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Online Monitoring of Effluent Quality for Assessing the Effect of Wastewater Treatment Plant

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ABSTRACT
In general, industry uses water in its production process so that it will produce wastewater that contains many contaminants, it will affects the surrounding environment by contaminating the water bodies. Information on monitoring the quality of industrial wastewater is very important to be perceive by examining changes in water quality. Industrial wastewater monitoring is a device system that collects real time data. Online monitoring technology is one part that plays an important role in supporting activities to control water environmental pollution. Real-time monitoring of wastewater quality remains an unresolved problem to the wastewater treatment industry. One of the problem in most industries in Indonesia is the nonoptimal condition of operational and performance of wastewater treatment plants (WWTP), and need improvement. The application of industrial technology concept 4.0 and automation systems in the industry is expected to improve the WWTP supervision process which has advantages such as reducing down time, reducing consumption of raw materials, reducing the energy used, etc. The cost savings that can be made by implementing it may reach up to 20-40% (estimation) with several assumptions applied. This review is to provide information about the assessment of WWTP performance through online monitoring of wastewater effluent quality.

1. INTRODUCTION

River is one of the environmental components that has important functions for human life, including to support economic development. In general, industries use water for the production process, which consequently will produce wastewater. Currently, the quality has deteriorated due to increasingly uncontrolled water pollution. One of the causes is the existence of industrial activities that produce a lot of wastewater. Wastewater that is disposed of without being treated first will result in an increase environmental pollution and decreasing river water quality. Pollution that occurs in the some rivers in Indonesia has begun to raise concern for Indonesian Goverment. To avoid more dangerous impact of pollution, the government has determined that all business units has to treat their produced waste to qualify with the quality standards before being discharged into the surrounding water environment. Industrial wastes are usually containing organic and inorganic materials at various levels of concentration, while the wastewater is generally strong and may contain toxic pollutants.

The application of wastewater treatment technology abroad are already at more advanced stage including fenton oxidation, photocatalys, ozonation, etc., while in Indonesia most of the industries are still on the optimalization of biological treatment. Online monitoring is one of the tools to quickly determine the performance of the wastewater treatment plant (WWTP) and also to

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determine whether or not the technology used is compatible with standard effluent.

The purpose and objective of this literature review is to provide information about the assessment of WWTP performance through online monitoring of wastewater effluent quality before discharge into the receiving river. In addition, this paper may provide information for the industry and may be used as a tool in monitoring WWTP performance.

2. ISSUES AT WASTEWATER TREATMENT PLANT

Industrial wastewater treatment systems vary greatly, the process can be in the form of primary, secondary or tertiary treatment. Generally used technologies are: coagulation and/or flocculation, membranes (microfiltration, nanofiltration and reverse osmosis), adsorbents (silica, clay, granular activated carbon, natural and bio-synthetic adsorbents), oxidation (Fenton-reagent, photocatalyis, oxidation process advanced, ozonation) and biological treatments (aerobic and anaerobic). The application of wastewater treatment technology depends on the characteristic of wastewater produced. The characteristics of wastewater are specific, so that each industrial wastewater must be characterized in advance and the same exact wastewater treatment system does not necessarily apply to every type of industry or type of wastewater.

The WWTP performance cannot be monitored continuously, this is a problem in the industry. This is due to the high operational costs related to labor and testing. It is necessary to introduce an automation system in the field that can reduce downtime, reduce consumption of raw materials, reduce the energy used, increase productivity, improve product quality and utilize resources and processes efficiently, with the aim of reducing overall operational costs. Currently, the control process is still done manually, so by introducing the application of the automation system it is also expected to reduce human error that occurs so as to increase system efficiency.

To quickly detect industrial waste contamination, a continuous and efficient monitoring system is needed. One of the efforts to implement a reliable industrial wastewater quality monitoring technology can be monitored in real-time (instantaneously) and online (connected to the internet). This online wastewater quality monitoring technology could be installed at the wastewater effluent outlet of the industrial Wastewater Treatment Plant (WWTP) that leading to the river body. The wastewater quality data may be monitored continuously, thus, may immediately determine whether the WWTP is effective or not. While real-time or online automation and control technologies cannot eliminate all the variabilities in WWTP operations, they can eliminate significant ones. Applying an automation system to sewage treatment might produce wastewater quality that cannot be achieved manually.

