faster than the traditional flocculants), and low sludge volume. Therefore, this model of water treatment technology for catfish ponds will help saving water (no longer need to change pond water) and reduce environmental pollution.

This paper will present the research results of applying flocculants with strong electrical charge to handle turbidity and suspended solids in the catfish ponds water of Vinh Long province.

2. Materials and Methods

2.1 The Charging Flocculation Agent

The electrically charged flocculation agent Kiyomaru was made on the basis of activating surface sand, clay, volcanic ash then combined with strong electrical charge on the surface. Thus, it is the flocculant with natural and inorganic origin including 24.7% Na, 11.5% Al, 19.6% Si, 22.5% S, 1.8% K, 19.0% Ca and 0.9% Fe. Since this flocculant is not yet sold in Vietnam, all sample of this electrically charged flocculant was sufficiently supplied by Halvo Group (Japan), in accordance to the research needs.

2.2 Catfish Farming Wastewater in Vinh Long

On 25th April 2014, the Environmental Technology Center (ENTEC) conducted a survey and collected water samples from a catfish farm pond with an area of 6,000 m² belonging to Mr. Phan Thanh Vinh's family at Tan Xuan village, Tan Ngai commune, Vinh Long city, Vinh Long province. The total of 40-liter sample water was collected and then got cryo preserved and transported back to the laboratory for

analysis and experiments. The catfish pond water samples were taken and preserved in accordance with TCVN 6663-3: 2008, guiding the preservation and handling of samples.

2.3 Experiment

Jartest experiments have been implemented to evaluate the effectiveness of the coagulation and flocculation process corresponding with different flocculant levels. A series of experiments were conducted in beakers with the capacity of 500 mL per cup. In order to reproduce the coagulation and flocculation stage occurring in a typical water treatment chain, each experimental session involves the procedure of pouring 500 mL of pond's water samples into the beaker, stirring for 30 seconds with a speed of 400 stirs/minute and adding an extra predetermined amount of flocculants concentration (M) (0.10; 0.16; 0.20; 0.24 g/L), and then stirring more slowly in 1 minute (using a stirrer or by hand). Then, water samples were settled for 15 minutes before conducting a quality analysis for the settled water portion. All experiments were carried out at room temperature.

Each experiment identifies some particular parameters, including large particle deposition time T_b (second), small particle deposition time T_s (minute)-measured with a stopwatch, sludge volume V_b using measure cups (ml), floccules size Z (mm) by observing via OLYMPUS CX 21FS1 microscope and measuring the particle diameter using micro-rulers with the smallest resolution bar of 1 mm and cell counting chamber with the smallest resolution bar of 50 μ m. The analyzed parameters in catfish ponds wastewater before and after treatment includes pH, TDS, colour, turbidity, TSS, COD, BOD₅, DO, Total N and Total P. The analytical methods are in compliance with the provisions in Vietnam's current regulations.

2.4 Regulation

The regulation applied to evaluate the quality of

catfish ponds wastewater after treatment is QCVN 08-MT:2015/BTNMT-National technical regulations on surface water quality (Column A2-used for the aquatic fauna conservation purposes).

3. Results and Discussion

3.1 Analysis Results of the Catfish Pond Wastewater

The water sample used for the experimental research was taken at the catfish farming pond of Mr. Phan Thanh Vinh's family with an area of 6,000 m² at Tan Xuan village, Tan Ngai commune, Vinh Long city, Vine Long province. The analysis results of 10 parameters in catfish pond water before treatment with the flocculation method are presented in Table 1.

The analyzed results of sample AC2-0 presented in Table 1 show that the level of colour, turbidity, TSS, BOD, COD concentrations in catfish pond water at Vinh Long province is higher than that in the technical regulation QCVN 08-MT: 2015/BTNMT (column A2).

3.2 Experimental Results of Catfish Pond Wastewater Treatment

The results of wastewater treatment corresponding with different flocculants levels for AC2 samples are shown in Table 1.

