The 1st International Conference on Business and Management of Technology (IConBMT)
August 3rd 2019, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

Study of Karangpilang II Water Production Quality Control Using Statistical Process Control (SPC)

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***Abstract*—IPAM Karangpilang's water quality has fluctuated and there are several parameters whose quality is not in accordance with the quality standard. Therefore, IPAM Karangpilang II needs to carry out quality control to maintain the quality of drinking water products according to the applicable quality standards. This research aims to analyze the application of the quality control system for drinking water products at IPAM Karangpilang II and look for the causes of decreasing production water quality at IPAM Karangpilang II. So that alternative improvements can be determined to maintain drinking water quality at IPAM Karangpilang II.**

Quality control method in this study using Statistical Process Control (SPC). Analysis were using primary data on drinking water quality starting from March to April 2019. Measurement parameters used include pH, Total Dissolved Solid (TDS), Turbidity, and Organic matter. Determination of a process controlled using control chart and then implemented using a fishbone diagram to determine the factors that result in decreased production of water quality.

Control charts are in a statistically uncontrolled condition on the pH parameters in the clearator and filter units, Total Dissolved Solid (TDS) parameters on the clearator unit, turbidity parameters in the pre-sedimentation unit, clearator and filter, and organic matter parameters in pre-sedimentation and filter units. While in the production of water control chart in a state of uncontrolled statistically in the turbidity. Based on the fishbone diagram, factors that cause the control chart to be in an uncontrolled condition are that the overflow rate clearator does not appropriate with design criteria, technical errors such as clogging of the tube settler on the clearator, congestion coagulant pump stagnation, tube settler replacement in the clearator, seldom using coagulant dosage, decrease in the quality of raw water in the parameters of organic matter and raw water conditions that fluctuate due to the rainy season.

***Keywords*—IPAM Karangpilang II, Quality Control, Control Chart, Drink Water Production, Statistical Process Control.**

I. INTRODUCTION

A company cannot be separated from consumers and the products it produces. Consumers certainly hope that the goods they buy will be able to meet their needs and desires so that consumers expect that the product has a good and guaranteed condition. Therefore companies must see and maintain that the quality of the products produced is guaranteed and accepted by consumers and can compete in the market.

The Karangpilang II Drinking Water Treatment Plant (IPAM) is a drinking water treatment installation that provides clean water treatment facilities to serve clean water needs for residents of the Surabaya and surrounding areas. As a processing plant for drinking water IPAM Karangpilang II produces drinking water as its product. The production water must of course have good quality in accordance with the quality standards continuously.

The water needed to fulfill daily needs must meet biological, physical, radioactivity and chemical requirement[1]. In order to meet the requirements of drinking water quality management it is necessary to continuously and sustainably to ensure quality and quantity[2]. The drinking water quality standard that applies in Indonesia is based on the Regulation of the Minister of Health of the Republic of Indonesia Number: 492MENKES/PER/IV/2010 concerning Drinking Water Quality Requirements.

The quality of IPAM Karangpilang II water production has fluctuated where the water produced has varying quality and there are several parameters that are not in accordance with drinking water quality standards. The quality of raw water in rivers is affected by the rainy season. In the dry season the content of organic matter is high, turbidity is low and many contain colloidal particles. Whereas in the rainy season the turbidity level is very high, this is caused by soil erosion which is carried by rain that occurs in the watershed[3].

Quality control executed properly will affect the quality of products produced by the company. Even though the production processes have been carried out well, in reality there are still errors that result in the quality of the production of drinking water being produced not in accordance with the quality standards[4].

Water quality control of production can be done quantitatively using methods Statistical Processing Control (SPC). This method is used to improve the quality of production when a process is not optimal. Statistical Processing Control (SPC) is the application of statistical methods for the measurement and analysis of process variations. By using SPC, it can be analyzed and minimizing deviations, to evaluate the ability of the

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process, and make connections between concepts and techniques exist to conduct process improvement. SPC target mainly is held against the reduction of variation or errors process[5].

Based on the explanation above, the researcher was interested in examining the quality control of drinking water production produced by the IPAM Karangpilang II using Statistical Processing Control (SPC) method. This research is expected to be a consideration for companies to improve the quality of their products.

II. Method

The analysis model in this study regarding the quality control of drinking water production uses a quality control analysis tool in the form of a control chart and fishbone diagram. The control chart is a process control technique. The control chart can also be used to estimate the parameters of a production process and determine process capabilities. Control charts can also provide information that is useful in improving the process. The final goal is to eliminate the statistical process control variability in the process, although the graphics controller can not eliminate variability more but graphics controller / control charts is an effective tool in reducing variability as much as possible[6].