3. STUDY OF AUTOMATION AND ONLINE MONITORING APPLICATION ON WWTP PROCESSES

WWTP automation system and realtime monitoring will follow the development of industry 4.0 by using a microcontroller-based device that is connected to the Programmable Logic Controller (PLC) and then integrated through the internet with a machine-human interface such as a smartphone and PC media via an internet network from Wi-Fi or hotspot points cellular access that can be controlled automatically or manually. Microcontrollers are small computers on one integrated circuit, which are used in automatically controlled products and devices, such as car engine control systems, implantable medical devices, remote control, office machines, equipment, electrical equipment, toys and other embedded systems. The microcontroller-based device will decode the incoming analog data into a signal that will be sent to the PLC. The PLC itself can be programmed to have a certain optimal range of values in a parameter, where if the incoming signal is outside the optimal range programmed, the PLC will carry out an operation on WWTP automatically such as opening or closing a valve or motor, depending on programs that have been included on the

PLC. Human-Machine Interface itself will translate the program into graphical visualization that can be monitored by operators or online managers from anywhere, and does not have to be in the factory (Figure 1).

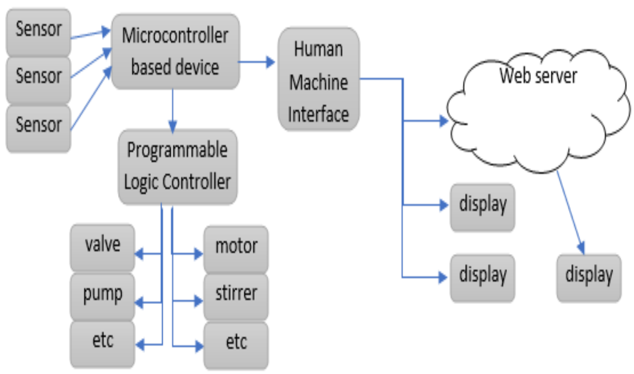

Figure 1. Typical Diagram of Online Monitoring Automation system

Sensors for important parameters are already available on the market and already being studied from previous study, which was showed by Table 1. These sensors are capable to measure the parameters, send analog data, and adequate compatibility with PLC. pH sensor is the most common sensor on the studies and it was also easily available on the market with a range of price. Temperature parameter is also usually measured with other sensor such as pH, DO or UV sensor (Table 1) thus make temperature parameter easily available. pH sensor was the most common application because it is may be applied on primary or secondary treatment. The importance of pH sensor on both primary and secondary treatment will be discussed on the following section.

The suitable application of technology industry 4.0 on wastewater treatment plant depends on the type of wastewater plant, the amount of motors, type of sensor, etc (Table 2, 3 and 4). Installation of instrumentation and automation technology in WWTPs is not yet a common thing in the industry in Indonesia. There needs to be studies to describe the level of success, advantages, disadvantages and other things that need to be considered in the application of this automation technology. In addition, we also need to observe at which operating units and process units any automation system may be applied in addition to studies application and experiences that we may take lessons to improve the success rate of applying this industrial automation 4.0 technology to WWTPs in Indonesia.

The implementation of sensor data can be monitored in real time through the LCD screen on the panel, in addition for being able to be viewed graphically via a smartphone or PC anytime and anywhere through the internet network. The system's connection to the internet allows supervision by operators/managers not only from onsite but also from off site which can be separate from the location. One important supporting instrument in the application of industrial technology 4.0 in WWTP is the availability of sensors. A sensor is a device used to record changes in the system.

PLC will act as controller for all components. Instruments at WWTP such as valves, pumps, stirrer, motors, etc. will be connected to the PLC as input output devices. The signal sent to the PLC by the WWTP instrument can act as a trigger for subsequent actions. The PLC can then send the actuation signal to various actuators to perform the specified task.

