Optimum Dosage of Coagulant and Flocculant on Sea Water Purification Process

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Abstract: This study aims to determine the appropriate dose in the use of coagulant and flocculant, thereby make the use of chemicals. This study used a design of experiment methods to determine the effect of treatment variation on water quality, i.e., coagulant and flocculant dose, raw material flow rate and sea water condition to turbidity and pH. As a reference, pH and turbidity must be below the maximum allowed for process water. The test was done in laboratory by using jar test method. The chemicals used as coagulants and flocculants was PAC polymers (poly amylum chloride). The results showed that coagulant and flocculant dose, flow rate and sea water condition had significant effect on turbidity and pH. The condition of seawater studied here is the tidal and low tide conditions. After variation of dosage and flow rate in sea tide and low tide conditions, the following conclusions were obtained; in tidal conditions, the optimum dose of coagulant and flocculant was 70 ppm at a flow rate of 450 m³ with reference turbidity 0.9 NTU and pH 6.9. While at low tide conditions, the optimum dose of coagulant and flocculant was 70 ppm at a flow rate of 420 m³ with reference turbidity 1.1 NTU and pH 6.9. This result is expected to be applied to factories that use seawater as raw material for process water.

Keywords: coagulant, flocculant, optimum dose, seawater, process water

1. Introduction

The use of seawater as a raw material for industrial process water is now needed along with the limited availability of groundwater, especially for factories located close to residential areas. But the use of sea water is certainly not as simple as the use of groundwater because sea water has a high salt content and metal content that will damage the equipment if not processed first. In this study, the method used in seawater treatment is the method of coagulation and flocculation, with consideration of equipment that is simpler and can be done anywhere.

Coagulation and flocculation are the process of collecting particles of the clouds that can not be precipitated by gravity, into larger particles that can be precipitated and separated from the fluid. In the method of coagulation and flocculation, it is necessary to use chemicals that function as coagulant and flocculant. Determination of appropriate dosage in the use of coagulant and flocculant is needed to use of chemicals and processing costs become efficiently.
2. The review

2.1 Water as primary needs in industry

Water is a natural resource necessary for the livelihood of many people, even by all living things. Therefore, water resources must be protected in order to remain well utilized by humans and other living things. The use of water for various interests must be done wisely, taking into account the interests of present and future generations. Aspects of saving and conserving water resources must be invested in all water users [3].

Water is also an important requirement in the industry. There are three water use divisions in the industry, namely:

- Cooling water: Water is a cooling medium that is selected in many industries because of its abundant availability, easy to absorb heat and can absorb high heat volume unity.
- Boiler feed water: Water is the main raw material in steam manufacturing. To be used as boiler feed water, water must meet the requirements, namely
  a) Clear, not cloudy, does not contain impurities
  b) Does not contain ingredients that can cause corrosion
  c) Does not contain ingredients that can cause foaming
- Water for office utilities and employee consumption: Water for employee needs must of course meet the following criteria:
  a) Clear, not cloudy, does not contain dissolved solids
  b) Normal ph (6-7)
  c) Does not contain harmful bacteria
  d) Does not contain dangerous heavy metals

The raw water used comes from sea water. Water intake from the sea is carried out in the jetty area which is equipped with an intake pump (sea water transfer pump). Sea water as raw water is pumped into the process of clean water treatment and continued with demin water process. Water treatment from seawater to demin water is done through several process stages as follows:

a. Disinfectant. Sea water to be processed must be free of bacteria, algae and organic, for that purpose before being sent to the clarifier should be injected with hypochlorite to sterilize it. this process should prevent the moss and its scaling from the SWRO and BWRO units.

b. Adjustment of PH. The pH adjustment process is used to increase the pH in the water to be treated in order to obtain the optimal pH required by the Coagulation and Flocculation process and to achieve normal pH after the Sea Water Reverse Osmosis (SWRO) process. This process must prevent bacterial growth and as a need for coagulation and flocculation to form in neutral pH

