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MORALITY BEFORE KNOWLEDGE

Conflict analysis in chemical wastewater management: A case study on the recycling process in the heavy equipment industry in Jakarta

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ABSTRACT

Background: One cause of water degradation is the large quantities of water consumption in industries, along with water pollution. Recycling wastewater offers a solution to this problem. As a wastewater-producing company, XYZ has implemented this solution. However, analysis of wastewater management revealed that some WWTPs did not meet the clean water requirements, necessitating additional processing units, specifically the addition of a recycling unit. **Method:** The recycling unit was added to reduce wastewater chemicals such as arsenic, iron, fluoride, cadmium, and others. A comparative analysis was conducted to assess the effectiveness of the recycling unit. **Findings:** The comparison indicated that the water parameters of the recycling unit's effluent results were better than PDAM parameters, showing improvements in the water chemistry. **Conclusion:** The effectiveness of the recycling unit was validated, as it significantly lowered some chemical parameters in wastewater, producing effluent that was better than PDAM water and meeting the clean water quality standards outlined in Permenkes No. 416 of 1990 on Water Quality Monitoring. **Novelty/Originality of this article:** The novelty of this article lies in demonstrating the effectiveness of an added recycling unit in improving wastewater quality. It highlights a successful case of reducing harmful chemicals to surpass PDAM water quality, adhering to national standards.

KEYWORDS: performance evaluation; water recycling; recycle units; clean water parameters.

1. Introduction

The consumption of water used by a company or industry every day very much for production and domestic activities. The water requirement is taken from groundwater and water from the water company (PDAM). For industrial water consumption is allocated approximately 10% of total demand, compared to agriculture and cities (Prieto et al., 2015). However, the amount of water allocated was not available for many of these industries because of limited access (Kamizoulis et al., 2003; Vigneswaran, 2009). The disposal of wastewater in residential areas without an effective purification process will increase the level of contamination of the surrounding surface water and groundwater resources (Borah et al., 2010). The disposal of waste water in residence areas without effective purification process will increase level of contamination of surrounding surface water and ground water resources (Song et al., 2018). Water by untreated sewage into water bodies naturally causes some severe threats for life on land/water and increases the cost of handling contaminated water (Azapagic et al., 2016; Papa et al., 2016). Pollutants accumulate in the ecosystem and

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will have a negative effect on humans and the environment (Heidel et al., 2016). The industrial waste contains heavy metals and if disposed of directly in rivers or seas will accumulate in fish bodies. Fish that have been contaminated will be very dangerous if consumed by humans (Razak et al., 2001). The purpose of wastewater treatment is to disrupt the natural ecosystem by complying the government regulations, not only avoid the environmental pollution.

Liquid waste is categorized as wastewater, among others liquid household waste, industrial and other public places that endanger human life and other living beings and interfere with the environment (Metcalf & Eddy, 2003). The amount of water consumption and water pollution in some places, making clean water resources dwindling resulting in a freshwater crisis in the society especially the people of the city. The water crisis in the world makes it difficult for some countries, especially in developing countries, whose land is semi-arid/arid and some have natural water resources (Hess et al., 2015; Wang & Bai, 2017). Control of environmental pollution related to the energy crisis is an alarming problem, so the removal of pollutants on water is a significant concern in many countries (Hu et al., 2013, 2015) especially in Indonesia. The challenge to the water requirements for the industry in relation to the water crisis has raised the question of how to manage wastewater to ensure the quality of the final product efficiently that is guaranteed for industrial operations and human health. According to the problem, reuse of industrial wastewater to be consumed again can be done intensively as a practical solution to provide water needed by the industry and prevent environmental damage resulting sustainable development goals regarding water and wastewater management (Piadeh et al., 2014; Veiga & Magrini, 2009). Therefore, the water resource crisis is a global issue so waste water treatment and waste management is now the most critical issue (Higgins et al., 2018; Martín et al., 2018; Raghuvanshi et al., 2017). Wastewater treatment that should be wasted greatly contributes to energy savings and can minimize production costs in the industry (Koymatcik et al., 2018).

Such a situation of wastewater treatment in the residential area can cause several hazards related to public health and environmental degradation. However, some countries have developed the comprehensive and effective innovation in the water sector (Jeuland, 2015). Recycle the wastewater is the best alternative, recycled water can be carried out using equipment known as "Recycle unit." The material used as a recycle unit manifold, it is adapted to the characteristics of domestic wastewater to be treated. Some rational reason recycling waste water can be used as a source of clean water include: water is a limited resource, existing knowledge about water recycling, water recycling is an effort to achieve water resources sustainable, recycled water supports environmental protection efforts and reduce the amount of wastewater discharged into water bodies (Metcalf & Eddy, 2003). The process of recycling water at industrial facilities is an alternative which gives some advantage for industry facility itself and customers as well. To some extent, recycling the water will decrease the cost or reducing the production cost, for example, recycling hot water in manufacture process leads to natural gas savings (Verbruggen et al., 2010). Waste Water Treatment Plant (WWTP) is designed to process industrial wastewater to set the quality of treated water which meets the government standards.

One of the industries in Jakarta engaged in the development and assembly of heavy equipment is XYZ. To deal with the wastewater generated, company XYZ builds the WWTP that is used to recycle wastewater. However, the processed water WWTP applied not meet the requirements of clean water that should be added to other processing units, namely the addition of a recycling unit. With this background, the requirements for an evaluation related to the effect of the installation of a water recycling has been implemented and its influence on changes in water parameters, particularly the water chemistry parameters. This study aims to analyze changes in water chemistry parameters resulting from the installation of a wastewater recycling. This research is essential to determine the alternative raw water as a resource for clean water. The recommendation will contribute to preventing water pollution.