3.1. Automation and Online Monitoring Application on Primary Treatment

The potential application of the online monitoring and control system to the WWTP primary process can be seen on Table 2. The application of online monitoring in WWTP primary process is usually the monitoring of pH (Andhare & Palkar, 2014; Animireddy & Rao, 2016; Harivardhagini & Raghuram, 2015; Hiray et al., 2017) and temperature (Safonyk, Bomba, & Tarhonii, 2019) which will affect the effectivity of the primary treatment process; turbidity (Andhare & Palkar, 2014; Bersinger, Pigot, Bareille, & Le Hecho, 2013; Haimi et al., 2010; Qin, Gao, & Chen, 2012), TSS (Haimi et al., 2010; Qin et al., 2012), COD (Qin et al., 2012), and conductivity (Haimi et al., 2010) as the wastewater quality; also water flow (Farah, 2017; Safonyk et al., 2019) and water level (Farah, 2017) as the wastewater quantity. The Implementation of automation systems to the clarification or sedimentation processes is usually in monitoring or control of pH as well as the addition of coagulant chemicals.

Table 1. Application of each sensor parameters on WWTP

Sensor Parameters	Standard	Brand used on literature	Spesification and performance brand used on literature	Parameter application on reviewed literatures
pH	Precision ±0.02 pH unit Accuracy ±0.05 pH unit. (SNI 6989.11:2019), (Standard Method for the Examination of Water and Waste Water 23rd 2017 Washington DC: APHA, AWWA, and WEF. Section 4500-H^+, pH Value)	pH sensor E201-C Leici Instrument Incorporated (Yu, Liu, Sui, & Wei, 2015)	pH range 0-14 Temperature range 0-60°C Zero point pH value 7 + 0.25 Repeatability <0.017 (Aliexpress.com, 2020)	(Andhare & Palkar, 2014; Animireddy & Rao, 2016; Bagyaveereswaran, Vijayan, Manimozhi, & Anitha, 2016; Dries, 2016; Harivardhagini & Raghuram, 2015; Hiray, Chinchkar, Butte, & Pyla, 2017; Mundhe & Somani, 2017; Patil, Patil, Patil, & Patil, 2015; Robles et al., 2015; Ruano, Ribes, Seco, & Ferrer, 2012; Souza, Belchior, Pontes, & Junior, 2009; Won & Ra, 2010; Yu et al., 2015)
		Hach pHD sc (Ruano et al., 2012)	pH range 0-14 Accuracy ±0.002 pH Pressure max 10.7 bar Repeatability ±0.05pH Sensitivity ±0.01 pH Transmission distance 100m Operating temperature: -5-105°C (analog sensor), and -5-70°C (digital sensor) Temperature accuracy: ±0.5°C (uk.Hach.com, 2020)	
Temperature	Bias 0.1°C (Standard Method for the Examination of Water and Waste Water 23rd 2017 Washington DC: APHA 2550)	PT100-sensor (Patil et al., 2015)	Temperature precision: ±0.5°C Measuring range: -50-230°C Calibration factor (Patil et al., 2015)	(Patil et al., 2015; Robles et al., 2015; Ruano et al., 2012; Souza et al., 2009)
TSS ; TDS	TSS precision %RSD 6.13%, accuracy %R 80-115%, %bias=(-20)-15% (SNI 6989.3:2019)	S::CAN spectro::lyser (Byrne et al., 2011)	TSS: 0-3000 ppm (for paper mill and municipal) Accuracy standard solution (>1ppm): COD ±2% + 10/optical pathlength in mm (s::can Messtechnik GmbH, 2020) Measuring range UV-Vis 190-720 nm Operating temperature 0-45°C Temperature sensor: -10-50°C Resolution temperature sensor: 0.1°C COD: 0-5000 ppm (for paper mill)	(Bagyaveereswaran et al., 2016; Haimi, Mulas, & Vahala, 2010; Mundhe & Somani, 2017; Robles et al., 2015)
COD	COD %RSD 3.79%, akurasi %R 90-108%, bias (-10)-8% (SNI 6983.2 :2019)			(Qingyi, Wei, & Sixiang, 2013)
DO	DO accuracy 0.1 mg DO/L, precision 0.05 mg DO/L (Standard Method for the Examination of Water and Waste Water 23rd 2017 Washington DC: APHA 4500 O)	Hach LDO (Ruano et al., 2012)	Accuracy ±0.05 (DO<5ppm) Accuracy ±0.1 ppm (DO>5ppm) Measurement range: 0-20.00 mg/L Operating Temperature: 0-50°C Temperature accuracy: ±0.2°C Response time 40-60 s (at 20°C) Pressure max 3.5 bar Repeatability ±0.1 ppm Resolution 0.01 ppm (Hach, 2020)	(Animireddy & Rao, 2016; Dries, 2016; Haimi et al., 2010; Ruano et al., 2012; Wade, Sanchez, & Katebi, 2005; Won & Ra, 2010; Zhu & Qiu, 2017)