2.2 Coagulation and Flocculation

Coagulation and flocculation After going through disinfection and the process of pH adjustment, proceed to coagulation and the process of flocculation before entering the clarifier unit. The process of forming floc will occur when the pH is normal. The coagulation process aims to form floc from particles / solids suspended in the raw water. The chemical used in the coagulation process is Alum / PAC. For chemicals diluted homogeneously using a fast mixer so that the fine floc will form properly. the process of flocculation intends to form a large flock of fine floc formed from process coagulation. Chemicals used to bind fine floc are PE / Polymers (polyelectrolytes). This process must be carried out by slow mixing so that the floc is not split and loosened again.
Coagulation is the process of mixing chemicals (coagulants) with raw water to form a homogeneous mixture. By coagulation, colloidal particles will attract and clump to form a flock. The colloidal particles formed are generally too difficult to remove if only by gravitational deposition. But if the colloids are stabilized by aggregation or coagulation into larger particles, these colloids can be eliminated quickly [5].

Coagulation is a chemical process used to remove particles that can cause environmental pollution[2]. These particles cannot settle themselves and are difficult to handle physically. The addition of coagulant will destabilize the particles to form a microfloc. The microfloc is then coagulated into macrofloces which can be deposited through the process of flocculation. This clotting process depends on time and slow stirring in water. Generally the flocculation period will occur for 10-30 minutes after the coagulation process. The faster the mixing time, the larger the flock.

Coagulation generally has a high degree of aggregation and facilitates the neutralization mechanism. The performance of coagulation and flocculation depends on many factors, some of which are interrelated, which makes it difficult to optimize. Characteristics of the water source, stirring conditions, flocculation time, selected chemicals, and addition to the coagulation process will affect the performance of coagulation. Coagulants are divided into several types, namely Poly Aluminum Chloride (PAC), Chitosan, Ferro Sulfate, Ferric Sulfate, Ferro Chloride, Ferric Chloride, and Aluminum Sulfate. Optimization of pH needs to be done to ensure the pH value received in the distribution system of the coagulant so that the coagulation process goes well. The pH value for the coagulation process varies, depending on the coagulant and the water characteristics chosen[3].

2.3 Factors Affecting Coagulation-Flocculation

In water treatment, to achieve the optimum coagulation-flocculation process, it is necessary to regulate all conditions that are interrelated and affect the process. Affecting conditions include pH, temperature, coagulant concentration and stirring.

1) pH: a coagulation process can take place perfectly if the pH used is at a certain distance according to the optimum pH of the coagulant and flocculant used.

2) Temperature: the coagulation process can be reduced at low temperatures as the viscosity increases and the aggregate structure changes becomes smaller so that it can pass from the filter, whereas at higher temperatures that have smaller densities will flow to the bottom of the pond and damage the mud.

3) Coagulant concentration: coagulant concentration is very influential on particle collisions, so the addition of coagulants must be in accordance with the need to form floc. If the coagulant concentration is less, the collision between particles is reduced, making it difficult to form a floc. The opposite is true if the concentration of coagulants is too much, the floc is not formed properly and can cause turbidity again.

4) Stirring: good stirring is needed to obtain optimum coagulation and flocculation. Stirring too slowly results in a prolonged period of growth of the flock, whereas if it is too fast, the flocks that have formed become broken again.

3. Research Methods

This research was conducted on STT Dumai chemical laboratory, during April-June 2018. Sample was taken from feed water PT.X which located on Lubuk Gaung, Dumai. Sample was taken on two spots: intake water and clarifier. Sample tested pH and turbidity using jar test method.

As coagulant we use Poly Amylum Chlorida (PAC) and as flocculant we use Acrylic acid copolymer PA322 (polymer). For standard of treatment water, we use Peraturan Pemerintah No. 416/MENKES/PER/IX/1990. For reference of dose coagulant and flocculant, we use standar operasional procedure of PT. X, a palm oil refinery company in Dumai who use sea water as feed water on their process.
4. Result and discussion

The data collected in this research was turbidity dan pH. Data taken from samples from sea water intake and samples from clarifier. First, the experiment was conducted by varying the dose of coagulant and measured its turbidity and pH, as shown by table 1 below.