2. Methods

2.1 Research approach

This study uses a quantitative approach which especially useful for addressing specific questions about relatively well-defined phenomena. The quantitative techniques emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. The quantitative research focuses on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon (Muijs, 2010; Babbie, 2020). The study evaluates a specific process and aims to measure the success of a plan, program or specific activities. This study directs researchers to assess the success of the benefit, usefulness and feasibility of an activity of a particular activity.

2.2 Location and time

Location wastewater management is in the area of XYZ Company Wastewater Treatment Plant (WWTP). The timing of the study during the 4 (four) months starting in July until October 2017. Location of XYZ Company WWTP and Sketch of WWTP Company XYZ can be seen in Figures 1 and 2. Location WWTP in Figure 1 is in the middle of XYZ company. At the WWTP there are several stages of wastewater treatment included in the physical and chemical processing. Figure 2 visible sketches from the WWTP, the size, design, and shape of the WWTP that treat wastewater into clean water.

Fig. 1. Location of XYZ company WWTP

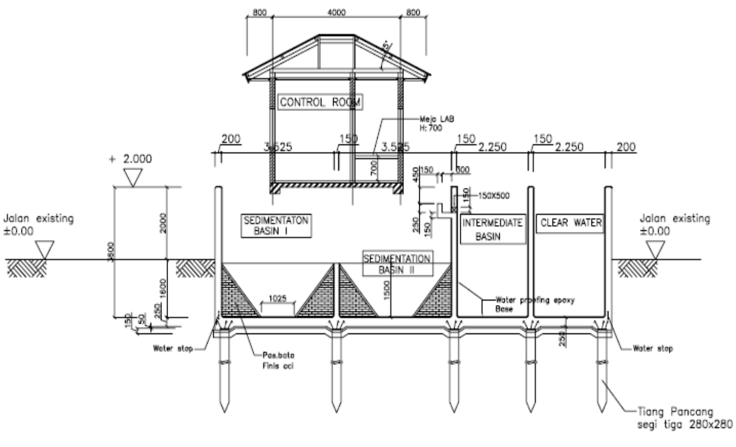

Fig. 2. Sketch of WWTP company XYZ

2.3 Materials and research equipment

Materials used is wastewater generated by XYZ Company, activated sludge (containing bacteria), bio-nutrients, urea and phosphate fertilizers. The tools used in the study were all installations are installed in the area of wastewater treatment plants (WWTP), among others: water reservoirs raw, like aeration I, aeration II, aeration II, blower, settling tanks, intermediate tanks, lamella clarifier, bathtub control water supply, distribution tanks and recycle unit form active zeolite filter activated carbon filters, bag filters, and ultrafiltration. The material on the recycling unit added can be seen in Figure 3.

Fig. 3. Recycle units are added

2.4 Wastewater treatment process

Wastewater treatment is classified into three fractions: the processing of the physics, chemistry, and biology. The wastewater treatment reduced the burden of their pollutants (heavy metals, bacteria, and viruses in feces, biological oxygen demand, organic chemicals, etc.) before being safely discharged into the surrounding environment (Jones et al., 2017). In this study, the wastewater treatment process begins with wastewater and domestic production activities on Company XYZ collected the water in the area of wastewater treatment. The first process is done in an aeration 1,2,3 after contained in a settling tank, then poured into an intermediate tank and the water effluent. Water effluent WWTP is pumped into the zeolite filter by using one pump filter. Fine dirt will be screened by the zeolite in the tank pressurized. The water coming out of the processing results are supplied to the zeolite filter activated carbon filter. Water from the zeolite filter is pumped into activated carbon filter using one pump filter. After the filtration process, the treated water coming out of the activated carbon filter will be supplied to the filter bag. Water from the activated carbon filter is pumped to the filter bag using a pump, with permeability and high porosity, then the treated water from the filter bag will be flown back to the ultrafiltration. The water from the filter bag supplied to ultrafiltration using a pump, contained in the ultrafiltration membrane, and the membrane will result in better water quality. The screening process includes ultrafiltration of 0.1 microns up to 0.01 microns. Nanoparticles of hydrophilic metal oxides (NPs) such as zeolite nanoparticles have usually been added to the ultrafiltration membrane as a material to reduce fouling by increasing hydrophilicity (Bae & Tak, 2005; Maximous et al., 2010; Qu et al., 2013). Membrane specially designed to separate floating particles, colloidal materials, TSS, organic substances, bacteria and other heavy molecules. Heavy metal can be released from water by many methods, some of them are adsorption and membrane technology (Siswoyo et al., 2014). The results of this wastewater treatment process produce mud and clean water. Afterward, the mud will be disposed of following a predetermined flow by the government, while the fresh water can be reused for industrial activities. The sketch of the research flow diagram can be seen in Figure 4.