Table 2. Potential application of automated and monitoring control on physical and chemical treatment

Process	Scale	Monitoring and Automation	Sensor location and fuction	Literature
Skimmer tank	Laboratory scale	Control: conveyor motor, valve	Conveyor motor might be adjusted automatically	(Nandkumar et al., 2017)
Netralization tank	Simulation	Sensor: pH, Control: chemical dosing	pH was monitored online	(Animireddy & Rao, 2016)
Netralization tank	Pilot plant	Sensor: pH Control: chemical dosing	pH sensor was located on the Continuous Stirred Tank Reactor (CSTR)	(Harivardhagini & Raghuram, 2015)
Clarifier tank	Simulation	Sensor: pH, turbidity Control: chemical dosing pump, stirrer motor, valve	Dosing was conducted automatically based on water quality, with pH and turbidity monitored online. RPM of the blade was controlled online.	(Andhare & Palkar, 2014)
Clarifier tank	Simulation	Sensor: pH, Control: chemical dosing, pump motor	Coagulant feed rates and dosage was automatic based on flow variation and water quality	(Animireddy & Rao, 2016)
Clarifier tank	Laboratory scale	Control: chemical dosing pump, stirrer motor, valve	Stirrer motor was controlled online	(Nandkumar et al., 2017)
Sedimentation tank	Field application	Sensor: pH, Control: flow	pH water was monitored online	(Hiray et al., 2017)
Sedimentation tank	Field application	Sensor: water level, water flow	Level sensors were located on the inlet of sedimentation tank	(Farah, 2017)
Electrocoagulation system	Simulation	Sensor: water flow, temperature, pressure	Electrocoagulation treatment with flow rate and temperature monitored	(Safonyk et al., 2019)
Electrocoagulation and electroflotation	Pilot plant	Sensor: COD, TSS, oil and grease	COD and TSS were monitored through UV/Vis Spectrometer	(Qin et al., 2012)
Primary clarifier	Field application	Sensors: TSS, turbidity, conductivity,	Conductivity, turbidity and TSS were used for the estimation of wastewater quality	(Haimi et al., 2010)

The application of pH sensors with a combination of chemical dose control could make the sedimentation process more effective by keeping wastewater within the effective pH of the coagulant chemicals used (example: aluminium sulphate 5.8-6.5, polyaluminium chloride 5.0-8.0, alumunium chlorohydrate 6.5-7.5, ferric sulfate and ferric chloride 4.0-12.0 (Gebbie, 2006; Reynolds & Richards, 1996)). Coagulant dosage may be controlled by adjusting dosing pump or valve from control room or adjusted automatically based in wastewater flow and quality (Animireddy & Rao, 2016). The application of pH sensors on netralization tank for pH monitoring and control of the tank is usually involving acid tank and alkaline tank which function were to maintain the neutral condition for wastewater (Aparna, 2014; Harivardhagini & Raghuram, 2015). Automation system also may involved the control of motors such as conveyor motor or stirrer motor (Nandkumar, Sanjay, Yusuf, & Jagtap, 2017).

Primary wastewater treatment is generally in the form of coagulation-flocculation process which accompanied by sedimentation process. The coagulation-flocculation process is greatly influenced by the effectiveness of coagulant and flocculant chemicals which generally have an effective pH and temperature range. Thus the application of pH and temperature online monitoring for the coagulation-flocculation process may help WWTP operators to ensure the process is conducted at its optimal condition hence ensure the effectiveness of the process. In the end, it can ensure the conformity of wastewater with government quality standards.

Online monitoring may quickly estimate the WWTP performance, which so far currently has not been possible or difficult to measure because of time required for laboratory testing of the wastewater parameter qualities for every stage.