Table 1. Turbidity Data
Source: Experiment Data (2018)

| No | Sample | Standard (NTU) | Intake (NTU) | Coagulant (ppm) | Flocculant (ppm) | Turbidity (NTU) |
|----|--------|----------------|--------------|-----------------|------------------|-----------------|
| 1  | 1      | 5              | 37.8         | 100             | 1.0              | 6               |
| 2  | 2      | 5              | 44.8         | 100             | 1.0              | 5.4             |
| 3  | 3      | 5              | 30.7         | 100             | 1.0              | 5.5             |
| 4  | 4      | 5              | 44.8         | 100             | 1.0              | 5.5             |
| 5  | 5      | 5              | 28.5         | 100             | 1.0              | 5.4             |
| 6  | 6      | 1              | 37.8         | 100             | 1.0              | 5.8             |
| 7  | 2      | 5              | 44.8         | 110             | 1.0              | 5.2             |
| 8  | 3      | 5              | 30.7         | 110             | 1.0              | 5.5             |
| 9  | 4      | 5              | 44.8         | 110             | 1.0              | 5.5             |
| 10 | 5      | 5              | 28.5         | 110             | 1.0              | 5.2             |
| 11 | 1      | 5              | 37.8         | 120             | 1.0              | **46**          |
| 12 | 2      | 5              | 44.8         | 120             | 1.0              | **4**           |
| 13 | 3      | 5              | 30.7         | 120             | 1.0              | **43**          |
| 14 | 4      | 5              | 44.8         | 120             | 1.0              | **43**          |
| 15 | 5      | 5              | 28.5         | 120             | 1.0              | **4**           |
| 16 | 1      | 5              | 37.8         | 130             | 1.0              | 5.4             |
| 17 | 2      | 5              | 44.8         | 130             | 1.0              | **48**          |
| 18 | 3      | 5              | 30.7         | 130             | 1.0              | 5.1             |
| 19 | 4      | 5              | 44.8         | 130             | 1.0              | 5.1             |
| 20 | 5      | 5              | 28.5         | 130             | 1.0              | 4.8             |
| 21 | 1      | 5              | 37.8         | 140             | 1.0              | 5.7             |
| 22 | 2      | 5              | 44.8         | 140             | 1.0              | 5.1             |
| 23 | 3      | 5              | 30.7         | 140             | 1.0              | 6               |
| 24 | 4      | 5              | 44.8         | 140             | 1.0              | 6               |
| 25 | 5      | 5              | 28.5         | 140             | 1.0              | 5.1             |
From the experiment shown that optimum dose of coagulant which required turbidity standard was 120 ppm.

Table 2 below shown pH data of sea water, before and after experiment with variation of dose of coagulant from 110-140 ppm

| No | Sample | pH max | pH min | pH intake | Coagulant (ppm) | Floculant (ppm) | pH result |
|----|--------|--------|--------|-----------|----------------|----------------|-----------|
| 1  | 1      | 8      | 6      | 7.3       | 100            | 1.0            | 7.1       |
| 2  | 2      | 8      | 6      | 7.5       | 100            | 1.0            | 7.2       |
| 3  | 3      | 8      | 6      | 7.3       | 100            | 1.0            | 7.0       |
| 4  | 4      | 8      | 6      | 7.6       | 100            | 1.0            | 7.1       |
| 5  | 5      | 8      | 6      | 7.7       | 100            | 1.0            | 7.2       |
| 6  | 1      | 8      | 6      | 7.3       | 110            | 1.0            | 7.3       |
| 7  | 2      | 8      | 6      | 7.5       | 110            | 1.0            | 7.2       |
| 8  | 3      | 8      | 6      | 7.3       | 110            | 1.0            | 7.2       |
| 9  | 4      | 8      | 6      | 7.6       | 110            | 1.0            | 7.2       |
| 10 | 5      | 8      | 6      | 7.7       | 110            | 1.0            | 7.4       |
| 11 | 1      | 8      | 6      | 7.3       | 120            | 1.0            | 7.4       |
| 12 | 2      | 8      | 6      | 7.5       | 120            | 1.0            | 7.6       |
| 13 | 3      | 8      | 6      | 7.3       | 120            | 1.0            | 7.5       |
| 14 | 4      | 8      | 6      | 7.6       | 120            | 1.0            | 7.4       |
| 15 | 5      | 8      | 6      | 7.7       | 120            | 1.0            | 7.5       |
| 16 | 1      | 8      | 6      | 7.3       | 130            | 1.0            | 7.6       |
| 17 | 2      | 8      | 6      | 7.5       | 130            | 1.0            | 7.5       |
| 18 | 3      | 8      | 6      | 7.3       | 130            | 1.0            | 7.4       |
| 19 | 4      | 8      | 6      | 7.6       | 130            | 1.0            | 7.6       |
| 20 | 5      | 8      | 6      | 7.7       | 130            | 1.0            | 7.4       |
| 21 | 1      | 8      | 6      | 7.3       | 140            | 1.0            | 7.7       |
| 22 | 2      | 8      | 6      | 7.5       | 140            | 1.0            | 7.8       |
| 23 | 3      | 8      | 6      | 7.3       | 140            | 1.0            | 7.8       |
| 24 | 4      | 8      | 6      | 7.6       | 140            | 1.0            | 7.7       |
| 25 | 5      | 8      | 6      | 7.7       | 140            | 1.0            | 7.8       |