Selection type of control chart based on the type of data to be processed. Data were processed in the form of variable data and individual that is not affected by the previous value. Thus, in the manufacture of a control chart that is used is a control chart types of individual variables. Cause and effect diagram or also called fishbone diagram is used to show the main factors that influence the quality and have an effect on the problem being studied. This method divides the problem consists of cause and effect which consists of several factors including machinery, management, material, human, environment, measurement, and method[7]. This fishbone diagram will be used to find factors that cause a decrease in the quality of drinking water production.

Methods of collecting data in this research is by direct observation in IPAM Karangpilang II. The data collection techniques carried out are as follows:

1) Interview

Interviews are a way to obtain data or information by conducting question and answer directly to people who know about the object under study. Interviews in this study will be conducted at the management / employees of IPAM Karangpilang II to analyze the problems that are the cause of uncontrolled drinking water production processes.

2) Observation

Observation is a way to get data or information by making direct observations at the research site by observing the system or the workings of the production process from beginning to end and quality control activities.

3) Sampling

Sampling is done by taking water samples to analyze the quality according to the parameters that have been determined, namely pH, turbidity, Total Dissolved Solid (TDS), and organic substances. Sampling is carried out on production water. Sampling is conducted from March to April 2019.

III. Results and Discussion

A. *Statistical Process Control Analysis*

Sampling is carried out every day during March until April 2019. Samples are taken from production water and water in the process unit. Water in the process unit is taken from pre-sedimentation, clearator and filter units. Making the control chart using Minitab program.

1) Control chart for water in unit process

a) pH parameter

➢ Prasedimentation outlet

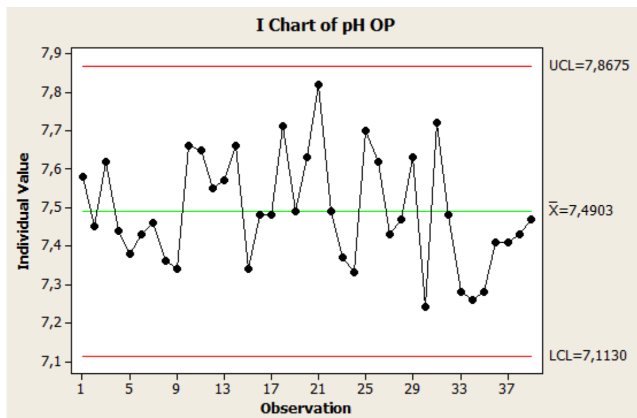

Figure 1. Control Charts of pH Prasedimentation Outlet

From the Figure 1, it can be seen that the control chart is under controlled conditions.

➢ Clearator outlet

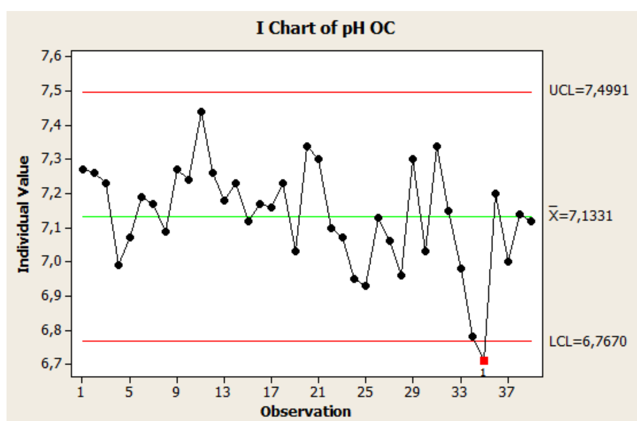

Figure 2. Control Charts of pH Clearator Outlet

From the Figure 2, it can be seen that the control chart is in an uncontrolled condition. There is 1 point that is outside the lower control limit at the 35th point. This shows that there are special causes of variation in the 35th data that are outside the lower control limit. In the 31st data the pH value decreases to the 35th point the pH value is outside the lower control limit. Therefore, further analysis is needed for the causes of special variations to occur using fishbone diagrams.

