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Effect of Powder Activated Carbon (PAC) in Enhancing Turbidity Removal in Existing WTP

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ملخص البحث

أختبار الكأس هو اختبار يتم إجرائه بمعامل محطات تنقية المياه السطحية وذلك بغرض تحديد جرعات المواد الكيميائية المروبة اللازم استخدامها في محطات مياه الشرب. وهذة التجربة تحاكي عملية الإضافة ثم الترويب والتجلط وأخيرا عمليات الترسيب فى محطة تنقية مياه الشرب وبالتالي يساعد في تحديد الجرعات المناسبة لتجلط المواد العالقة الدقيقة نتيجة إضافة الشبة (كبريتات الألومنيوم) وهذا البحث تم أستخدام مسحوق الفحم النشط PAC لدراسة مدى كفاءة مسحوق الفحم النشط في إزالة العكارة من المياه السطحية.

Abstract

Jar testing is a pilot-scale test of the treatment chemicals used in particular surface water treatment plant. It simulates the coagulation and flocculation process in a drinking water treatment plant and helps operators to determine the optimum dose of coagulant as Alum and PAC, and to obtain the effect of adding PAC to improve the removal ratio of turbidity.

Keywords

Jar testing, Alum, PAC, Coagulation, organic matter, Surface water treatment plant

1. Introduction

Jar testing is a method of simulating a full scale water treatment process, providing system operators a reasonable idea on how treatment chemicals behave and operate with a particular type of raw water. Because it helps to determine the dose and the kind of chemical treatment that improves the removal ratio of turbidity.

This study investigated the feasibility of improving water treatment efficiency with powdered activated carbon (PAC). Jar tester was employed in experiments to simulate the conventional chemical coagulation/sedimentation process. Experimental results indicated that PAC could enhance the organic (COD) removal efficiency. The COD removal rate increased with the increase of PAC dosage. In addition, PAC could act as a coagulant aid to increase the removal rate of turbidity. Introducing PAC during rapid mixed period could obtain better organic (COD) removal rate than that of adding PAC at slow mixed (flocculation) period. Pre-contact of PAC with raw water for a period of time followed by coagulation and sedimentation. No matter where the application point of PAC in the treatment process is, this study found that, addition of PAC resulted in better COD removal efficiency than that without PAC.

2. Jar testing process

The jar testing process can be summarized as follows:

1. First, using a 1000 (ml) graduated cylinder, add 1000 ml of raw water to each of the jar test beakers. Record the temperature, pH, and turbidity of the raw water.

2. Then start a rapid mixing of 120 rpm for one minute.

3. Prepare a stock solution by dissolving (35 ppm) of aluminum sulphate coagulant into 1,000 ml distilled water. This alum dose (35 ppm) is the used dose at El Ameria WTP. Then add PAC of dose (5-10) ppm.

4. The purity (strength) of Alum (liquid) will be the same for plant operation using the prepared stock solution of alum & PAC.

5. Start the stirring machine and operate it for one minute at a speed of 120 rpm. While the stirrer operates, record the appearance of the water in each beaker. Note the presence or absence of floc, the cloudy or clear appearance of water, and the color of the water and floc.

6. Reduce the stirring speed to 25 rpm and continue stirring for 20 minutes.

7. Stop stirring apparatus and put samples in the beakers to settle for 30 minutes.

8. Determine which coagulant dosage has the best flocculation time and the most floc settled out. This is the optimal coagulant dosage.

9. Properly coagulated water contains floc particles that are well-formed and dense.

10. Measure the turbidity of the water in each beaker using a turbidity meter.

11. Measure the temperature & pH.

12. Tabulate all above data in tables showing comparison between alum doses & PAC doses.

Figure (1) Jar testing Apparatus

A jar testing apparatus as shown in figure (1) used for this experiment. It consists of six identical beakers (jars) each of one 1iter capacity, each equipped with a stirrer and the stirrers are driven by one motor, thus giving each the same rotation velocity.

The jar test was performed along May 2016 using Alum (aluminum sulphate) as a coagulant, and powder activated carbon (PAC) to enhance setting action and remove organic pollutant matter.

3. RESULTS OF JAR TESTING

Results of five runs of jar testing (each run was carried 3 times) using both alum and (PAC) by different dosages were tabulated after measuring (residual turbidity, pH, temperature, residual suspended solid and SS) in tables (1) to (5) and illustrated by figures (2) to (11).