Figure 1. Turbidity Chart

Figure 2. pH Chart
After coagulant dose was determined, next set the flocculant dose. Turbidity standard for boiler’s feed water is < 1.5 NTU. Data experiment presented on table 3

**Table 3** Turbidity data of boiler’s feed water for dose of coagulant

| No | Sample | Standard (NTU) | Intake (NTU) | Coagulant (ppm) | Flocculant (ppm) | Turbidity (NTU) |
|----|--------|----------------|--------------|-----------------|-----------------|-----------------|
| 1  | 1      | 1.5            | 37.8         | 130             | 0.5             | 2.1             |
| 2  | 2      | 1.5            | 44.8         | 130             | 0.5             | 2.2             |
| 3  | 3      | 1.5            | 30.7         | 130             | 0.5             | 1.9             |
| 4  | 4      | 1.5            | 44.8         | 130             | 0.5             | 2.4             |
| 5  | 5      | 1.5            | 28.5         | 130             | 0.5             | 2.2             |
| 6  | 1      | 1.5            | 37.8         | 130             | 0.6             | 0.9             |
| 7  | 2      | 1.5            | 44.8         | 130             | 0.6             | 0.8             |
| 8  | 3      | 1.5            | 30.7         | 130             | 0.6             | 0.7             |
| 9  | 4      | 1.5            | 44.8         | 130             | 0.6             | 1.2             |
| 10 | 5      | 1.5            | 28.5         | 130             | 0.6             | 0.8             |
| 11 | 1      | 1.5            | 37.8         | 130             | 0.7             | 1.74            |
| 12 | 2      | 1.5            | 44.8         | 130             | 0.7             | 1.64            |
| 13 | 3      | 1.5            | 30.7         | 130             | 0.7             | 1.54            |
| 14 | 4      | 1.5            | 44.8         | 130             | 0.7             | 2.04            |
| 15 | 5      | 1.5            | 28.5         | 130             | 0.7             | 1.64            |
| 16 | 1      | 1.5            | 37.8         | 130             | 0.8             | 1.8             |
| 17 | 2      | 1.5            | 44.8         | 130             | 0.8             | 1.7             |
| 18 | 3      | 1.5            | 30.7         | 130             | 0.8             | 1.4             |
| 19 | 4      | 1.5            | 44.8         | 130             | 0.8             | 1.9             |
| 20 | 5      | 1.5            | 28.5         | 130             | 0.8             | 1.7             |

Source: Experiment Data (2018)

**Figure 2** Turbidity data for coagulant 130 ppm and flocculant 0.6 ppm
5. Conclusion

From the experiment we can get the following conclusion:

1) Optimum dose of coagulant and flocculant for sea water treatment as feed water for industry was 130 ppm for coagulant Poly Amylum Chlorida and 0.6 ppm for flocculant Acrylic acid co-polymer PA322 on general condition of feed water.

2) Optimum dose of coagulant and flocculant significantly affects the turbidity, but not the pH because raw water used still within the standard.

6. References

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