3.2. *Automation and Online Monitoring Application on Secondary and Tertiary Treatment*

Secondary wastewater treatment has quite of number of parameters that directly or undirectly have an important effect on the success of the ongoing treatment, such as pH, DO, COD/BOD, temperature, nutrient content, TSS, VFA, etc. Apart from the primary treatment, utilization of pH sensors is also very important in online monitoring applications in biological processes or secondary treatment at WWTP (Dries, 2016; Robles et al., 2015; Ruano et al., 2012; Won & Ra, 2010; Yu et al., 2015). The application of an automatic monitoring and control system can be applied to the aerobic system with DO, temperature, pH, conductivity, TSS , nitrogen and nutrient or COD/BOD sensors in wastewater. Online control strategy for aerobic process may involving DO control with oxygen uptake rate and time monitoring. Air flow and DO sensors are the most common technology to implement in the aeration system (Animireddy & Rao, 2016; Dries, 2016; Haimi et al., 2010; Ruano et al., 2012). DO was monitored with online DO meter, which may integrated with blower control and may be maintained automatically within a range which regulated with on/off controller blowers or adjustable blower speed. The oxygen uptake rate (OUR) may calculated online to create DO on/off strategy. The conductivity sensor is utilized to estimate the nitrogen load that will enter the aerobic reactor (Haimi et al., 2010). Conductivity value also may be related and utilized to estimate total suspended solids (TSS) and total dissolved solids (TDS) (Bagyaveereswaran et al., 2016; Bersinger et al., 2013; Irwan & Afdal, 2016). Online control strategy for anoxic process may involving DO control, with oxygen reduction potential (ORP), volume, and moving slope change (MSC) monitoring. Furthermore, the time required for anoxic process phase may determined from ORP control strategy. To obtain a full parameter monitoring for aerobic and anoxic processes, the online monitoring may be accompanied with laboratory testing and calculations, for calibration and also manual measurements such as COD, BOD, MLSS, sludge loading rate, nitrogen loading rate etc.

The application of an automatic monitoring and control system can be applied to the anaerobic system with temperature, pH, TSS and ORP sensors in wastewater. Organic loading rate (OLR) may be calculated from COD which may be correlated with online TSS and TDS monitoring (Robles et al., 2015). Keeping the pH in conditions suitable for the anaerobic process will make this specific process more effective. In the anaerobic reactor, biogas-pH automation monitoring and control may provide a self regultion pH buffer and a more stable pH environment, through two reactors which are acidification reactor with enriched VFA and methanogenesis reactor with enriched ammonium-bicarbonate buffer solution. VFA may be monitored via Middle infrared (MIR) sensor (Bongards, Gaida, Trauer, & Wolf, 2014) while ammonium may be monitored via ammonium analyzer (Ruano et al., 2012). The potential application of the monitoring and control system to the WWTP secondary and tertiary processes may be seen on Table 3 and Table 4 respectively. Some of the specification and performance of the sensors could be seen on Table 1.

Biological wastewater treatment has quite a lot of parameters that must be monitored, this makes the treatment quite vulnerable to problems and non-optimality. The application of online monitoring, besides being able to improve and guarantee the optimization of this biological processing, it can also prevent the biological treatment from problems that may arise and cause it to be inefficient and effective. In the end it may ensure the conformity of the wastewater effluent with the government's quality standards.

Table 3. Potential application of automated and monitoring control on biological treatment

