EVALUATION OF QUALITY OF INDUSTRIAL TREATED WASTE WATER AND REUSE POTENTIAL FOR AGRICULTURE IN YEN BINH INDUSTIAL PARK, DONG TIEN WARD, PHO YEN TOWN, THAI NGUYEN PROVINCE

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ABSTRACT

Water scarcity in Vietnam, as a result of environmental pollution and climate change, is having a detrimental effect on water resources, affecting people's lives and the country's economy in a variety of ways. Water scarcity, in particular, has a significant impact on our agriculture. In this situation, it is critical to find solutions that protect the environment while also ensuring irrigation water supply. The centralized wastewater treatment station at Yen Binh Industrial Park complies with Vietnamese standards for industrial wastewater and has a capacity of 60,000 m^3 per day. The amount of treated wastewater produced annually is sufficient to supply 1800ha of rice. The amount of phosphorus and nitrogen in treated wastewater can result in an annual savings of approximately 4 billion VND on fertilizer purchases. With these benefits, reusing industrial wastewater for agriculture in Yen Binh is an efficient way to meet irrigation needs, conserve water resources, and reduce fertilizer costs.

Keyword: *Industrial wastewater, treatment, nutrition, reuse, agriculture*

1. INTRODUCTION

1.1 Current status of industrial wastewater

The expanding industry has created a problem for the environment, one of which is industrial wastewater. According to the United Nations Industrial Development Organization data, the industry is a significant polluter because only a portion of sewage is treated before release into the environment. By 2025, the volume of industrial wastewater will have doubled. Industrial wastewater, on the other hand, can be considered a resource. The technology can be used to remove or recover contaminants from sewage, resulting in two products: treated water and recovered valuable materials such as minerals (phosphates) and metals.

In Vietnam, economic growth has been mainly based on resource exploitation and accompanied by increasing pressure on the environment. Industrial production activities from industrial zones, production facilities, and craft villages have discharged many waste, polluting the environment in the region [1]. By early 2020, there are 274 industrial zones (IZs) in operation nationwide, of which 244 zones have centralized wastewater treatment systems, accounting for 89%. In which 191/244 IPs have automatic monitoring stations, accounting for 78.3%. Around 276 industrial zones have environmental impact assessment reports, 160 industrial zones with rainwater and wastewater separation systems, 109 industrial zones with centralized wastewater treatment systems, reaching 15.8%, 10 industrial clusters having an automatic wastewater monitoring system [2].

1.2. Water shortage in agriculture

Population and economic growth have spurred a rapid increase in the demand for water resources. As a result, 36% of the world's population lives in water-scarce regions, particularly in low- and middle-income countries [3]. In addition, according to World Bank [4], Vietnam is one of the five countries that will be most affected by climate change and sea-level rise, which also affects water resources due to saltwater intrusion and drought. Agriculture is the largest consumer of water, accounting for 65% of 70% of global water demand and is also affected by water pollution [5][6]. In Vietnam, agriculture is the primaryleading industry. More than 80% of agricultural products are rice production, which requires a huge water demand. Regarding wastewater reuse, World Bank [5] reported that 10% of crops globally are irrigated with wastewater, yet only 10% are properly disposed of.

Pho Yen town is one of the provinces of Thai Nguyen's primary agricultural development areas. Although the economic structure is shifting in favor of industry, agriculture remains a sector that the government is interested in investing in and developing. Rice cultivation area exceeded 5,200 hectares (ha) in 2019, and crop cultivation area exceeds 3000 hectares (ha) annually [7]. In recent years, a lack of irrigation water in agriculture has had a significant impact on people's lives in some communes in Pho Yen town, Thai Nguyen, particularly in North hamlet, Tan Huong commune (Pho Yen). Due to a lack of irrigation water, annual crop yields have decreased by 30-40 percent [8].

1.3. Industrial wastewater treatment in the world

The wastewater industry is moving towards the recovery of high-value resources from waste and wastewater, providing new technology options and opportunities to solve modern social problems and environmental protection [9] [10]. Industrial wastewater treatment technology can be divided into three categories: chemical, physical, and biological methods. Chemical methods include chemical precipitation, chemical oxidation or reduction, etc. Physical treatment methods include sedimentation, flotation, filtration, removal, ion exchange, adsorption, and processes. To remove soluble and insoluble substances without necessarily changing their chemical structure. The biological method involves living organisms using organic or inorganic substances as food for them. In those processes, the chemical and physical properties of the organic and/or inorganic matter are altered [11]. Contaminants in industrial wastewater can be classified to see whether chemical, physical, biological or a combination of treatment types is most appropriate, based on the essential characterization of the contaminant and the handler's experience.