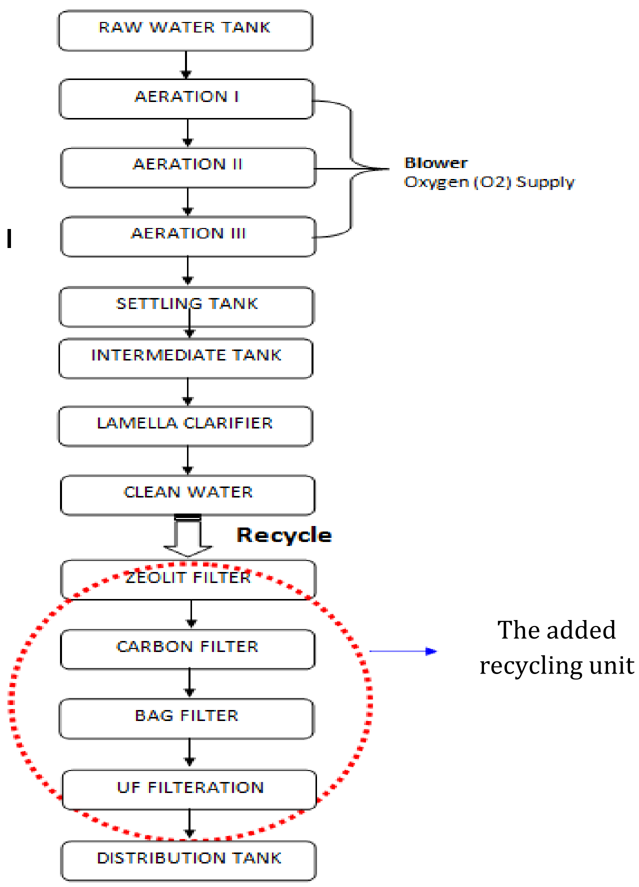

Fig. 4. Sketch of research flow diagram

2.5 Data analysis

This study analyzes the quality of water produced after the addition of the recycling unit. Water quality can be seen from the changes in water chemistry parameters were measured, among other parameters parameter arsenic, iron, fluoride, cadmium, hexavalent chromium, manga, nitrite, pH, zinc, and cyanide contained in the water results from the wastewater treatment process. Analysis of wastewater parameters performed by a laboratory accredited by the method of water sampling at the point of influent and effluent wastewater as well as checks on PDAM water.

3. Results and Discussion

The results of the data analysis shown in tables and graphs, the average analysis results are shown in Table 1. That table data from water analysis Drinking Water Company (PDAM), influent and effluent wastewater. This study was conducted to evaluate the performance by monitoring the water chemistry parameters were generated after using "recycle unit" by comparing the results of influent and effluent wastewater. Then compare the results back from parameters effluent the waste water with PDAM water analysis results, so it can be seen changes in water chemistry parameters are in accordance or not with the quality standards of clean water after using the recycle unit.

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Table 1. Results of average analysis July-October 2017

No.	Parameter	Unit	Maximum standard	PDAM Water analysis (6 Monthly)	Influent (months)					Effluent (months)				
					Jul-17	Aug-17	Sep-17	Oct-17	Average	Jul-17	Aug-17	Sep-17	Oct-17	Average
1	Arsenic	mg/l	0.05	-	0.005	0.005	0.005	0.005	0.01	0.001	0.001	0.001	0.001	0.001
2	Iron	mg/l	1	7.148	0.28	0.49	0.5	0.05	0.33	0.038	0.038	0.038	0.038	0.038
3	Fluoride	mg/l	1.5	0.17	0.61	0.51	0.6	0.4	0.53	0.19	0.19	0.19	0.19	0.19
4	Cadmium	mg/l	0.005	-	0.01	0.010	0.002	0.002	0.006	0.0022	0.0022	0.0022	0.0022	0.0022
5	chromium hexavalent	mg/l	0.05	0.027	0.005	0.01	0.01	0.01	0.009	0.009	0.009	0.009	0.009	0.009
6	manganese	mg/l	0.5	3.044	0.021	0.08	0.1	0.5	0.18	0.09	0.06	0.18	0.048	0.09
7	Nitrates	mg/l	10	0.02	3.09	2.36	10.3	8	5.94	1.12	0.66	0.44	1.19	0.85
8	Nitrite	mg/l	1	0.235	0.02	0.07	0.06	0.05	0.05	0.02	0.007	0.01	0.29	0.08
9	pH	-	6.5-9.0	7.8	7.46	7.3	7	7.3	7.27	7.15	7.62	7.4	6.91	7.27
10	Zinc	mg/l	15	0.08	0.1	0.14	0.2	0.5	0.24	0.304	0.304	0.27	0.197	0.27
11	Cyanide	mg/l	0.1	0.028	0.05	0.005	0.005	0.005	0.02	0.003	0.003	0.003	0.003	0.003

(Regulation of the Minister of Health of the Republic of Indonesia No. 416 of 1990)

3.1 Arsenic parameter monitoring

Arsenic (As) is a toxic metal that is often classified as metal but instead is non-metallic. Unlike other metals which form cations, Arsenic (As) in nature in the form of anions, such as H2SO4. The environment does not damage arsenic (As), move towards water or soil carried by dust, rain, or clouds. Arsenic is grey, but this form is rarely present in the environment. Arsenic in water found in the way of compounds with one or more other elements. Arsenic dissolved in water in the form of organic and inorganic (Braman & Foreback, 1973; Crecelius, 1974). The goal of water treatment from arsenic contamination is to reduce arsenic levels in the water to a standard level that has been provided by the government or to a minimum level until it reaches a contaminant level of 0. Thus, it reduces the risk of health in humans such as cancer or other health risks as a result of arsenic exposure. Arsenic in parameters influent wastewater XYZ Company in July - October 2017 amounted to <0.005 mg/l and effluent in July - October 2017 of 0.19 mg/l with a decrease in arsenic parameters by 36%. Therefore, the parameters of arsenic in the effluent resulting in smaller or better than PDAM water arsenic in the amount of <0.041 mg/l. Presentation of the results of the analysis of arsenic parameter can be seen in Figure 5.