Table (1) Results of jar testing no. (1)

No	Sample No.	1	2	3	4	5	6
	Alum Dose (ppm)	Blank	20	25	30	35	40
1	pH value	8.2	7.9	7.7	7.5	7.3	7.2
2	Temperature C°	25	25	25	25	25	25
3	Turbidity (NTU)	12.3	10	5	1	0.49	1
4	T D S (ppm)	261	264	266	379	271	275
5	S.S (ppm)	12	6	3	1	0	1
6	Conductivity	395	400	404	408	410	415

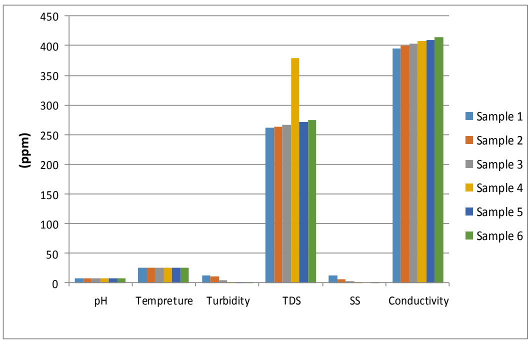

Figure (2) Jar testing no. (1) Parameters results

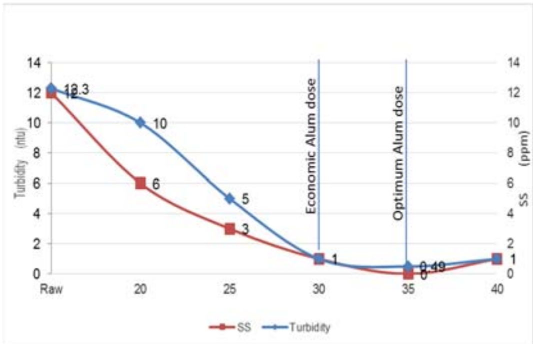

Figure (3) jar testing no. (1) Turbidity and SS results

Table (2) Results of jar testing no. (2)

No	Sample No.	1	2	3	4	5	6
	Dose (Alum) ppm	Blank	20	25	30	35	40
	Dose (PAC) ppm	Blank	2	4	5	6	8
1	pH value	8.23	8.23	8.23	8.23	8.23	8.23
2	Temperature C°	25.4	25.5	25.6	25.6	25.7	25.8
3	Turbidity (NTU)	13	1	0.5	0.56	0.55	0.57
4	T D S (ppm)	248	254	255	255	255	257
5	S.S (ppm)	14	5	0	0	0	1
6	Conductivity	375	378	376	376	380	389

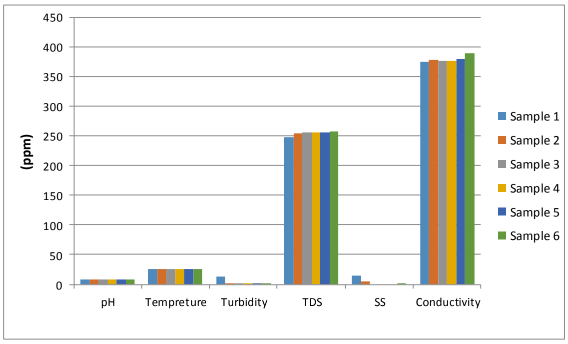

Figure (4) Jar testing no. (2) Parameters results

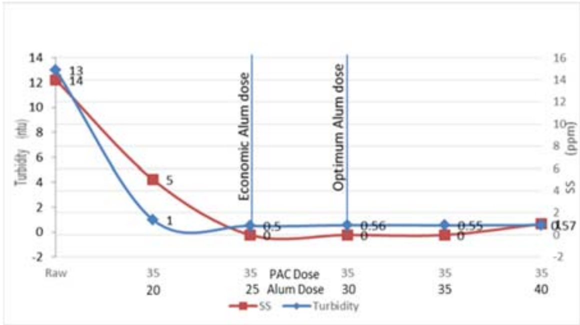

Figure (5) jar testing no. (2) Turbidity and SS results

Table (3) Results of jar testing no. (3)

No	Sample No.	1	2	3	4	5	6
	Dose (Alum) ppm	Blank	35	35	35	35	35
	Dose (PAC) ppm	Blank	10	12	14	16	18
1	pH value	8.2	8.0	7.8	7.6	7.5	7.3
2	Temperature C°	27	27	27	27	27	27
3	Turbidity (NTU)	12.8	2	3	4	5	7
4	T D S (ppm)	244	248	250	251	252	253
5	S.S (ppm)	14	11	10	10	3	4
6	Conductivity	369	370	375	380	384	384