Experimental results of AC2-1, AC2-2, AC2-3, AC2-4 samples when increasing the concentration of Kiyomaru flocculant from 0.10 g/L to 0.24 g/L in Table 1 show that:

- the pH levels after treatment (7.4-7.5), are higher than those before treatment (7.1), qualified with the technical regulation QCVN 08-MT: 2015/BTNMT, column A2;
- the TDS concentrations after treatment (252-268 mg/L), are higher than those before treatment (231 mg/L);
- the colour levels after treatment (50-62 Pt-Co) are lower than those before treatment (173 Pt-Co), with treatment efficiency achieved from 64% to 71%;

- the turbidity levels after treatment (3.0-9.2 NTU) are lower than those before treatment (280 NTU), with treatment efficiency achieved from 96.7% to 98.9%;

- the concentrations of TSS after treatment (4-8 mg/L) are lower than those before treatment (62 mg/L), qualified with the technical regulation QCVN 08-MT: 2015/BTNMT (column A2), with treatment efficiency achieved from 87.1% to 93.5%;

- the concentrations of COD after treatment (21-25 mgO₂/L) are lower than those before treatment (30 mgO₂/L), higher than technical regulation QCVN 08-MT: 2015/BTNMT (column A2), with treatment efficiency achieved from 16.7% to 30.0%;

- the concentrations of BOD₅ after treatment (10-12 mgO₂/L) are lower than those before treatment (14 mgO₂/L), higher than technical regulation QCVN 08-MT: 2015/BTNMT (column A2), with treatment efficiency achieved from 14.3% to 28.5%;

- the concentrations of DO after treatment (6.1-6.2 mgO₂/L) are higher than those before treatment (5.5 mgO₂/L), qualified with the technical regulation QCVN 08-MT: 2015/BTNMT (column A2);

- the concentrations of Total N after treatment (10.24-13.21 mg/L) are lower than those before treatment (15.34 mg/L), with treatment efficiency achieved at 13.9% to 33.2%;

- the concentrations of Total P after treatment (0.045-0.064 mg/L) are lower than those before treatment (0.355 mg/L), with treatment efficiency achieved from 82.0% to 87.3%;

- the optimal concentration of the electrically charged flocculation agent to treat AC2 sample is 0.2 g/L;

- time of large particle deposition (T_b) is under 60 seconds; time of small particle deposition (T_s) is around 15 minutes; flocculesize (Z) is around 2-5 mm and sludge volume (V_b) is approximately 2-4 mg.

Experimental results of surface water treatment for AC2 with flocculant concentrations from 0.1 g/L to 0.24 g/L are presented in Fig. 1.

Table 1 Result of wastewater treatment corresponding with different flocculants levels for AC2 samples.

No	Parameter	Unit	AC2-0	AC2-1	AC2-2	AC2-3	AC2-4	QCVN 08-MT 2015/BTNMT, column A2
1	M	g/L	0.00	0.10	0.16	0.20	0.24	
2	T _b	second		60	60	60	60	
3	T _s	minute		15	15	15	15	
4	Z	mm		2-5	2-5	2-5	2-5	
5	V _b	mL/L		2	3	4	4	
6	pH	-	7.1	7.4	7.4	7.5	7.4	6.0-8.5
7	TDS	mg/L	231	252	263	263	268	-
8	Colour	Pt-Co	173	62	50	50	50	-
9	Turbidity	NTU	280	9.2	5.3	3.0	4.4	-
10	TSS	mg/L	62	8	7	4	5	30
11	COD	mgO ₂ /L	30	25	21	22	25	15
12	BOD ₅	mgO ₂ /L	14	12	10	11	12	6
13	DO	mgO ₂ /L	5.5	6.1	6.2	6.1	6.1	≥5
14	Total N	mg/L	15.34	13.21	12.06	10.24	11.06	-
15	Total P	mg/L	0.355	0.064	0.045	0.063	0.051	-

The experimental results of wastewater treatment for sample AC2 with optimal flocculant's concentration of 0.2 g/L are shown in Table 2 and Fig. 2.