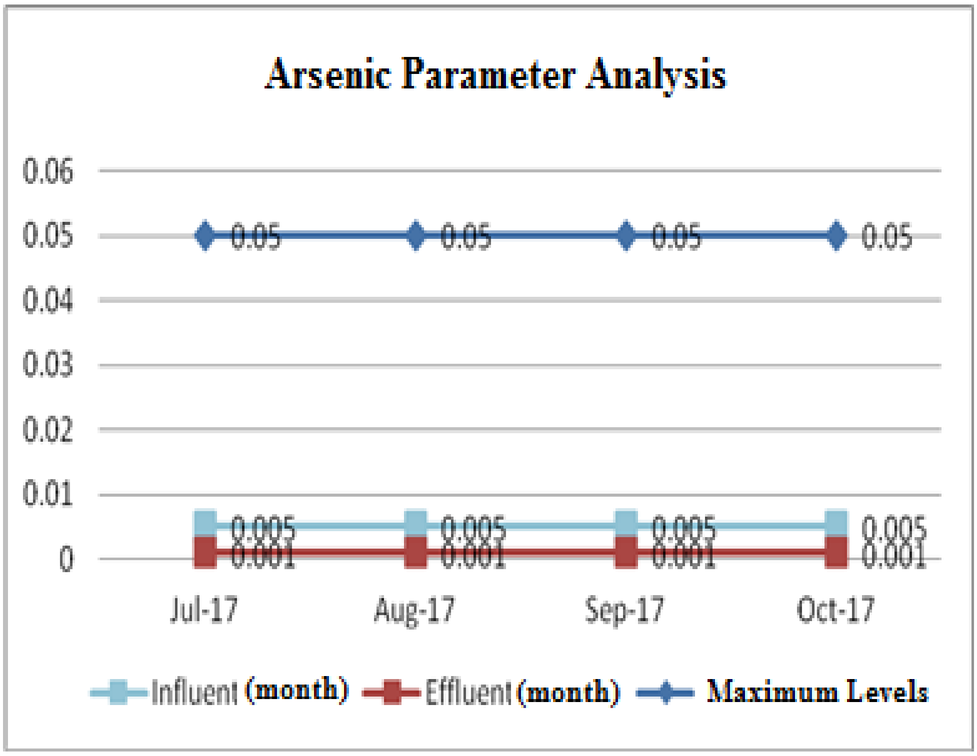

Fig. 5. Arsenic parameter analysis

3.2 Iron parameter monitoring

Iron (Fe) is a silvery-white metallic compound, clay and can be molded (American Public Health Association, 2005). Iron usually appears in two forms: ferrous (Fe2+) and ferric (Fe3+) (Vasudevan et al., 2009). Results of analysis of influent iron in the WW parameters XYZ Company in July-October is 0.28 mg/l, 0.49 mg/l, 0.5 mg/l and 0.5 mg/l with an average of 0.33 mg/l. Results of analysis of effluent parameters of iron in the month of July-October amounted to 0.038 mg/l with an average reduction level of 12% iron parameters. PDAM for water analysis results obtained every six months iron analysis results of 7148 mg/l. Hence the levels of iron in the parameters effluent resulting in smaller or better than PDAM water iron. Presentation of the results of the analysis of iron parameters described in Figure 6.

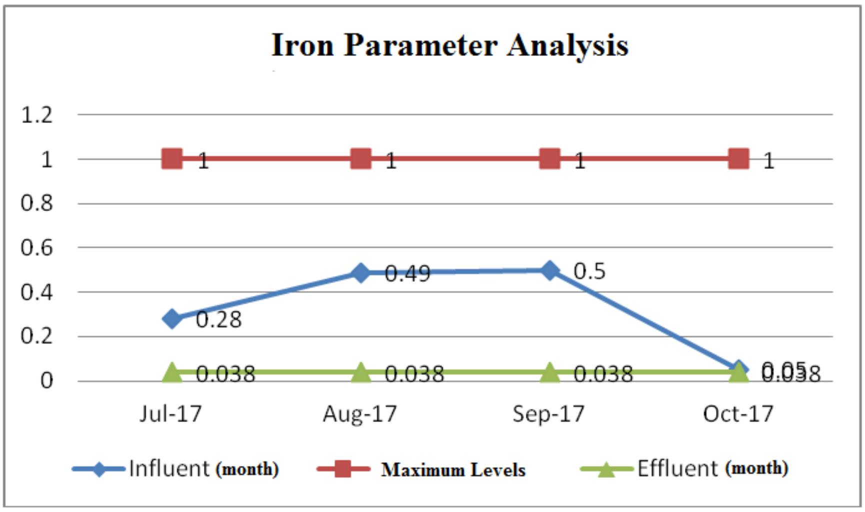

Fig. 6. Iron analysis results

3.3 Fluoride parameter monitoring

Fluoride in water can cause adverse effects on human health and the environment. Therefore, the World Health Organization/WHO (2011) provides a standard of fluoride content that is still allowed on the water content of 1.5mg/L. Results of fluoride parameter analysis at influent WWTP XYZ Company in the month of July - October 2017 amounted to 0.61 mg/l, 0.51 mg/l, 0.6 mg/l and 0.4 mg/l. With an average of 0:53 mg/l. Results of analysis of effluent parameters of fluoride in the month of July-October is <0.19 mg/l with an average reduction level of 36% iron parameters. For the results of PAM 6 monthly water analysis of 0.17 mg/l. Hence the parameters of fluoride levels in effluent resulting in smaller or better than PDAM water fluoride. Presentation of the results of the analysis of parameters of fluoride shown in Figure 7.

