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Hazard Identification and Risk Assessment in Wastewater Treatment Plant of Di An City

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ABSTRACT

The wastewater treatment plant is an extremely important infrastructure to ensure the quality of life, water use of human life, and other ways to ensure water quality for the natural environment. In the operation of it, there are always potential hazards affecting the health of the workers working in the factory. The study was performed using the Semi-quantitative risk assessment method to calculate the values of operational risks in the water treatment plant (WWP). The results of the study obtained 18 high potential hazards that may lead to the present in the water treatment process. The hazards were the leakage of deodorizing towers and the generation of toxic emissions of dead microorganisms that have the highest value with a risk scale of 20 points- frequent impacts on employees. The study has also identified the dangers present in WWP and this will be the premise for mitigating solutions for problems occurring at its.

Keywords: *hazard, risk assessment, wastewater, Di An*

1. Introduction

Environmental health and safety reflect activities in the plants that directly affect workers' health and occupational safety. Works performed directly in the factory in taking to potential hazards that may be physical, chemical, or psychological factors that can lead to workplace failures and related injuries works, which affects the quality of work and the profitability of the organization (Bahn, 2012). Hazard identification

(HIRA) is a process of identifying and describing hazards by describing their probability, frequency, and severity and assessing adverse consequences, including potential loss and injury. The industry needs to identify hazards and assess associated risks for tolerance on an ongoing basis using risk assessment standards and guidelines (Lim et al., 2012; Ramesh, Prabu, Magibalan, & Senthilkumar, 2017). Risk assessment is a method of systematically identifying and analyzing hazards associated with an activity and establishing the level of risk for each hazard (Lim et al., 2012). Hazards cannot be eliminated, and therefore it is necessary to determine and estimate the extent to which an accidental risk can be prevented quantitatively or qualitatively of the hazard mechanism.

The wastewater treatment plant is an important infrastructure to ensure human health and the environment. In the treatment process, the health and environmental safety aspects need to be addressed (Brown, 1997). High-risk workplaces often become the cause of occupational accidents and illnesses. Working in water treatment is considered to be a hazardous job, as workers often work at high altitudes and are exposed to polluted working environments. Occupational safety and health are rarely paid more attention. Many managers believe that this job is now somewhat less dangerous, but workers in the WWP are still capable of affecting their health and may be death, especially from exposure to deodorizing chemicals (Brown; Vantarakis et al., 2016) and electrical sources present in there.

The operations in the wastewater plants are modernized and operate automatically, but in addition to those automatic activities there is always human supervision (Trịnh, 2009; TS, CHÍNH, & ANH) to ensure that those automated operating processes are in place (Rubio, Menéndez, Rubio, Martínez, & Practice, 2005) and at the lowest level of errors, employees must know the operation to ensure safety issues (Rubio et al., 2005) and solve the machine problems (Rubio et al., 2005). In addition to these automated operations, the plant is a more concerning threat than the odor treatment system, where the plant must always use gases such as CO_2, SO_2, NH_3, H_2S, CH_3-SH, etc and these gases cannot be released to the air. Components in the air will react with impurities to create more toxic gases and direct effects on the respiratory such as dizziness, nausea, fainting, and so on (Kilroy, Ebner, Chua, & Venkatasetty, 1985). With workers who have a long-time intake and often work in odor handling positions. In the water treatment plant, machines, and equipment with large capacity and continuous operation are also used, so the risk of injury to workers is very high. Accidents occurred can be caused by employees' negligence when operating machinery or equipment or due to unsecured working environment conditions. Potential hazards often occurred operational defects, chemical exposure, or fatigue at work.

Currently, Vietnam's economic growth rate is increasing rapidly, industrial parks appear

more and more. In particular, in key economic zones, the number of industrial parks in this region is extremely dense. Binh Duong is a province in the Southern key economic Zones, being 28 industrial parks and industrial zones. Therefore, the province's environmental issues are receiving special attention from the authorities. In which, Di An city is the South Binh Duong area. Di An City is adjacent to Ho Chi Minh City to the south and west, with Dong Nai province to the north and east. The city has a total land area of about 60 km^2 and a population of about 381,000 people in 2014 (Kỳ, Nguyên, & Hưng, 2019). Two-thirds of Di An's population come from the provinces to work in the town's industrial zone (Hạnh & Nguyên, 2019).With the goals of environmental protection and public health, Di An's domestic wastewater treatment plant located in Binh An Ward, Di An, Binh Duong was put into operation in May 2013. However, the study on the hazard and risk of Di An domestic wastewater treatment plant has not been implemented yet. In this paper, hazards and risk assessment at Di An wastewater treatment plant will be identified to provide basic information for avoiding disruption and proposing solutions to work efficiency.