Experimental results of wastewater treatment for Sample AC2-3.1. AC2-3.2. AC2-3.3 with optimal flocculant's concentration of 0.2 g/L in Table 2 shows that:

- the pH value after treatment is 7.5, reaching the technical regulation QCVN 08-MT: 2015/BTNMT, column A2;
- the concentrations of TDS after treatment are changed from 255 mg/L to 256 mg/L;
- the colour levels after treatment are changed from 45 to 47 Pt-Co, with treatment efficiency achieved at 72.8% to 74.0%;
- the turbidity levels after treatment are changed from 2.5 NTU to 3.4 NTU, with treatment efficiency achieved at 98.7% to 99.1%;
- The concentrations of TSS after treatment are changed from 3 mg/L to 4 mg/L, qualified with the technical regulation QCVN 08-MT: 2015/BTNMT (column A2), with treatment efficiency achieved from

93.5% to 95.2%;

- the concentration of COD after treatment is changed from 22 mgO₂/L to 23 mgO₂/L, higher than technical regulation QCVN 08-MT: 2015/BTNMT (column A2), with treatment efficiency achieved from 23.3% to 26.7%;

- the concentration of BOD₅ after treatment is 11 mgO₂/L, higher than technical regulation QCVN 08-MT: 2015/BTNMT (column A2), with treatment efficiency achieved at 21.4%;

- the concentration of DO after treatment is 6.2 mgO₂/L, qualified with the technical regulation QCVN 08-MT: 2015/BTNMT (column A2);

- the concentrations of Total N after treatment are changed from 10.14 mg/L to 10.37 mg/L, with treatment efficiency achieved at 32.4% to 33.9%;

- the concentrations of Total P after treatment are changed from 0.038 mg/L to 0.052 mg/L, with treatment efficiency achieved at 85.4% to 89.3%.

- Time of large particle deposition (T_b) is under 60 seconds; time of small particle deposition (T_s) is around 15 minutes; floccule size (Z) is around 2-5 mm; sludge volume (V_b) is approximately 2-4 mL.

Fig. 1 Experimental results of surface water treatment for sample AC2 corresponding with different flocculants levels.

Fig. 2 Experimental results of wastewater treatment for sample AC2 with optimal flocculants level of 0.2 g/L.

Table 2 Experimental results of wastewater treatment for sample AC2 with optimal flocculants level.

N	Parameter	Unit	AC2-3.1	AC2-3.2	AC2-3.3	QCVN 08-MT : 2015/BTNMT, column A2
1	M	g	0.2	0.2	0.2	
2	T _b	second	60	60	60	
3	T _s	minute	15	15	15	
4	Z	mm	2-5	2-5	2-5	
5	V _b	mg	4	4	4	
6	pH	-	7.5	7.5	7.5	6-8.5
7	TDS	mg/L	256	255	256	-
8	Colour	Pt-Co	45	46	47	-
9	Turbidity	NTU	2.5	3.4	3.2	-
10	TSS	mg/L	4	3	3	30
11	COD	mg/L	22	22	23	15
12	BOD	mgO ₂ /L	11	11	11	6
13	DO	mgO ₂ /L	6.2	6.2	6.2	≥5
14	Total N	mg/L	10.37	10.14	10.31	-
15	Total P	mg/L	0.052	0.038	0.049	-

4. Conclusion

Based on the experimental results, it can be concluded that:

- The charging flocculation agent Kiyomaru is capable of treating turbidity and suspended solid of catfish pond water with quick deposition time and high treatment efficiency. When the concentration of this flocculate agent is 0.2 g/L, turbidity treatment efficiency can range from 98.7% to 99.1%; TSS treatment efficiency can range from 93.5% to 95.2%. Besides, this flocculation agent is also capable of reducing 21.4-26.7% of the organic matter contents (BOD, COD), 32.4% to 33.9% of Total N and 85.4% to 89.3% of Total P.

- The floccule size is big so it can easily be separated from the water without the need for sludge dewatering stage.

- The water treatment process is simple so it would be cost saving.

With such good treatment efficiency, the charging flocculation agent Kiyomaru can be used for catfish pond water treatment in Vinh Long province, as well

as in Mekong Delta. However, in order to have sufficient basis to evaluate the economic efficiency of using Kiyomaru in comparison with other flocculants, it is essential to conduct a real-scale experimental model.

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