The stages of a wastewater treatment process are usually divided into primary, secondary, and tertiary treatment. The primary stage is mainly a physical process to separate solids in wastewater from liquids. Depending on local conditions and requirements, this step may also include removing fat and grease, adjusting pH and temperature. Primary treatment typically removes about 60% of suspended solids and only 35% of biological oxygen demand (BOD_5) from wastewater.

Secondary treatment is an aerobic biological process. There are many technologies that can be used depending on the scale of the water treatment plant, location (near aquifer, river, sea), age of the treatment facility, and others. Two of the most common types of biological treatment are the relatively newer suspended growth systems such as activated sludge (AS) and the older, more stable stationary growth systems, such as Trickling Filters.

Tertiary treatment can remove up to 99 percent of pollutants from raw wastewater, including bacteria. It is also becoming the industry standard. Furthermore, tertiary treatment costs can be as high as secondary treatment costs, and tertiary treatment is becoming more prevalent in developed countries as water quality standards become more stringent. The most frequently used tertiary treatment is disinfection, which can be accomplished through chlorination or ultraviolet (UV) light to eliminate any remaining pathogens in the water. Additionally, the more common and economical method is to use chlorine, which is effective against a wide variety of bacteria, viruses, and protozoa, including Salmonella, Shigella, and Vibrio cholera. The chlorine concentration supplied must be tightly controlled: sufficient to kill pathogens but not so much that it harms the environment, such as fish death.

Additionally, tertiary or advanced treatment may be required when insufficient nitrogen and phosphorus are removed during secondary treatment to avoid eutrophication, algal blooms, and other environmental problems.

Phosphorus is present in wastewater as organic phosphorus or phosphate and can be removed through a physicochemical process incorporating a precipitating agent such as aluminum sulfate (Al_2SO_4), also known as alum, ferric chloride, $FeCl_3$, or calcium oxide (CaO). The most commonly used method of nitrogen removal from wastewater is biological nitrification-denitrification. The nitrification step of this process involves the conversion of ammonia nitrogen (NH_3 or NH_4+, depending on the pH of the system) to nitrite (NO_2-) and then to nitrate (NO_3-) via nitrifying bacteria or spontaneously. Nitrosomonas nutrient and aeration [12].

2. INDUSTRIAL WASTEWATER IN YEN BINH INDUSTRIAL PARK, PHO YEN, THAI NGUYEN

Thai Nguyen is a typical example of industrialization and modernization with its geographical position as the political, economic, and educational center of the North. Accordingly, industrial production facilities in the province discharge about 19 million m^3 of wastewater annually and are expected to increase by about 22% per year. Among 100 establishments causing environmental pollution in the province, 52 establishments have wastewater sources causing environmental pollution. Water in rivers and streams receiving wastewater from mineral mines and industrial production facilities has shown signs of contamination with total suspended solids (TSS) and some heavy metals (Fe, As, Cd, Pb). , Zn). Currently, Yen Binh is one of the largest industrial zones of Thai Nguyen. There are six businesses and companies that have been discharging about 60,000 m^3 per day. To meet environmental protection and production needs requirements, the Industrial Zone Management Board has invested in building a wastewater treatment station of 60,000 m3/day. The quality of wastewater produced and collected by 6 different companies must meet pre-treatment quality requirements (QCVN 40: 2011/BTNMT column B) before being put into the centralized treatment station of the whole industrial park. Parameters of wastewater after treatment meet QCVN40:2011/BTNMT column A: National technical regulation on industrial wastewater. All treated wastewater will flow to Giao stream, Deo stream, and Cau river by self-flowing, surface discharge, and bank-side methods.