2. Data and research methodology

Data

The data were collected from monitoring data and surveying at Di An wastewater treatment plant in 2020. Parameters were used in this study including pH, chrominance, TSS, COD, BOD_5, NH^{4+}, NO^{3-}, N total, P total, and Cl^- with monitoring frequency 4 times/month.

The Semi-quantitative risk assessment method (HIRA)

The study used the HIRA method (hazard identification and risk assessment) to identify potential hazards in the workplaces in the WTP. A variety of work conditions were expected to facilitate workplace safety management and control to minimize the likelihood of occurring accidents.

Hazard identification and risk assessment using the HIRA can apply as a risk assessment tool that will help identify hazards and estimate the risks associated with each identified hazard. This risk assessment tool will identify the potential hazards associated with each task within the management and departments. Once a hazard has been identified, the associated risks are estimated and classified. At the same time, it also allows us to demonstrate our commitment to a safe workplace. We must identify hazards and potential hazards in the workplace so that action can be taken to eliminate or control them(Ebadat, 2010). To eliminate or minimize the risk of injury, illness to workers and damage to properties, equipment, and the environment. These are a worksite and work inspection process completed to identify all the hazards inherent to

the job or the worksite (Aneziris et al., 2008). The Semi-quantitative risk assessment method.

To be able to assess the level of risks, and to identify the hidden hazards that exist around the working process, it is the responsibility of the management department to learn a defined system to assess and control the term. effective risk. The steps include:

• Hazard assessment: identifies hazards and potential hazards identify risks and assign (ranks) hazards related to hazards based on likelihood and severity to be There are 5 levels.

• Control of hazards - control of hazards and hazards associated with hazards.

• Provide information, education, training, and monitoring of hazards, risks, and controls to employees affected by hazards.

• Review of the hazard assessment and control process.

TABLE 1. Description of Likelihood Level (Falakh & Setiani, 2018)

Level	Frequency	Consequence	Description
1	Rare	Very light	● Minor local injuries (first aid and accident, reportable injuries). ● Property damage less than base level amount ● Minor environmental impact ● Loss of production less than base level amount
2	Unlikely	Injured without care	● Serious onsite injuries (temporary worker injuries). ● Moderate environmental impact (clean up or remedy consequences in less than 1 week and no long-term effects on the organism). ● Minor offsite impact (public nuisance to the public - noise, smoke, odor, traffic).
3	Possible	Injured needs care	● Permanent paralytic injury or may cause death. ● Significant environmental impact (clean up or treat less than 1 month and small impact on the organism). ● Moderate external effects
4	Likely	Emergency	● Onsite fatality or less than four permanent disabling worker injuries ● High level of property damage ● Serious environmental impact (cleaning or remediation takes 3–6 months) ● Significant external effects property damage, short-term health effects for the community
5	Almost certain	Dead	● Multiple onsite fatalities or injuries cause permanent on-site injury. ● Property damage was high ● Large-scale environmental impact (cleaning up or remedying consequences for more than 6 months) ● Serious external impacts, long-term health effects

In the process of surveying and experiencing actual work at the factory, as well as during the preliminary survey of a part of factory employees. To be able to know the severity of each hazard is divided into 5 levels ranging from light to death. After the

scale of the frequency-specific consequences from levels 1-5, the value of the risk will be at a relative level and should be analyzed using the Risk Assessment Matrix displayed in Table 1 (Patil, Nagaraj, & Venkataramu).

Risk is expressed in a variety of ways to convey the distribution of risk across the factory and the workplace. In this work, risk was calculated using the following formula and Table 2.