➢ Filter outlet

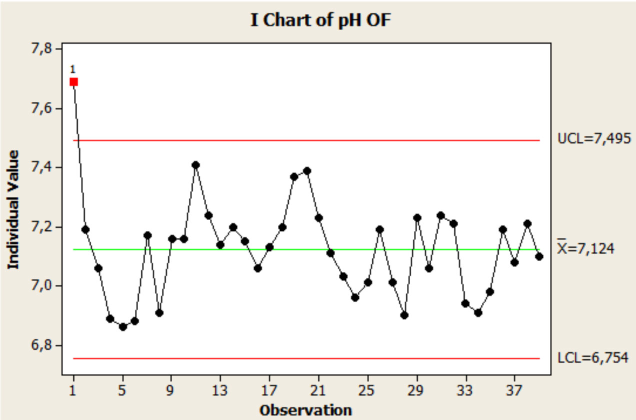

Figure 3. Control Charts of pH Filter Outlet

From the Figure 3, it can be seen that the control chart is in an uncontrolled condition. Variations in special causes are indicated by the presence of a number of points that come out of the control limit. There is 1 point that is outside the upper control limit at the first point. This indicates that there are variations in specific causes in the first data that are outside the upper control limit. Therefore, further analysis is needed for the causes of special variations to occur using fishbone diagrams.

b) Total Dissolved Solid parameter

➢ Prasedimentation outlet

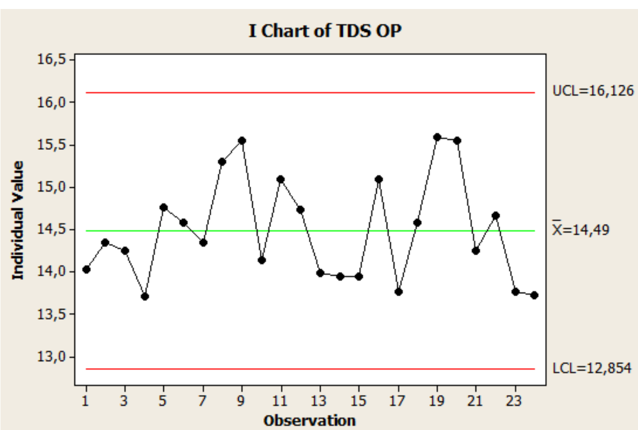

Figure 4. Control Charts of TDS Prasedimentation Outlet

From the Figure 4, it can be seen that the control chart is under controlled conditions. All points are between the upper and lower control limits.

➢ Clearator outlet

From the Figure 5, it can be seen that the control chart is in an uncontrolled condition. Variations in special causes are indicated by the presence of a number of points that come out of the control limit. There is one point that is outside the upper control limit, namely at the 7th point. This shows that there are special causes variations in the 7th data that are outside the Upper Control Limit (UCL). Therefore, further analysis is needed for the causes of special variations to occur using fishbone diagrams.

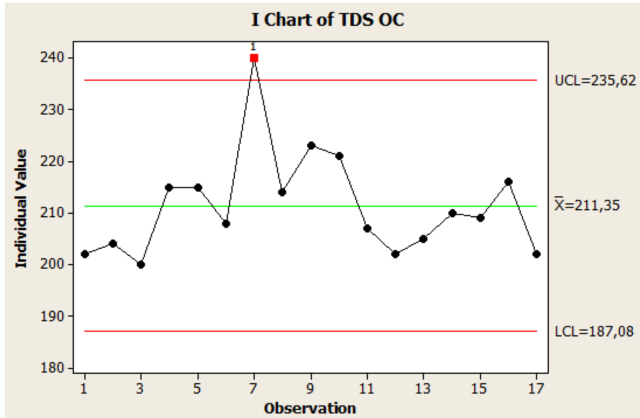

Figure 5. Control Charts of TDS Clearator Outlet

➢ Filter outlet

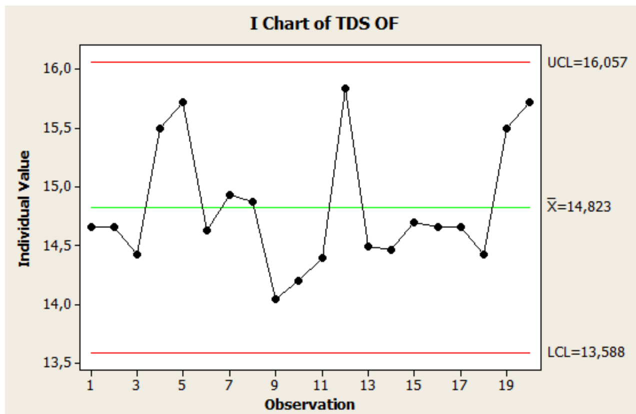

Figure 6. Control Charts of TDS Filter Outlet

From the figure 6, it can be seen that the control chart is under controlled conditions.