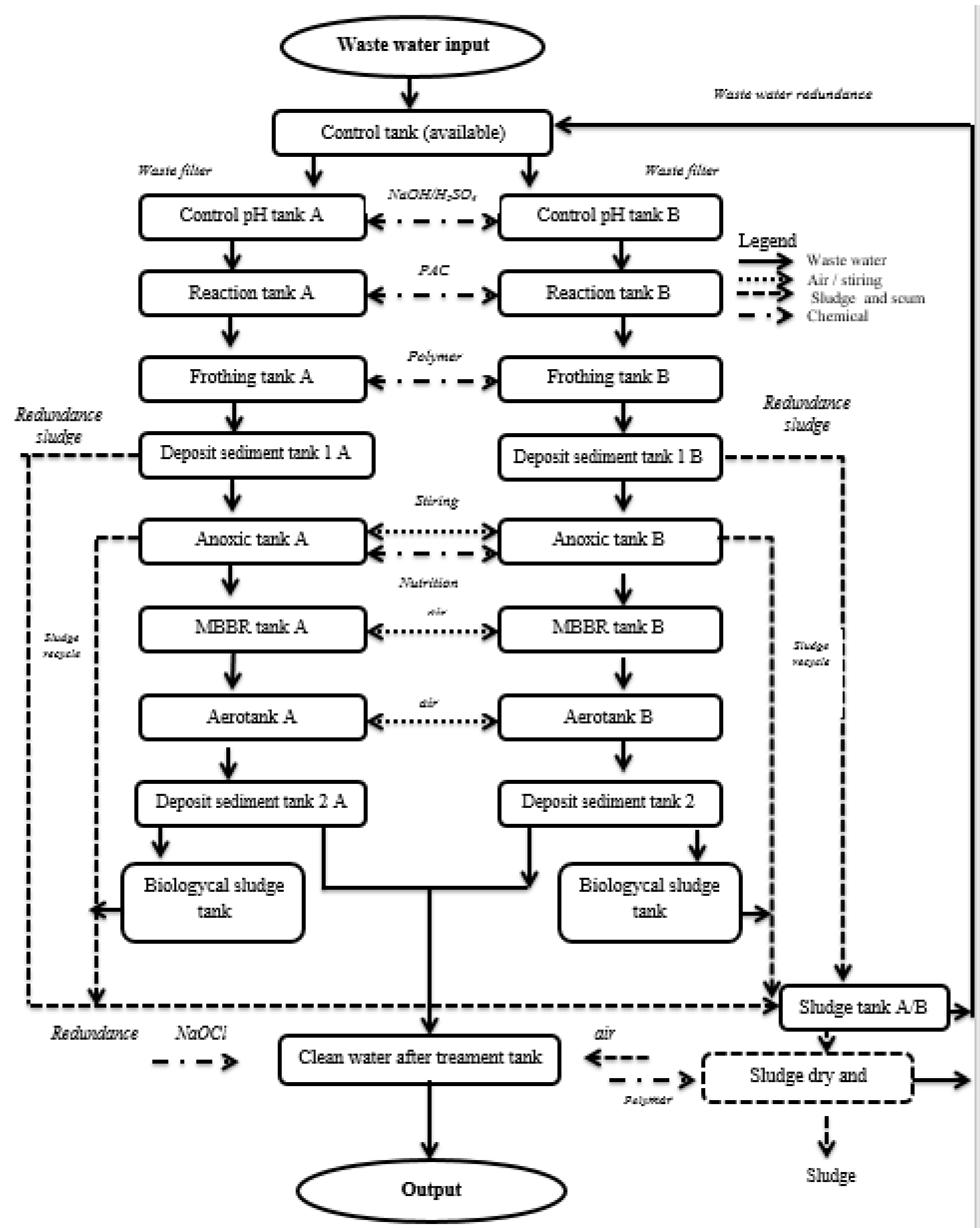
2.1. Efficiency of wastewater treatment at concentrated wastewater treatment station in Yen Binh Industrial Park

Wastewater treatment process

The concentrated wastewater treatment station is designed to treat wastewater for the entire 400-hectare industrial zone, including four treatment modules, with a capacity of 60,000 (m^3/day). Each module's system is designed with two lines to enable parallel and independent operation. When one of the two lines experiences a problem, the operator will manipulate the inlet flow control valve for that line to resolve the issue. At that point, the remaining one line will continue to function normally, while the other line will be repaired, troubleshoot, and rerun.

Modules 2, 3, and 4 are similar to Module 1, but instead of using conventional activated sludge microbial wastewater treatment technology, they utilize PVA Gel microbial media particles in anoxic and MBBR tanks. The PVA Gel microbiological substrates were imported from Japan Kuraray Corporation. They are made of PVA (Polyvinyl Alcohol) plastic and measure approximately 4-5mm in diameter. Along with serving as a habitat for wastewater treatment microorganisms, they direct microorganisms to grow in a specific strain based on the treatment characteristics of each reactor, preventing the rampant growth of filamentous bacteria. Simultaneously, the technology of using PVA Gel particles increases the contact area of microorganisms with the layers of wastewater to be treated in the reaction tank and evenly distributes them. Thus, the reactor's treatment capacity is increased, the construction area is reduced, the amount of sludge produced is reduced, the tank volume is reduced, and the wastewater treatment process is optimized, minimizing problems such as floating sludge.