Risk (R) = Frequency (X) x Consequence (Y) Eq. 1 (Ramesh et al., 2017)

The risk identification phase is essential, as it lays the foundations of risk analysis. Therefore, risk identification data will be a prerequisite for the assessment to obtain the best results (Schneider & Beblo, 2010).

TABLE 2. Risk assessment matrix (Falakh & Setiani, 2018)

Frequency / **Consequence**	Rare	Unlikely	Possible	Likely	Almost certain
Very light	1	2	3	4	5
Injured without care	2	4	6	8	10
Injured needs care	3	6	9	12	15
Emergency	4	8	12	16	20
Dead	5	10	15	20	25

From the consequence and frequency scales, we calculated the risk level. The level of impact was divided into four levels enclosing low risk, medium risk, high risk and extreme risk respective value [1-3; 4-6; 8-12; 15-25] (Table 4).

TABLE 3. Risk scale for the WWP

Level	**Risk value**
Extreme risk	15-25
High risk	8-12
Medium Risk	4-6
Low risk	1-3

Practical survey method: Observing, taking pictures, and operating Di An Wastewater Treatment Plant (Wastewater Treatment Area) to record the potential hazard and essential information of workers, unintended incidents and problems that the WTP deals with.

Methods of determining hazards

After observing and determining hazards and risks at Di An Wastewater Treatment Enterprise, the hazards are identified through the method of the checklist and work analysis. The analytical procedure is outlined as follows.

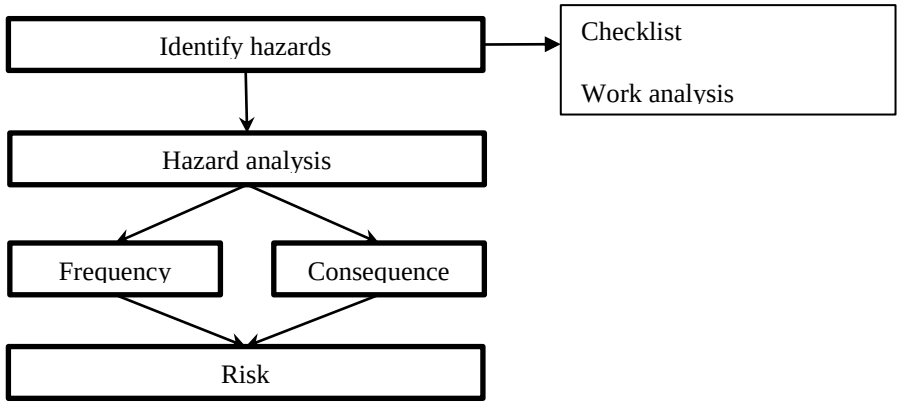


Figure 1. The scheme of Hazard determining

3. Results and discussion

The state of wastewater collection and treatment at Di An wastewater treatment plant

Di An wastewater treatment plant has been operating with a capacity of 20000 m^3/day and is expected to expand capacity by 2030 to 60,000 m^3/day with the current collection network as the drainage systems, separate wastewater (rainwater separate), collected directly (no need through the septic tank). Wastewater collection network includes a pipeline and drainage system with a total length of over 300km with 23,000 connection boxes and households to collect and transport wastewater to treatment facilities.