c) Turbidity parameter

➢ Prasedimentation outlet

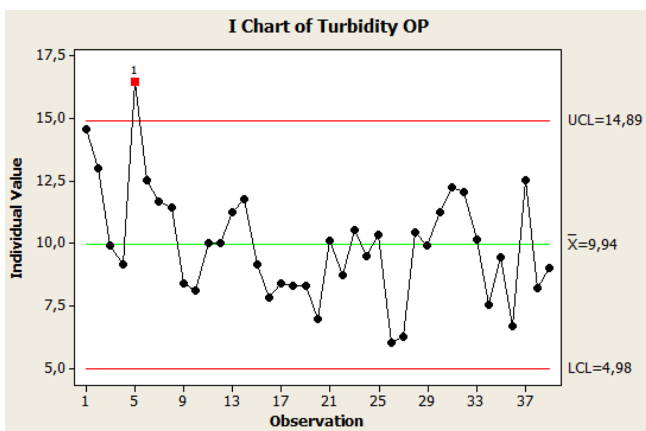

Figure 7. Control Charts of Turbidity Prasedimentation Outlet

From the Figure 7, it can be seen that the control chart is in an uncontrolled condition. There is 1 point that is outside the upper control limit at the 5th point. This shows that there are variations in specific causes in the 5th data that are outside the upper control limit (UCL). This can occur because of a specific cause that occurs in the pre-sedimentation unit.

➢ Clearator outlet

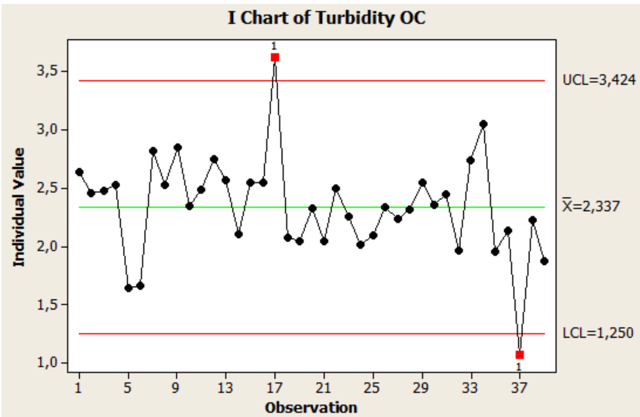

Figure 8. Control Charts of Turbidity Clearator Outlet

From the figure 8, it can be seen that the control chart is in an uncontrolled condition. There is 1 point that is outside the upper control limit at the 17th point. This shows that there are special causes of variation in the 17th data that are outside the Upper Control Limit (UCL). This indicates that the process that occurs in the clearator has the potential for errors.

➢ Filter outlet

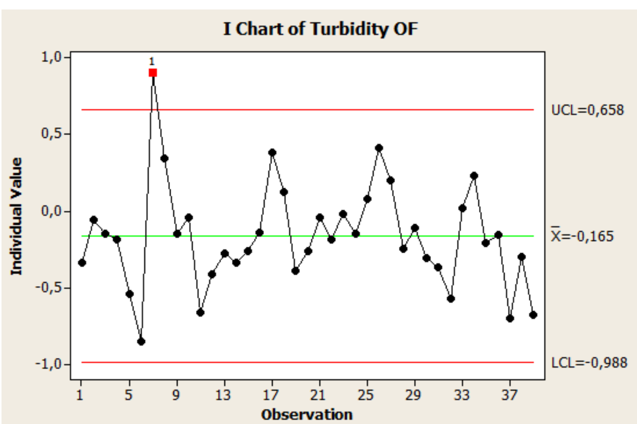

Figure 9. Control Charts of Turbidity Filter Outlet

From the Figure 9, it can be seen that the control chart is in an uncontrolled condition. There is 1 point that is outside the upper control limit at the 7th point. This shows that there are special causes variations in the 7th data that are outside the Upper Control Limit (UCL). This can occur due to special causes that occur in the filter unit. The specific causes in question will be analyzed using fishbone diagrams.