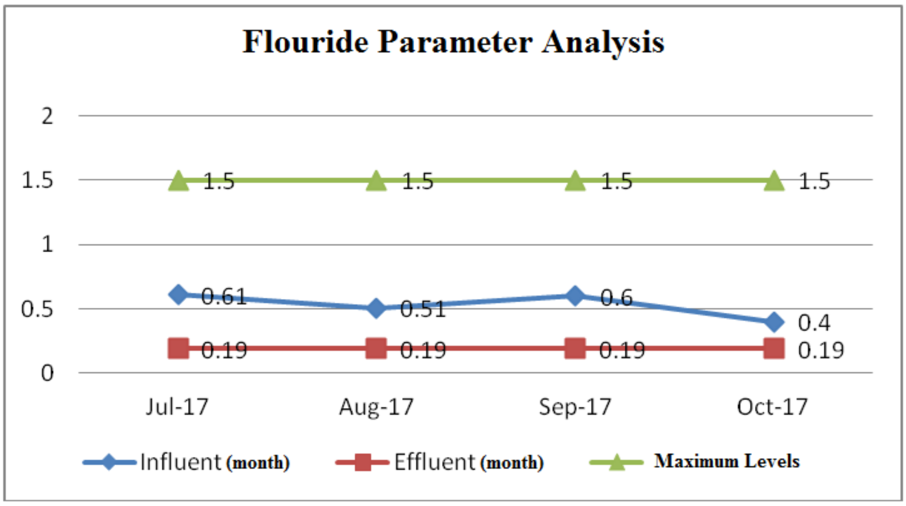

Fig. 7. Fluoride analysis results

3.4 Cadmium parameter monitoring

Analysis results influent WWTP parameters of cadmium in XYZ Company in July-October subsequently are 0.01 mg/l, 0.01 mg/l, 0.002 mg/l and 0.002 mg/l with an average of 0.01 mg/l. Results of analysis of effluent parameters of cadmium in the month of July-October is <0.0022 mg/l with an average decrease in the levels of cadmium parameter by 36%. Besides, the levels of cadmium in the parameters effluent resulting smaller or better than PDAM water cadmium. Cadmium is a heavy toxic metal, potentially causes long-term human health and ecological issues or damages to the ecosystem (Weeraprapan et al., 2015). The concentration should Presentation of cadmium parameter analysis results can be seen in Figure 8.

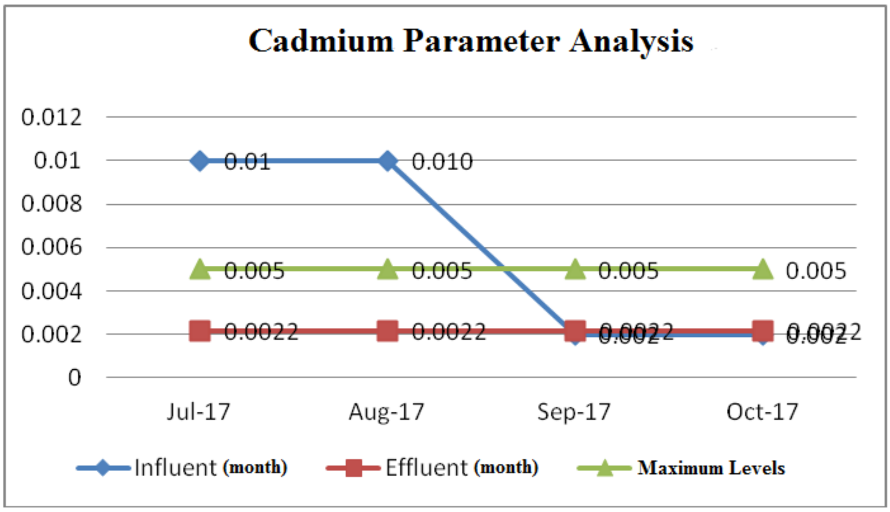

Fig. 8. Cadmium analysis results

3.5 Chromium hexavalent parameter monitoring

The analysis results influent Hexavalent chromium parameters in wastewater XYZ Company in July-October amounted to 0.005 mg/l, 0.01 mg/l, 0.01 mg/l and 0.01 mg/l with an average of 0.009 mg/l. Results of analysis effluent of hexavalent chromium parameters in the month of July-October is <0.009 mg/l. PDAM for water analysis results obtained every 6 months hexavalent chromium analysis result of 0.027 mg/l. The parameter levels of hexavalent chromium in the effluent resulted smaller or better than PDAM water hexavalent chromium. It is necessary to eradicate Chromium Hexavalent from the environment, to deter the negative impact on ecological system and public health. The effective technology for eliminating Chromium Hexavalent contaminated wastewater is profoundly required by the industries to comply with the regulations (Gupta & Babu, 2008). Presentation of the results of the analysis of the iron content can be seen in Figure 9.