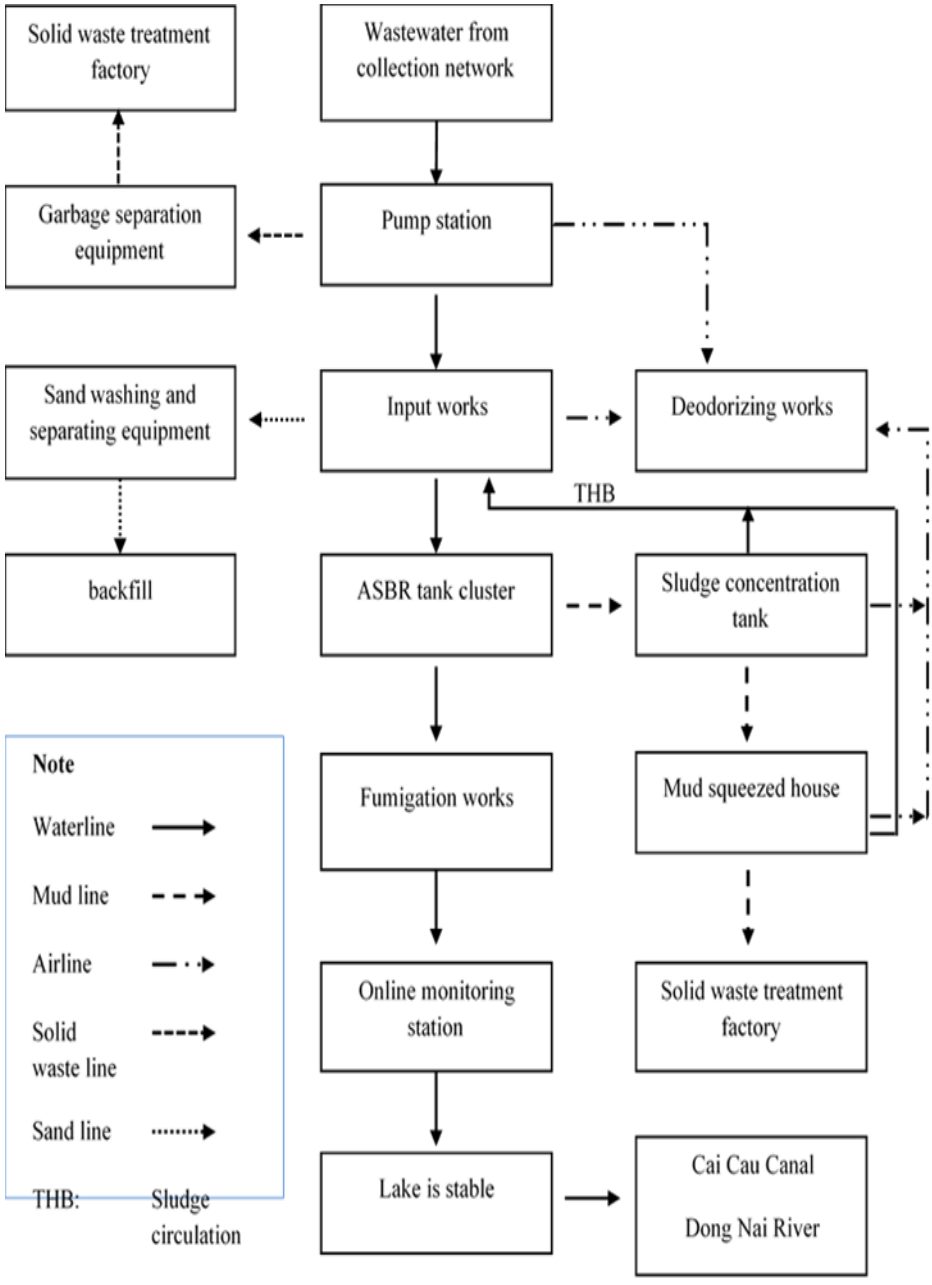
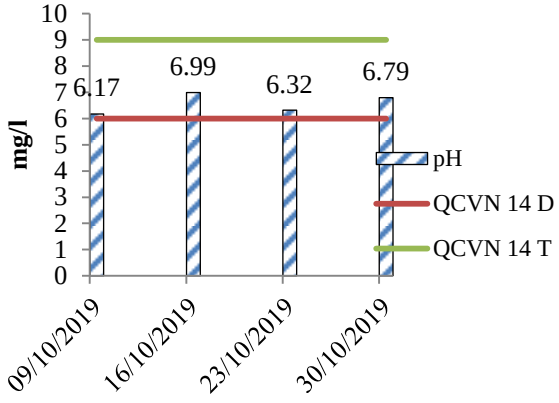


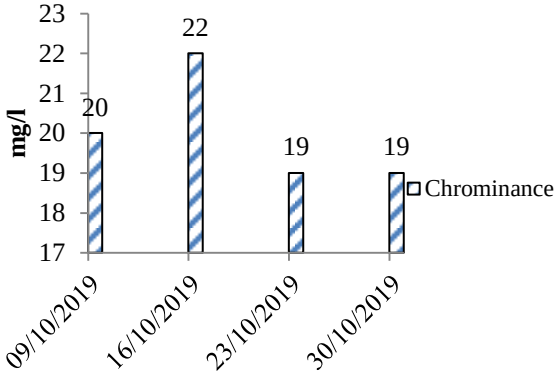
Figure 2. The Process of wastewater treatment in Di An plant