d) Organic matter parameter

➢ Prasedimentation outlet

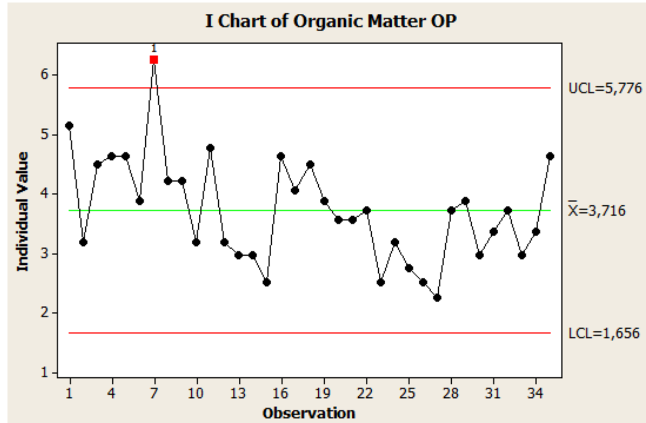

Figure 10. Control Charts of Organic Matter Prasedimentation Outlet

From the Figure 10, it can be seen that the control chart is in an uncontrolled condition. There is 1 point outside the control limit on the olive at the 7th point. This shows that there are special causes variations in the 7th data that are outside the Upper Control Limit (UCL). This can occur because of a specific cause that occurs in the pre-sedimentation unit. The specific causes in question will be analyzed using fishbone diagrams.

➢ Clearator outlet

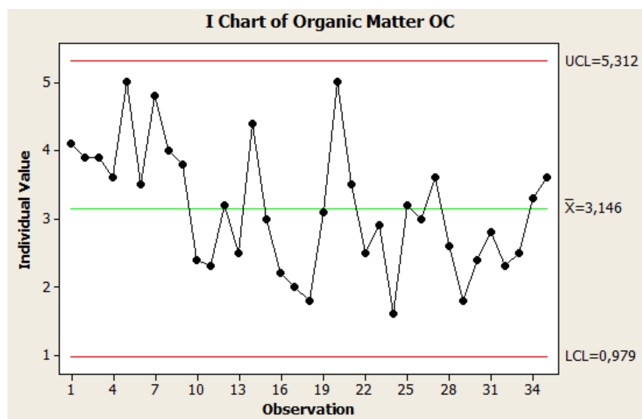

Figure 11. Control Charts of Organic Matter Clearator Outlet

From the Figure 11, it can be seen that the control chart is under controlled conditions.

➢ Filter outlet

From the Figure 12, it can be seen that the control chart is in an uncontrolled condition. There is 1 point that is outside the upper control limit, namely at the 3rd point. This shows that there are variations in specific causes in the 3rd data that are outside the upper control limit (UCL). This can occur because of a specific cause that occurs in the pre-sedimentation unit. The specific causes in question will be analyzed using fishbone diagrams.

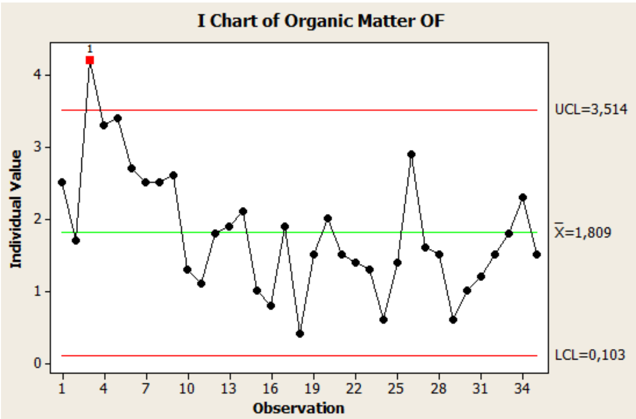

Figure 12. Control Charts of Organic Matter Filter Outlet

2) Control Chart for production water

a) pH parameter

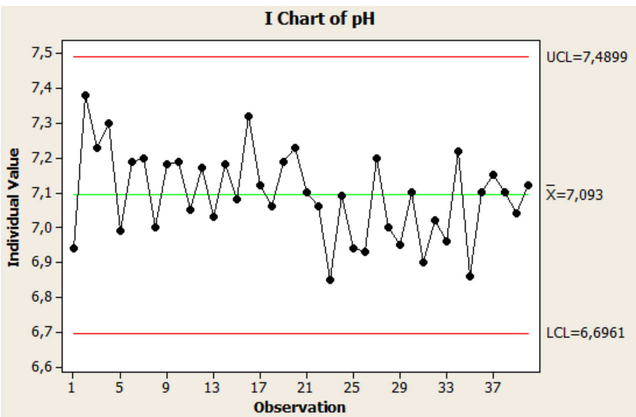

Figure 13. Control Chart of pH

From the Figure 13, it can be seen that the control chart is under controlled conditions.