Process	Scale	Monitoring and Automation	Sensor type, location, and fuction	Literature
Biological reactor	Simulation	Sensors: DO, Control: pumps, blower control	Simulation study using SCADA DO was measured online and number/speed of blowers were adjucted automaticly according to DO	(Animireddy & Rao, 2016)
Activated sludge basin	Field application	Sensors: DO, TSS, NH_4-N, conductivity, pH Control: air flow and air pressure, chemical feed, influent pump, excess and return sludge pump, flow measurement	Optical DO sensors Nutrient sensors were located at activated sludge basin and effluent Conductivity sensors were used for nitrogen load prediction Most sensors would work/function properly.	(Haimi et al., 2010)
Anoxic-aeration batch reactor	Field application	Sensor: pH Control: air flow, mixer, flow measurement	Sensors were placed in the aerator tank. pH profile was monitored online. Real time control is also successful and feasible.	(Won & Ra, 2010)
Anoxic-aeration batch reactor	Laboratory scale	Sensor: DO, pH, nitrate UV Control: air flow	Sensors were placed in the sequencing batch reactor. Nitrate and DO were monitored online. Online monitoring was succesfully studied the dynamic process of anoxic-aeration batch reactor	(Dries, 2016)
Anoxic-aerobic batch reactor	Pilot plant	Sensor: pH, DO, temperature, nitrate, ammonium, oxygen reduction potential (ORP) Control: blower speed (air flow), waterflow, nitrification controller, denitrification controller	pH sensor was Hach pHD-S sc DO sensor was Hach LDO Sensors were located in the aerobic and anoxic reactors Nitrogen and DO profiles were monitored online. pH and ORP sensors successfully control the biological nitrogen removal on the pilot plant	(Ruano et al., 2012)
Anaerobic membrane bioreactor	Laboratory scale	Sensor: pH, ORP Control: water flow, gas flow	pH sensor was E201-C Leici Instrument Incorporated Sensors were located in the methanogenesis reactor. pH and ORP profiles were monitored online. pH control strategy were used to prevent feed overload and underload of methanogenesis reactor.	(Yu et al., 2015)
Anaerobic membran bioreactor	Pilot plant	Sensor: pH, temperature, TSS, ORP Control: waster flow, gas flow, sludge wasting, pressure, temperature	Sensors were low cost sensors type	(Robles et al., 2015)
Biogas plants of anaerobic digestion	Laboratory and field application	Sensor: UV/vis and middle infrared (MIR) spectroscopic for volatile fatty acids (VFA)	UV/vis was used to monitor organic acid concentration, while MIR was used to monitor VFA Controlled laboratory standard errors of cross-validation 0.372 g/L (VFA: R^2 = 0.971)	(Bongards et al., 2014)

Table 4. Potential application of automated and monitoring control on tertiary treatment

Process	Scale	Monitoring and Automation	Performance and sensor location	Literature
Desinfection	Field application	Sensor: UV absorbance for residual chlorine	UV sensor was S::CAN spectro::lyser Sensor was located at the end of the treatment process, after the filtration Chlorine residue profile was monitored online and may detect the chlorination dosing performance	(Byrne et al., 2011)
Filter	Field application	Sensor: water level, water flow, TSS	Level sensors were located on the filter tank to check the level in the filter	(Farah, 2017)
Rapid sand filter	Simulation	Backwash	Backwashing was controlled by the SCADA system	(Andhare & Palkar, 2014)

Table 5. Advantage of Automation and Online Monitoring

Expected Advantages	Feature	Advantages detail	Literatures
Labour saving	Automatic operation may lead to labour cost efficiency	40% saving (estimation)	(Animireddy & Rao, 2016)
Efficiency energy	Cost estimation or simulation showed a more energy efficient process	20% saving (estimation)	(Animireddy & Rao, 2016)
		21.4% saving (estimation)	(Safonyk et al., 2019)
Efficiency chemicals	Closer control of chemical dosing sysitem may increase the efficiency of chemical utilization	30% saving (estimation)	(Animireddy & Rao, 2016)
Data record and log	Chronological record for any changes at the system	Any stored data may be recalled at any time	(Andhare & Palkar, 2014)
	Easier to find the root of a failure		(Bagyaveereswaran et al., 2016)
	Able to estimate and predict the quality and quantity of wastewater using a simulator or software		(Haimi et al., 2010)
Real time and online alarm	Automatic notification if any problem occurs	creates a quick response in case of anomalies	(Andhare & Palkar, 2014)
Real time and online control	Command set as a programming tools to control WWTP process	Enable automation features such as automatic pumps, valves etc	(Andhare & Palkar, 2014)
Real time and online monitoring	Capable to visually displaying real time data, trends and other sophisticated monitoring tools	Provide operator and manager a more visualized information	(Andhare & Palkar, 2014)
	Enable monitoring and control from remote location		(Dinis & Popa, 2014)
More smooth output (not oscillated)	Smooth output may be obtained instead of oscillated result	Through the application of Sliding Mode Controller	(Dinis & Popa, 2014; Harivardhagini & Raghuram, 2015; Robles et al., 2015)
Time efficiency	Reduce the time to check the parameters		(Patil et al., 2015)
Potential integration	Programmable controller has potential to integrate wastewater treatment plant stations		(Korodi, Huple, Silea, & Stefan, 2017)
Easier operation for operators	Provides more monitoring information and remote control for operators		(Dinis & Popa, 2014)
	May provides more specific information		(Davies, 2017)
More effective process	Process monitoring and controlling strategy allows a more effective operation process		(Yu et al., 2015)
		25% saving (estimation)	(Animireddy & Rao, 2016)