Wastewater from drainage households in Di An city follows the main pipeline flowing to the pumping station. Then, wastewater is led to the pump pit and pumped to the inlet at a height enough for wastewater to flow through the plant by itself and after treated wastewater releases to the receiving source, Cai Cau canal, which flows into Dong Nai River. Rotary drum filter is installed to remove materials larger than 3mm, waste is automatically collected in the container and disposed of periodically. Then, the wastewater flows itself through the rotating sand settling tank, with the continuous

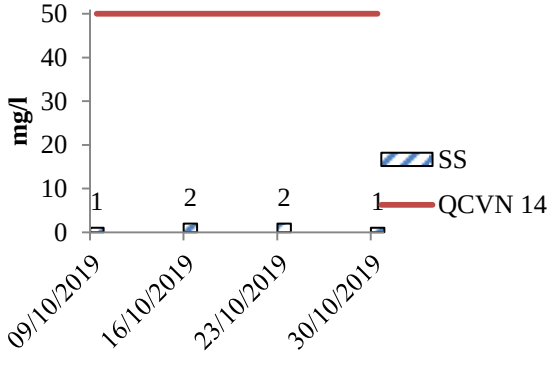
rotation of the mixer, the sand (gravel) will be collected at the center of the sand settling tank and then deposited into the sand collection hopper. The lifting gas pump system will collect sand (gravel) which will be collected and disposed of periodically, and wastewater continues to flow through the grease separation tank. Oil and grease are collected by pumping floating scum and discarded periodically. Garbage, sand, and scum, after being separated, will be transported to the Waste Treatment Plant for treatment. Wastewater, after being preliminarily treated, will go to the water distribution compartment so that the wastewater flow is evenly distributed to 4 ASBR tanks. The most of the pollutants in the wastewater are removed by a biological process that takes place in the ASBR tank. Wastewater after treatment at ASBR tank is a decanter with Decanter device and self-flowing through a pipeline through a UV sterilizer with a wavelength of 254 nm in a few seconds to destroy microorganisms in water before discharging to the receiving source. The treated wastewater reaches column A, QCVN 14:2008/BTNMT and is discharged into the Cai Cau canal, which flows into Dong Nai river. Water quality at the plant is being operated and gives very good treatment efficiency and is expressed as follows:



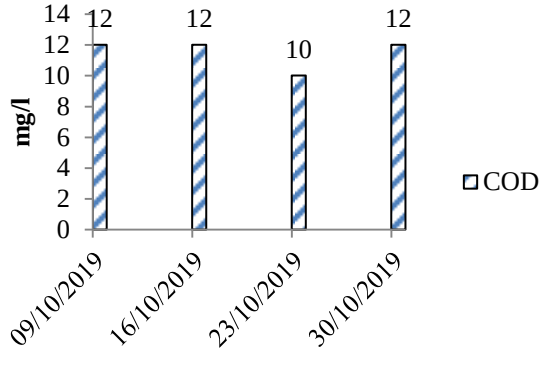
a) Output pH parameters 9/10/2019 – 29/10/2019



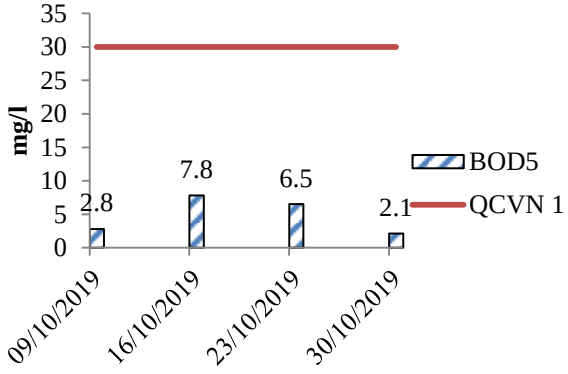
b) Output chrominance parameters 9/10/2019 – 29/10/2019