b) Total Dissolved Solid Parameter

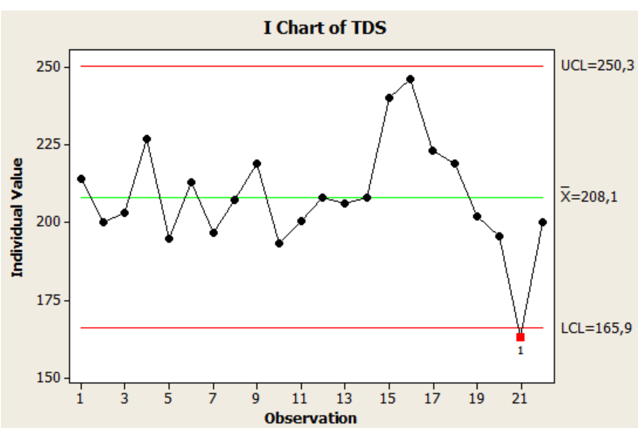

Figure 14. Control Chart of TDS

From the Figure 14, it can be seen that the control chart is in an uncontrolled condition. Variations in special causes are indicated by the presence of a number of points that come out of the control limit. There is 1 point that is outside the lower control limit, which is at the 21st point. This shows that there are variations in specific causes in the 21st data which are at the lower control limit. In the 16th data the TDS value decreases until the 21st data is outside the lower control limit. This decrease in TDS value is a good event because the quality of the water produced is getting better. So that conditions like this can be said to be a controlled condition.

c) Turbidity parameter

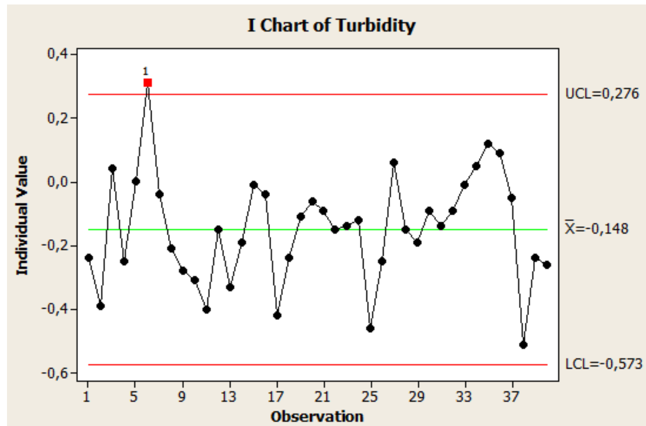

Figure 15. Control Chart of Turbidity

From the Figure 15, it can be seen that the control chart is in an uncontrolled condition. Variations in special causes are indicated by the presence of a number of points that come out of the control limit. There is 1 point that is outside the upper control limit, namely at the 5th point. This shows that there are variations in specific causes in the 5th data which are at the Upper Control Limit (UCL). This can occur due to special causes that occur in the previous unit.

d) Organic matter parameter

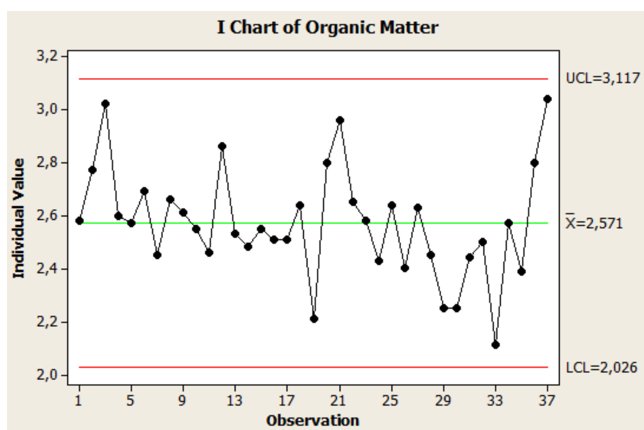

Figure 16. Control Chart of Organic Matter

From the Figure 16, it can be seen that the control chart is under controlled conditions.

B. Fishbone Diagram Analysis

After knowing the uncontrolled point in the process, it is necessary to do an analysis to find out the cause of the uncontrolled process. Tools to find out the causes of water quality degradation using a fishbone diagram. In this section the fishbone to be discussed is the factor that causes the control map in a state of uncontrolled statistics and factors that cause a decrease in the quality of drinking water. This analysis is expected to be able to find factors that cause the decline in drinking water quality. Analysis is carried out by factors of production units, methods, humans and raw water quality.