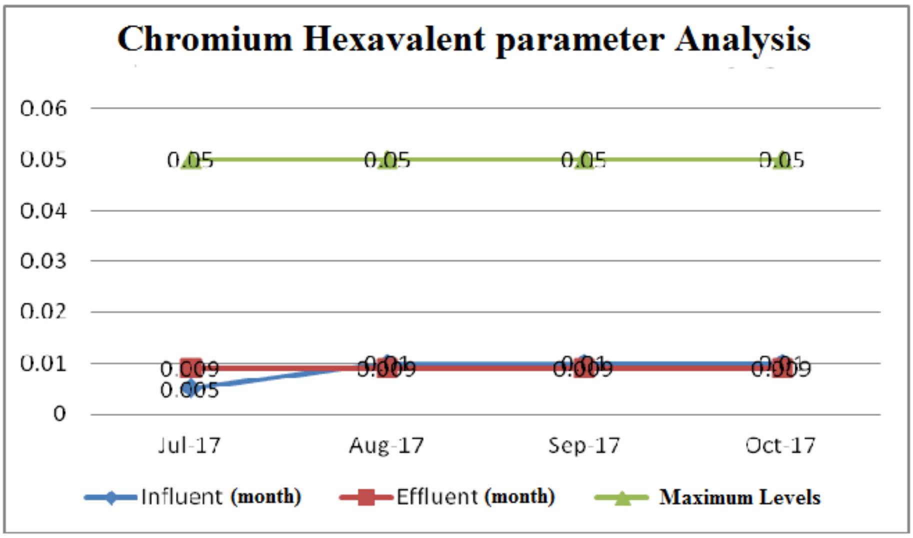

Fig. 9. Hexavalent chromium analysis results

3.6 Manganese parameter monitoring

Results of analysis of influent manganese in the WW parameters XYZ Company in July-October amounted to 0.021 mg/l, 0.08 mg/l, 0.1 mg/l and 0.5 mg/l with an average of 0.18

mg/l. Results of analysis of effluent parameters of manganese in the month of July-October amounted to 0.09 mg/l, 0.06 mg/l, 0.18 mg/l and 0.048 mg/l with an average reduction level of 54% manganese parameters. PDAM for water analysis results obtained every 6 months manganese analysis results of 3.044 mg/l. Moreover, the levels of manganese in parameters effluent resulting in smaller or better than PDAM water manganese. Presentation of the results of the analysis of parameters of manganese can be seen in Figure 10.

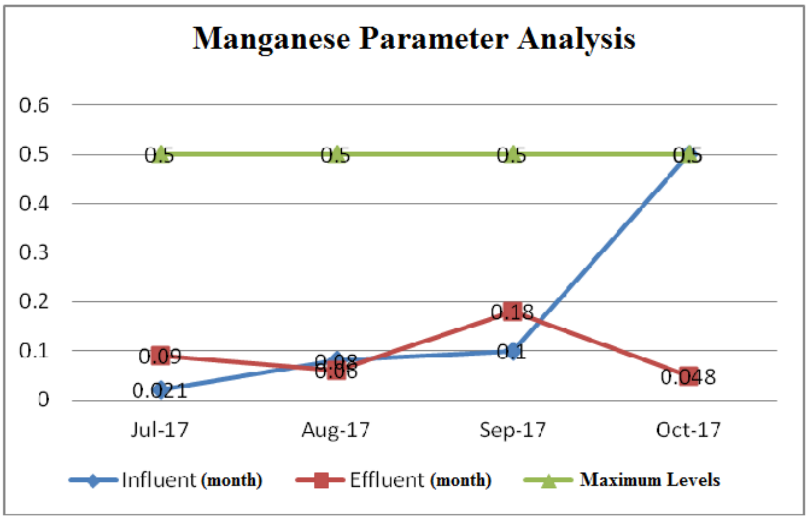

Fig. 10. Manganese result analysis

3.7 Nitrate parameter monitoring

Analysis results influent on the WWTP nitrate parameters XYZ Company in July-October amounted to 3.09 mg/l, 2.36 mg/l, 10.3 mg/l and 8 mg/l with an average of 5.94 mg/l. Results of analysis of effluent nitrate in the parameters in July-October amounted to 1.12 mg/l, 0.66 mg/l, 0.44 mg/l and 1.19 mg/l with an average reduction of nitrate parameter levels by 14%. PDAM for water analysis results obtained every 6 months nitrate analysis results of 0.02 mg/l. Thus, the parameter levels of nitrate in the effluent produced greater than PDAM water nitrates. Presentation of the results of the analysis of nitrate parameters can be seen in Figure 11.