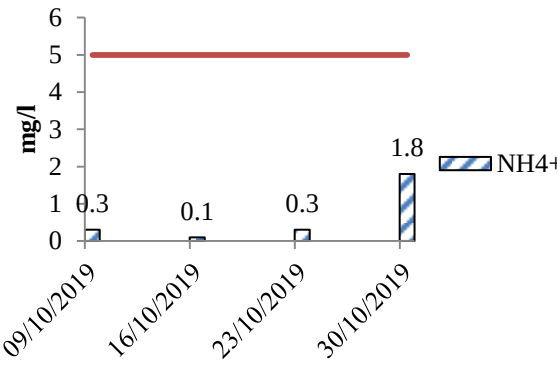
c) Output SS parameters 9/10/2019 – 29/10/2019



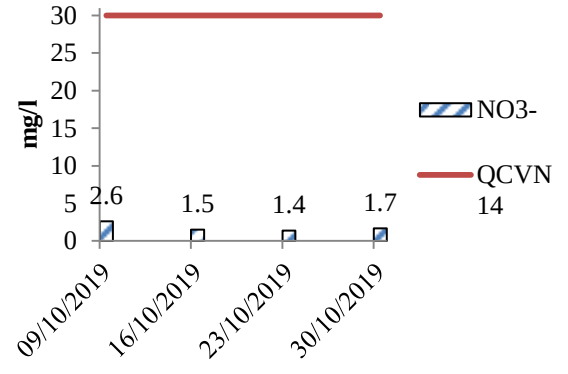
d) Output COD parameters 9/10/2019 – 29/10/2019



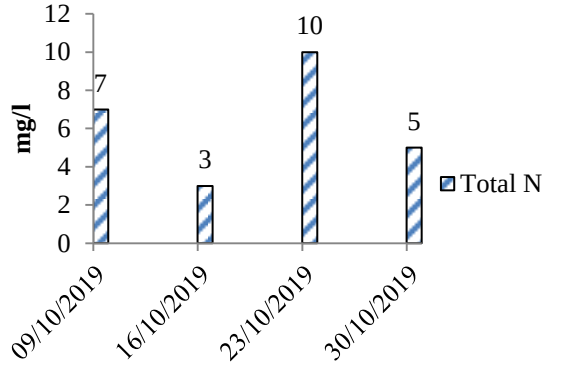
e) Output BOD_5 parameters 9/10/2019 – 29/10/2019



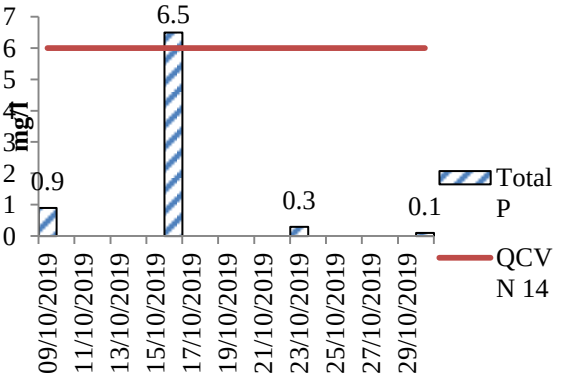
f) Output NH^{4+} parameters 9/10/2019 – 29/10/2019



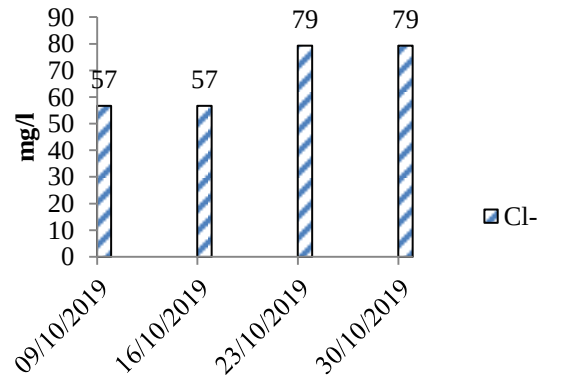
g) Output NO^{3-} parameters 9/10/2019 – 29/10/2019



h) Output total N parameters 9/10/2019 – 29/10/2019



j) Output total P parameters 9/10/2019 – 29/10/2019



k) Output Cl^- parameters 9/10/2019 – 29/10/2019

Figure 3. *Wastewater quality parameters after treatment in October 2019*

As you can see from Figure 4 the quality of cashew water is within the prescribed range of regulations on domestic wastewater treatment QCVN 14:2008/BTNMT. However, we saw that the total P concentration on October 16, 2019, is 6.5 ml/g compared to the allowable limit of 6.0, which is more than 0.5. The excess is insignificant as it was stabilized the next day with a specific index of 0.3, so it showed that the wastewater

treatment system at the factory has very good treatment efficiency.