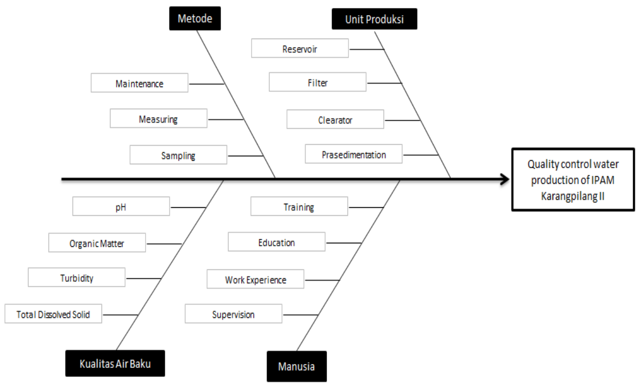

Figure 17. Fishbone Analysis

1) Production Unit

The water production unit at IPAM Karangpilang II consists of pre-sedimentation, clearator, filter and reservoir units.

a. Prasedimentation

Before the water enters the pre-sedimentation unit, the water goes through the aeration process using an aerator. Aeration in principle is the process of adding air to water which has the following uses:

1. Eliminate the content of hydrogen sulfide in water.
2. Removes some of the odor that caused by the gas content in the water as a result of the decay process of organic matter.
3. Carbon dioxide contained in water can be removed up to 70%
4. Oxidizing the content of Fe and Mn and remodeling detergents
5. Increase the level of oxygen gas in water

Aerator type in IPAM Karangpilang II is cascade aerator amounting to 2 units with a diameter of 8.5 m and a diameter of 1.5 m. Aeration is used to increase the level of oxygen received by and break down the layer of water so that contact between air and water occurs. After the aerator, the water is flowed towards the pre-sedimentation tank.

Pre-sedimentation unit are used to precipitate discrete particles or coarse particles or mud. In pre-sedimentation there is a calculation of residence time or detention time. According to SNI 6774: 2008 a good time for settling tanks is 1.5-3 hours. At IPAM Karangpilang II the detention time in the pre-sedimentation bath is 3 hours. Total of sedimentation tanks at Karangpilang IPAM is 10 units with a length of 80 m, a width of 15 m and a depth of 2.75 m.

In the pre-sedimentation unit there are out of control data on turbidity and organic matter parameters. Out of control data turbidity parameters are caused by rain conditions that occur in March that fluctuate. While the out of control data for organic matter parameters are due to the condition of raw water which has a high value of organic matter so that the aerator is unable to reduce the level of organic matter before entering pre-sedimentation.

b. Clearator

Before entering the clearator the water enters the flash mix. The function of this flash mixer is to place the coagulation process between the coagulant and suspended particles in the raw water from the pre-sedimentation bath. The stirring used in the flash mix process is the hydraulic jump system by utilizing the high difference between the pre-sedimentation outlet and the fast stirring unit inlet

The coagulant added to the flash mix process is aluminum sulfate. There are 8 aluminum sulfate tanks with dimensions of 4.2 meters long, 1.4 meters wide and 2.6 meters deep. The volume of aluminum sulphate bath is 15000 L. The number of pumps available is 4 pieces and 3 blowers. Tank is divided into 2 parts, 4 tubs as pure alum and 4 tubs of solvent volume of 2200 L with a dose of 0.1 ppm or depending on the condition of raw water in the field.

The addition of coagulant was carried out according to the conditions of the raw water in the field using a jar test. However, in the field conditions the jar test analysis is rarely done or carried out under certain conditions. The operators hold on to experience in determining the dosage of coagulant affixing because it is felt too long if using the jar analysis test first to determine the coagulant dose. This results in less control of coagulant affixing because in March to April the weather conditions are uncertain so that the raw water conditions fluctuate . The result of this uncontrolled affixing of coagulants is the emergence of fluctuating water quality parameter values in the clearator unit.

After the flash mix process, water will flow to the clearator. Clearator is a cone-shaped water treatment building that functions as a building for sedimentation and flocculation processes. Flocculation is slow stirring which aims to form floc clumps so that floc can settle by gravity at the base of the clearator. The flocculation process uses flocculant PE (poly electrolyte) 0.01 ppm. Clean water from the clearator comes out through a rectangular channel and the water moves up to the settler tube. Then the water will float through gutter and out to meet the outlet channel.

Decreasing water quality in the turbidity parameter clearator unit occurs because of maintenance activities by replacing the tube settler in one of the clearators. This results in the clearator being unable to be used so that the other clearator loads increase and the other clearator efficiency decreases. In addition, in March 2019 there was a jam in the coagulant pump so the water in the clearator became cloudy.