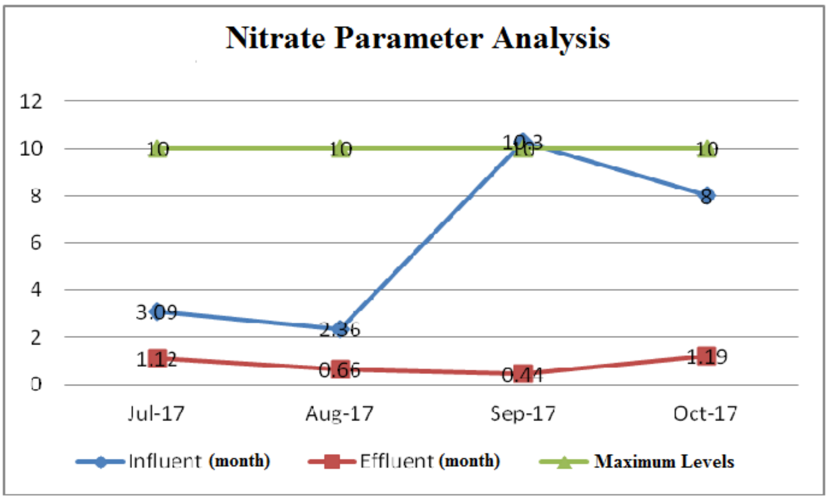

Figure 11. Nitrate result analysis

3.8 Nitrite parameters monitoring

Analysis results influent on the WWTP nitrite parameter XYZ Company in July-October amounted to 0.02 mg/l, 0.07 mg/l, 0.06 mg/l and 0.05 mg/l with an average of 0.05 mg/l.

Results of analysis of effluent parameters of nitrite in the month of July-October stood 0.02 mg/l, 0.007 mg/l, 0.01 mg/l and 0.09 mg/l. PDAM for water analysis results obtained every 6 months the results of analysis of nitrite of 0.235 mg/l. Thus, the levels of nitrite in the parameters effluent resulting in smaller or better than PDAM water nitrite. Presentation of the results of the analysis of parameters of nitrite can be seen in Figure 12.

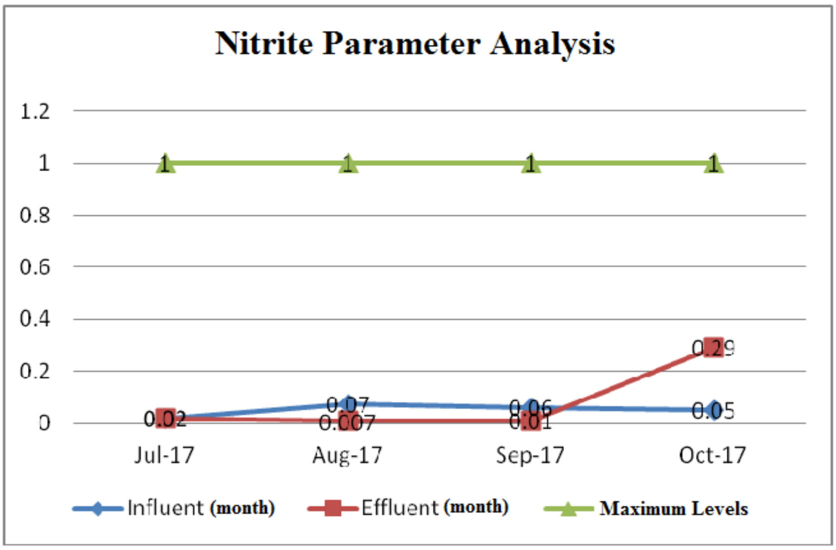

Fig. 12. Nitrite analysis results

3.9 pH parameters monitoring

pH is the acidity level to express the degree of acidity or alkalinity of a solution. Results of analysis of influent the WWTP pH parameters XYZ Company in July-October amounted to 7.64, 7.3, 7 and 7.3 with an average of 7.27. Results of analysis of effluent parameters of pH in the month of July-October amounted 7.15, 7.62, 7.4 and 6.91. The parameters of pH levels in effluent produced little or better than PDAM water pH. Presentation of the results of the analysis of pH parameters can be seen in Figure 13.

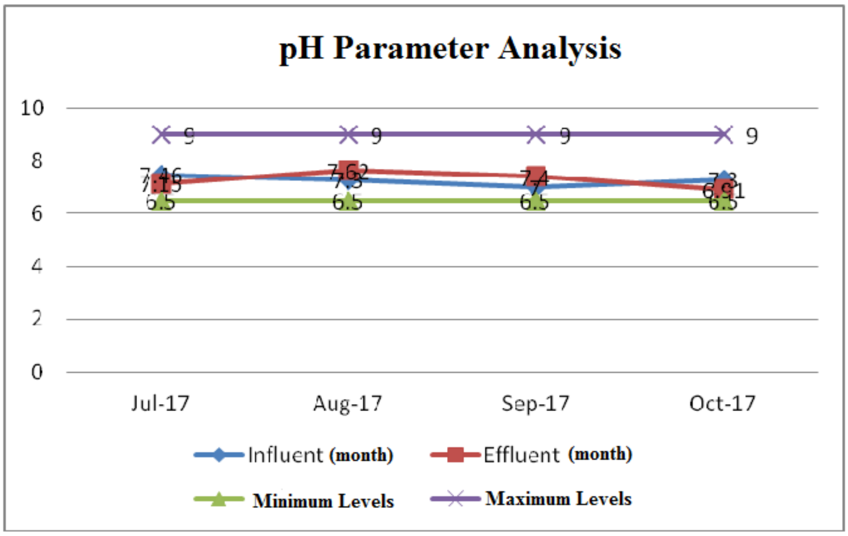

Fig. 13. pH analysis report

3.10 Zinc parameters monitoring

Analysis results influent zinc on the WWTP parameters XYZ Company in July-October amounted to 0.1 mg/l, 0.14 mg/l, 0.2 mg/l and 0.5 mg/l with an average of 0.24 mg/l.