Determination of hazards of the wastewater treatment system

As we can see that the treatment capacity of 20000 m^3/day is an extremely large number and must always be in continuous operation so the risks that may occur in the plant will cause a huge impact. Moreover, sub-activities supported to the operating plant such as chemical, equipment and emission gas from the treatment system also existed some hazard for employee's health and environment.

TABLE 4. Hazardous and potential risks related to Di An wastewater treatment plant

Workplace	Hazardous situation	Risk potential
Wastewater treatment system: - Rotation of the filter coarse crystals - Slitting, stirring and pumping at ASBR tank	Work often at altitude, noise, odor	Falls falls, occupational deafness, respiratory diseases,
	The air blowing devices in the ASBR tank were damaged	The quality of treated water is not satisfactory. Interrupt the handling operation
	The sludge pump was damaged	Environmental effects
Mud pressing	Noise generation Labor accident The odor of sludge arises	Occupational deafness, health effects Risks due to the carelessness of workers Prolonged exposure to the smell of sludge can lead to health problems
Mud storage area	Generating foul odor due to death microorganisms	Health effect Environmental effects
Odor treatment system	Out of deodorant chemicals	The concentration of exhaust gas does not meet the prescribed standards
	Leaks in deodorant chemicals - Sulfuric acid (H_2SO_4) to remove NH_3 - NaOH and NaOCl to remove H_2S and CH_3SH	Polluting the air Causing acute poisoning to workers
	The gas line leaks	Spreading H_2S emissions into the surrounding environment, increasing H_2S, poisoning, causing environmental pollution
	The defective exhaust fan system	The processing system does not function well, reducing the processing efficiency
	The treatment system did enclosed to national standard	Contaminate the surrounding environment Reduces air quality
Control room	Power failure, electric leakage, short circuit	Health effects, economic damage
Laboratory	Electrical leakage from machinery	Health effects, property damage, and health
	Chemical leaks	Environmental effects

		Health effect
House sterilization	Water inlet overload	The wastewater does not disinfect and clean residual bacteria in the wastewater
	Excess muscle excess specified	Poisoning the system of receiving water is the Saigon River

Each process has different operations, thus any carelessness and an equipment failure at the plant also led to the risk causing injuries and certain consequences, affecting workers' health and equipment in the factory from chemical and releasing odor.

Assessment of safety risk characteristics

Through the risk assessment matrix, it can be seen that the Di An wastewater treatment plant includes 18 hidden hazards in the operating wastewater treatment system and auxiliary works. The most hazard problems that arise in the risk assessment can be most clearly seen as problems with fire and explosion due to system overload or short circuit caused by industrial pumps with high capacity and reduction systems. Factory odor always leaks chemicals (NH_3, H_2S, CH_3-SH) in the deodorizing process. The leakage of deodorant and the risk of fire and explosion are the risks that have a great impact on the health of workers and the efficiency of the plant's treatment. The odor is unavoidable and these gases absorb through the eyes, causing burning or discomfort, burning eyes, unconsciousness, redness, and watery eyes. A large number of chemicals in the air can cause severe burns, pain, and blurred vision.

Therefore, warehouse workers must conduct carefully scheduled inspections so that the presence of gases (NH_3, H_2S, CH_3-SH) can be safely controlled, in addition to an emergency management control system that refers to exhaust gas leaks and industrial fires, efforts should be made to prevent known potential hazards.