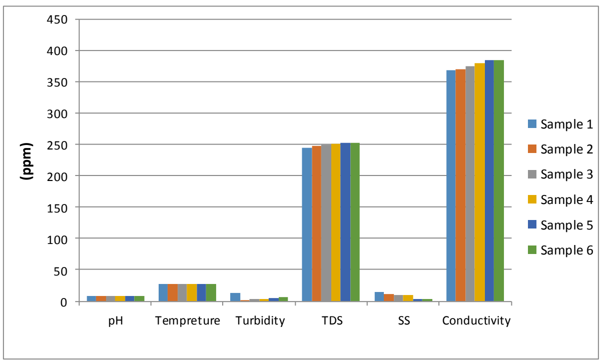

Figure (6) Jar testing no. (3) Parameters results

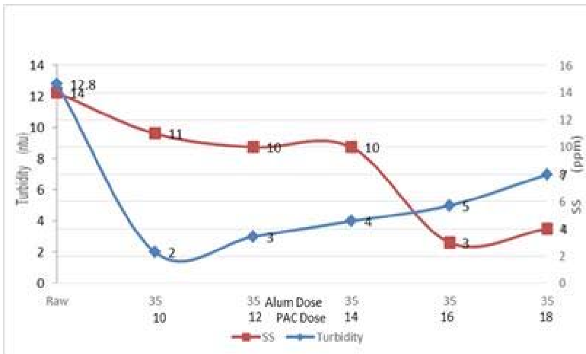

Figure (7) jar testing no. (3) Turbidity and SS results

Table (4) Results of jar testing no. (4)

No	Sample No.	1	2	3	4	5	6
	Dose (Alum) ppm	Blank	15	20	25	30	35
	Dose (PAC) ppm	Blank	4	4	4	4	4
1	pH value	8.15	8.0	7.9	7.8	7.5	7.33
2	Temperature C°	25.7	25.5	25.5	25.5	25.2	25.0
3	Turbidity (NTU)	11.1	5	4	0.6	0.5	0.65
4	T D S (ppm)	249	252	253	255	256	258
5	S.S (ppm)	16	4	3	0	0	1
6	Conductivity	378	379	382	385	390	391

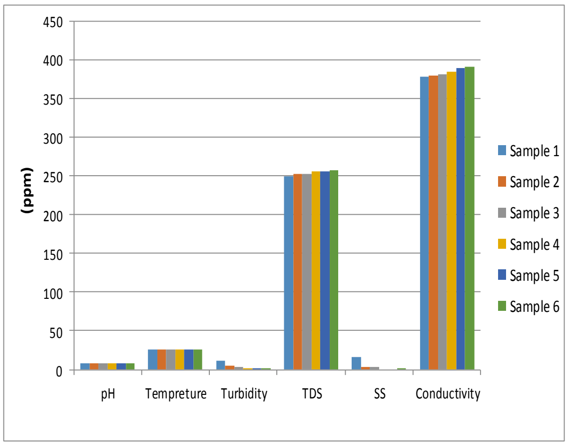

Figure (8) Jar testing no. (4) Parameters results

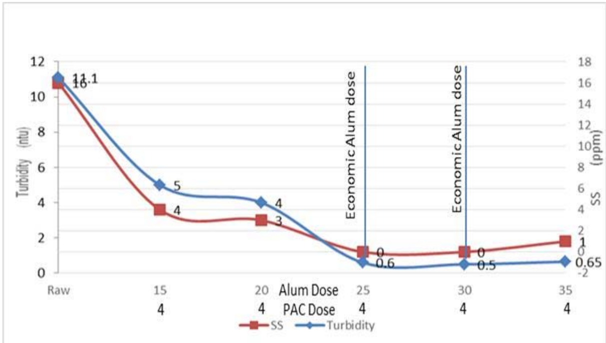

Figure (9) jar testing no. (4) Turbidity and SS results

Table (5) Results of jar testing no. (5)

No	Sample No.	1	2	3	4	5	6
	Dose (Alum) ppm	Blank	15	20	25	30	35
	Dose (PAC) ppm	Blank	1	2	3	4	5
1	pH value	8.2	8.0	7.8	7.6	7.5	7.3
2	Temperature C°	25	25	25	25.5	25.5	25.5
3	Turbidity (NTU)	11	2	1	0.6	0.5	0.56
4	T D S (ppm)	250	252	254	256	258	259
5	S.S (ppm)	10	2	1	0	0	1
6	Conductivity	379	383	385	388	390	392