Table 6. Weaknesses/Limitation of Automation and Online Monitoring

Potential weaknesses	Parameters	Scale	Literature
There are sharp variations of measured values as an instinsic weaknesses of the equipment	Flow, pH, temperature	Upflow Anaerobic Sludge Blanket (UASB) reactor	(Souza et al., 2009)
Lack of well trained existing personnel	Physical (such as flow etc), and non physical parameters (such as documentation etc)	WWTP	(Korodi & Silea, 2014)
• Wastewater treatment processes are not considered as a core activity in SME thus lack of well trained and sceptical existing operators • Investment costs are generally considered too high • Design of the existing WWTP did not allow for real time control	DO, Nitrogen, pH, chemical dosing, sludge concentration, toxicity, TOC, flow measurement	Industrial WWTPs	(Cornelissen et al., 2018)
• Calibration is quite chalenging • Simulation and modelling software is not considered yet	DO, nitrogen, chemical feed, flow (pump),	Industrial WWTP	(Haimi et al., 2010)
• Adequate maintenance should always be conducted for sensors and actuators. • Cost-benefit analysis should be considered before implementation. • Specific aspect should be considered for different mill • Separate zone need special control	DO, flow meter, pH ammonium, sludge control	A review of Aerobic process on WWTP	(Åmand, Olsson, & Carlsson, 2013)
• Power failure might caused a system halt (fail-safe) • Limited capability of multiprogramming in PLC • Skilled operator is needed • PLC need a strong financial support	pH	Sewage water treatment plant	(Hiray et al., 2017)

4. ADVANTAGES AND WEAKNESSES OF AUTOMATION AND ONLINE MONITORING

The utilization of online, automatic monitoring and control instruments may be expected to provide several advantages as described in Table 5. The automatic monitoring and control system is expected to reduce the involvement of operators and laboratory personels, thus give the advantage of a more efficient workforce. It may estimate the performance of the WWTP and estimate online the parameters that are less than optimal or problematic so that it might be followed up more quickly. Improved and more stable results may be expected because of a more uniform quality and flow, especially with automatic and more evenly distributed motor, thus creates a less oscillation wastewater quality. The consumption of chemicals also may becoming more efficient because of the use of monitor and controls that are more stringent and also automatic system. Energy consumption also may become more efficient due to tighter process control and use of automatic air blowers. The utilization of programmable controller also may disclose some potentials of integration of WWTP with other stations such as fresh water stations, white water stations, etc.

The cost savings that can be made by implementing online monitoring can reach up to 20-40% (estimation) with several assumptions applied. However, the application of automated monitoring and control may also need advanced preparation which would affected the effectiveness of the system applied as described in Table 6. These advanced preparation are such as competencies of WWTP operators, proper design for the automatic system, alternative strategy for low-cost sensor to improve reliability and accuracy, separate control for separate zone, system basic requirements and safety, adjustable automated system design, regulation from Government, integration of online control, maintenance plan, etc.

5. CONCLUSION

Information on monitoring the quality of wastewater in industry is very important to be perceived by examining changes in effluent conditions that are getting better or worse. It is necessary to develop a system that monitors the condition of industrial wastewater. It may improve the optimization of either or both primary and secondary wastewater treatment, and also prevent some problems that may arose due to parameter changes that might occured and caused inefficient and ineffective performance.

The application of industrial technology concept 4.0 and automation systems in the industry is expected to improve the WWTP supervision process which has advantages such as reducing down time, reducing consumption of raw materials, reducing the energy used, increasing productivity, improving product quality, making efficient use of resources and processes, so as to reduce industrial operating costs, etc. The cost savings that can be made by implementing online monitoring can reach up to 20-40% (estimation) with several assumptions applied.

However, there are severals important affair that need to be addressed and considered so that the application of this technology could be effective, such as competencies of WWTP operators, proper design for the automatic system, alternative strategy for low-cost sensor to improve reliability and accuracy, separate control for separate zone, system basic requirements and safety, adjustable automated system design, regulation from government, integration of online control, maintenance plan, etc.

The results of the above review indicate that online effluent quality monitoring technology may help the industry to quickly monitor the effectiveness of WWTP performance.

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