The pH parameters included in the out of control category are on the control chart in the clearator unit. Addition of coagulant doses can cause an increase in precipitate formation which will be followed by an increase in collision frequency between particles so that it can form a larger floc. So that higher doses will widen the pH of the operation.

c. Filter

Filter unit is a unit that functions to filter floc which is still present in water that is not settled in the clearator unit. The filter units in the Karangpilang II IPAM are 16 units with a length of 10 meters, a width of 6 meters and a depth of 3.25 meters. The filter media used is silica sand with a thickness of 50 cm in size from 0.5 to 2.8 mm, anthracite sand with a thickness of 40 cm in size from 0.8 to 1.8 mm and nozzle with a number of 23,520 pipe diameters of 0.5 inches.

In the unit filter, there is an out of control data on turbidity parameters. This is because the filter media is thinning. Thick media filter is inversely related to turbidity. The thicker the filter media make the smaller the turbidity. While the out of control data on pH parameters are due to the pH value of the previous unit due to affixing coagulants.

d. Reservoir

Reservoir is a unit for collecting water produced before it distributed to customers. Before getting into the water reservoir through the disinfection process with the intention to kill pathogenic microorganisms in the water. In addition, disinfection is also useful to oxidize the remaining organic matter, reduce odor, and prevent bacterial breeding in drinking water distribution systems. At the IPAM Karangpilang II channel after the filter there is a point of affixing chlorine gas as a disinfectant. Chlorine is used routinely for disinfection with a dose of 1.9 ppm with a limit of 1.0-0.2 ppm

2) Method

Some methods that can cause a decrease in water quality of the production of IPAM Karangpilang II include unit maintenance such as filter drainage, backwash, replacement of the clearator tube settler, and pump maintenance. Maintenance efforts carried out on a daily, weekly and monthly basis must be carried out optimally so as not to affect the quality of drinking water production.

Measurement of production water quality must be carried out carefully, especially in key parameters taken every 2 hours, namely pH and turbidity. Errors in measurement can result in handling errors such as adding coagulant doses or giving chlorine doses. The method used to determine the coagulant dose using the jar test method. Jar test method must be done carefully so that the dose can be given proper coagulant and did not result in decreased production of water quality. The operators usually do jar test the event of a significant change in turbidity in turbidity.

Sampling should be sufficient to represent the conditions during production. The number of samples and the frequency of sampling should be done more intensely, especially for parameters that are only carried out weekly or monthly testing.

3) Human

Humans carry a very important role in the resulting product. Awareness of workers in carrying out activities is influenced by the motivation received by the employees concerned. Motivation can be caused by the supervision and rewards given. Through supervision, employees will feel that their performance is always considered whether it is in accordance with work procedures or not. Whereas through awards can lead to pride in employees about the work they have done. The ability or expertise of employees can be determined from experience, training provided and the level of education. The longer the working period of an employee will be more experience and more skilled in his work. The level of education taken by employees will help employees to quickly understand all things that are related to their work, especially towards the absorption of training materials provided and in handling problems that often occur during the production process.

4) Raw Water Quality

The raw water used by IPAM Karangpilang II comes from Kali Surabaya river. Raw water quality is influenced by seasons, namely the dry season and the rainy season. In the dry season the content of organic matter is high, turbidity is low and many contain colloidal particles. Whereas in the rainy season the turbidity level is very high, this is caused by the erosion of soil carried by rain that occurs in the watershed[3].

The quality of raw water has extreme changes in the parameters of organic matter. On the water control chart the production of parameters of organic matter is under controlled conditions but the value shown exceeds drinking water quality standards. This shows that the production process is not able to achieve ideal conditions for the parameters of organic matter. The high quality of organic matter in raw water is not able to be processed with the existing units at IPAM Karangpilang II.

IV. Conclusions

Based on the analysis using statistical process control, it is known that the quality control process at IPAM Karangpilang II is in a statistically uncontrolled condition on the pH parameters in the clearator and filter units, Total Dissolved Solid (TDS) on the clearator unit, turbidity in the pre-sedimentation unit, clearator and filter and organic matter in pre-sedimentation and filter units.

Based on the fishbone diagram, the factors that cause uncontrolled conditions can be divided into production units, methods, humans and decreases in the quality of raw water.

The 1st International Conference on Business and Management of Technology (IConBMT)
August 3rd 2019, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

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