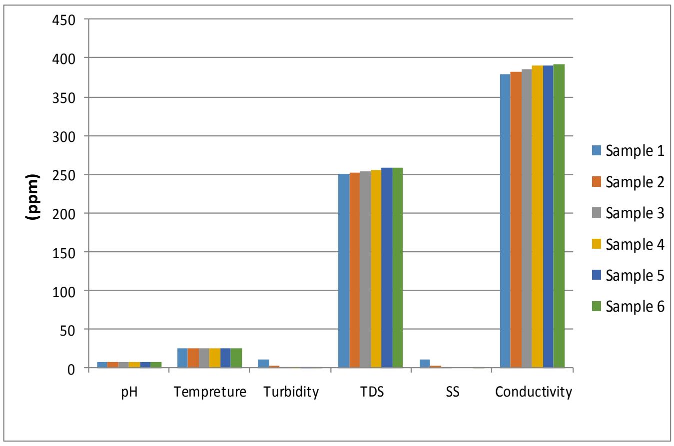

Figure (10) Jar testing no. (5) Parameters results

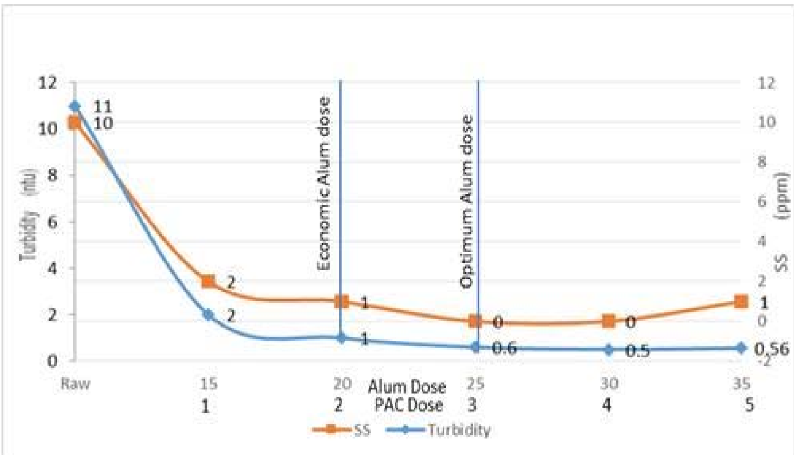

Figure (11) jar test no. (5) Turbidity and SS results

4. Discussion

a- The experimental work of Jar testing no. (1) showed that the optimum dose of Alum coagulant is (35 ppm) and the economic dose is (30 ppm).

b- When using (PAC) to reduce Alum dose and monitoring the effect of PAC in enhancing turbidity removal, it was found that the optimum dose of (PAC) was (4 ppm) plus alum dose (25 ppm).

The above conclusion means that we can reduce alum dose by (10 ppm) i.e. 30% approximately reduction in alum dose. Thus, we can avoid the residual aluminum compounds which have harmful effect on human's brain.

5. CONCLUSION

Our conclusion is the suitability of powder activated carbon for the coagulation process as it enhancing the turbidity removal and reduce the alum dose. Moreover, (PAC) makes shadow through depth of water which alter the penetration of sun rays to avoid the development of algae which considered as organic pollutant.

6. RECOMMENDATIONS

PAC is normally added early in the treatment process and is subsequently removed either by sedimentation or by the filter beds during backwashing. The PAC application point should allow for:

1. An adequate contact time between the PAC and organics.
2. Avoid coating PAC particles with other water treatment plant chemicals.

References

1. Pask, David. 1993 "Jar Testing : Getting Started on a Low Budget." On Tap : National Environmental Service center.

2. Lafleur, Tina. 1997. "Jar Testing".

3. NYC Water Summit, 9 April 2010

4. Zane Sat terfield, P. E. Engineering Scientist

5. Enhancement of coagulation process with powdered activated carbon in PCB and heavy metal ions removal from drinking water, Agata Rosinska & Lidia Dabrowska, Department of Chemistry, water and wastewater technology, Czestochowa University of Technology, April 2016

6. APHA, AWWA and WEF, Standard method for examination of water and waster water, American Public Health Association, Washington D. C. 2005