TABLE 5. The level of risk in Di An wastewater treatment plant

No.	Hazardous situation	Frequency (X)	Consequence (Y)	Risk value (R)
1	Work at height	5	3	15
2	Working in environmental noise	5	1	5
3	Working in environmental odor	5	1	5
4	The air blowing device in the ASBR tank is damaged	1	5	5
5	The sludge pump is damaged	1	5	5
6	The pump generates noise	5	2	15
7	Toxic emissions are generated after the death of microorganisms	5	4	20
8	Out of deodorant chemicals	2	4	8
9	Leaks in deodorant chemicals	5	4	20

10	The gas line leaks	1	4	4
11	The defective exhaust fan system	1	4	4
12	Power failure, electric leakage, short circuit	2	5	10
13	Electrical leakage from machinery	2	4	8
14	Laboratory chemical leaks	3	4	12
15	Water inlet overload	3	4	12
16	Work in wet conditions	3	1	3
17	Manual work at the factory	5	1	5
18	Exposure to ultraviolet radiation (UV lamp)	5	2	10

The semi-quantitative (HIRA) identified all the risks in the plant and described the danger level for each risk. There were four hazards at extreme risk including work at height, the pump generates noise, Toxic emissions and leaking in deodorant chemicals. Six aspects were recorded at high risk such as Out of deodorant chemicals; power failure, electric leakage, short circuit; electrical leakage from machinery; laboratory chemical leaks; water inlet overload and exposure to ultraviolet radiation. The medium risk of hazards were working in environmental noise, odor, impaired pump, air blowing device in the ASBR tank, gas line leaks, defective exhaust fan system and manual work at the factory (Table 6 and Figure 5). There is only low risk obtained at the work in wet conditions. Overall, Di An wastewater treatment plant existed in a variety of potential hazards that were record high risk. Therefore, training activities and equipping personal protection equipment need to be implemented rapidly. Besides, prevention of risks from chemical leakage and gas emission affecting employees must be bustled to minimize consequences to health.

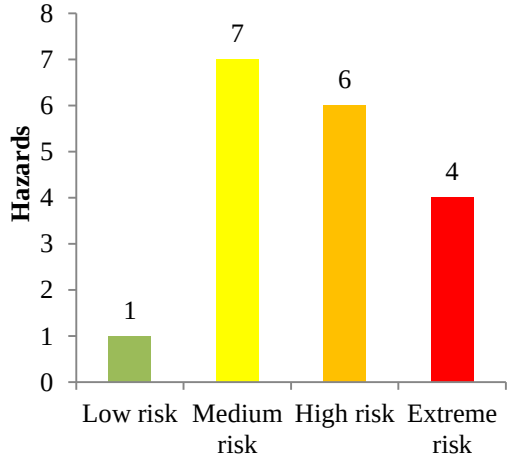


Figure 5. *Recapitulation of the risk value*

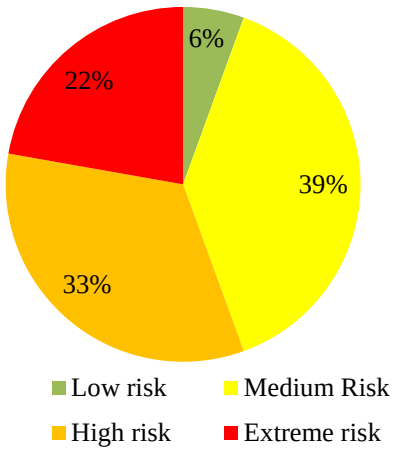


Figure 6. *The perception of risk level at Di An water treatment plant*

It can be seen Figure 5 and Figure 6 the probability occured in low risk accounts for 6%, medium risk 39%, high risk 33%, and extreme risk 22% of all activities that take place in the plant.

4. Conclusion

Di An wastewater treatment plant with a treatment capacity of 20.000m^3 always has to face a large source of waste components in the daily activities of the households in the Di An city. Safety risks always exist during the operation of the wastewater treatment system. The semi-quantitative HIRA method is used to assess hazards from operating wastewater treatment system showed that the factory has 18 risks, of which 4 have extreme risk - affecting the health of workers, accounting for 22% of the total risks at the factory, 6 aspects were high risk with accounts for 33%, 7 medium risk hazards at 39% and low risk at 6% only one factor. Health and safety risks presented in the plant may happen at any time and may cause unfortunate incidents, so it is necessary to have more attention of the leadership department to prevent these hazards.

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