Results of analysis of effluent parameters of zinc in the month of July-October amounted to 0.304 mg/l, 0.304 mg/l, 0.27 mg/l and 0197 mg/l with an average of 0.27 mg/l. PDAM for water analysis results obtained every 6 months zinc analysis results at 0.08 mg/l. Besides, the levels of zinc in the parameters effluent generated is greater than the zinc in PDAM water. Presentation of the results of the analysis of parameters of zinc can be seen in Figure 14.

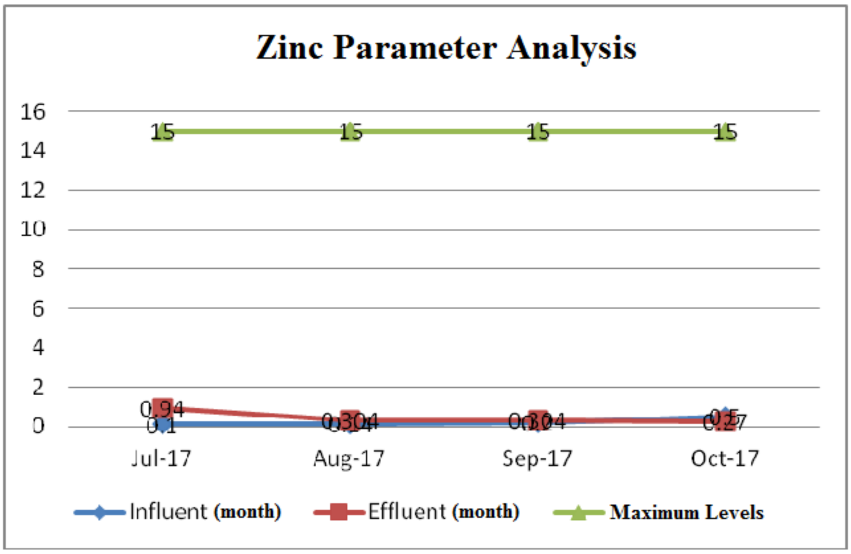

Fig. 14. Results analysis of zinc

3.11 Cyanide parameter monitoring

Analysis results influent WWTP parameters of zinc at XYZ Company in July-October is 0.05 mg/l, 0.005 mg/l, 0.005 mg/l and 0.005 mg/l with an average of 0.02 mg/l. Results of analysis of effluent parameters of zinc in the month of July-October was 0.003 mg/l with an average reduction level of 18% nitric parameters. PDAM for water analysis results obtained every 6 months zinc analysis results of 0.1 mg/l. Thus, the levels of zinc in the parameters effluent generated is greater than the zinc in PDAM water. Presentation of the results of the analysis of parameters of zinc can be seen in Figure 15.

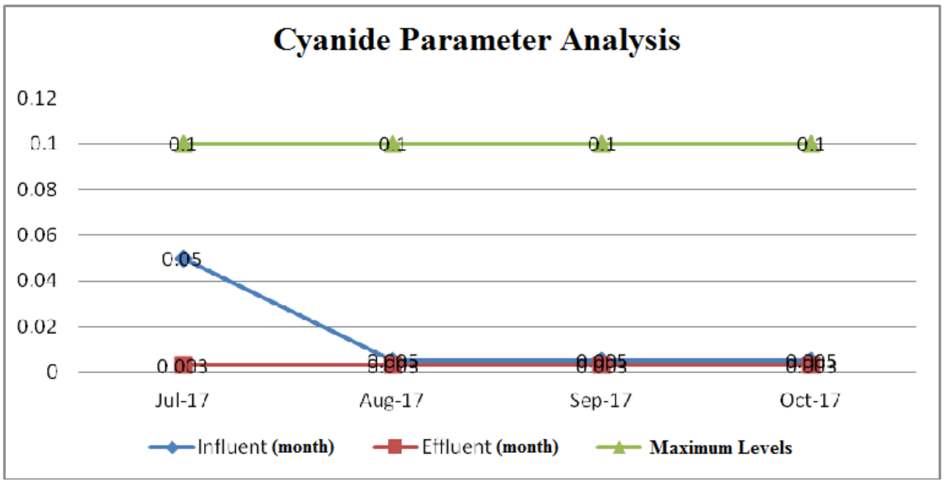

Fig. 15. Results analysis of cyanide

4. Conclusions

After using the recycle unit, it concluded that by using the recycle unit can reduce some of the parameters of wastewater, among other parameters of arsenic, iron, fluoride, cadmium, chromium hexavalent, manga, nitrites, zinc and cyanide in wastewater at WWTP Company XYZ, while the pH levels do not degrade or are not affected by the recycle unit. Comparison of the results of analysis water of effluent with PDAM water analysis it can be concluded that the wastewater parameters effluent the result is better than PDAM water parameters. While the results of the study of nitrate greater than PDAM water analysis results. Nevertheless, the results of the analysis of the levels of nitrates do not exceed the maximum allowed.

Meanwhile, the recycling units have a positive influence on water chemistry parameters so that the results of the analysis of these parameters are of better quality than the quality of PDAM water. Thus, the effectiveness of recycling units has been tested as able to reduce some of the parameters in wastewater and quality makes effluent wastewater better than PDAM water, as well as meet the clean water quality standards under Regulation of the Minister of Health of the Republic of Indonesia No. 416 of 1990 on Conditions and Water Quality Monitoring.

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Author Contribution
The sole author conducted the study design, data analysis, and manuscript preparation, ensuring the research's thoroughness and accuracy in all aspects.

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Data Availability Statement
Not available.

Conflicts of Interest
The author declare no conflict of interest.

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