Fig -1. Flowchart of wastewater treatment technology



The Yen Binh WWTP has a safe treatment process and an incident response plan. Additionally, the wastewater treatment technologies used are cutting-edge and effective in wastewater treatment and environmental protection. However, because the station is unable to handle the remaining sludge generated during the wastewater treatment process, the sludge, which contains numerous chemicals and heavy metals, will be transferred to another treatment facility for treatment. Moreover, advanced wastewater treatment technology based on imported microorganisms is expensive, has not yet achieved economic efficiency, and requires further research to be replaced by less costly technologies.

Quality of wastewater after treatment of Yen Binh Industrial Park

To assess the water quality of the wastewater treatment system during operation, we collected data on the results of wastewater quality monitoring after treatment for two years (2018-2019), the indicators including pH, COD, BOD_5, TSS, N, P, Cl, Hg, Cu, Zn, Pb, As, Coliform. Below is a summary table of the results.

Table -1: Wastewater quality after treatment in the process of 2018 – 2019

Indicators	Unit	Result	QCVN40:2011 BTNMT (Column A)	QCVN40:2011 BTNMT (Column B)
pH	mg/L	6.5-7.2	6-9	5.5-9
BOD_5	mg/L	5-9	24.3	-
COD	mg/L	<15	60	-
TSS	mg/L	7-14	30	-
CL-	mg/L	120-250	405	350
Cd	mg/L	<0.0005	0.041	0.01
Hg	mg/L	<0.0005	0.004	0.001
Zn	mg/L	0.01-0.02	200.081	2.0
Pb	mg/L	<0.0005	0.041	0.05
As	mg/L	0.00008-0.0028	16.2	0.05
N	mg/L	7.5-14	3.24	-
P	mg/L	0.5-1.5	3000	-
Coliform	MPL/100ml	<3		200*

Note: *(-): not specified; QCVN 40:2011/BTNMT: National technical regulation on industrial wastewater; (*) For plants eaten raw*

The results showed that: The quality of wastewater after treatment has 13/13 indicators within the permissible limits of QCVN 40. :2011/BTNMT column A: National technical regulation on industrial wastewater; 8/8 indicators are within the allowable limits of QCVN 39:2011/BTNMT: National technical regulation on water quality for irrigation

2.2. Water supply capacity for agriculture in the area

Treated wastewater provides an alternative irrigation water source and an opportunity to recycle plant nutrients [13]. Its application can ensure the transfer of fertilizer elements, such as nitrogen (N), phosphorus (P), potassium (K +), organic matter, medium and micronutrients into the agricultural soil [14]. Therefore, nutrients in wastewater can contribute to plant growth; however, it is necessary to monitor them, to avoid the imbalance in the nutrient supply.

Pho Yen town is one of the critical areas for the agricultural development of Thai Nguyen province. In 2019, rice cultivation area reached more than 5,200 ha/year, and the area of other crops was more than 3,000 ha annually [7]. Irrigation water sources for agriculture in Pho Yen are mainly from Cau and Cong rivers. The Cong River flows through Pho Yen town for about 25 km, joining the Cau River in Phu Loi village, Thuan Thanh commune, Pho Yen. However, the water from there was polluted due to untreated wastewater from industrial zones and domestic wastewater of people. The use of contaminated water for irrigation in agriculture can affect the quality of agricultural products and the health of consumers.

On the other hand, the quality of wastewater at the wastewater treatment station of Yen Binh Industrial Park is within the allowable standard limits according to QCVN 40:2011/BTNMT - column A and QCVN 39:2011/BTNMT, meeting the standards for use in agricultural irrigation. On average, each rice crop season needs 6,000 m^3 / ha for the plant to grow normally. At the same time, the plant's capacity is 60,000 m^3/day, which can supply enough for 1800ha per year. Consequently, the plant will provide about 200 tons of nitrogen (N) and 20 tons of phosphorus (P) annually, saving more than 4 billion VND of fertilizer. With a large capacity of 60000m^3/day and good water quality, the use of treated wastewater at Yen Binh WWTP for irrigation has a high potential.

3. CONCLUSION

The quality of wastewater discharged from the concentrated wastewater treatment station in Yen Binh Industrial Park complies with industrial wastewater discharge standards (QCVN40:2011/BTNMT) and irrigation water quality standards (QCVN39:2011/BTNMT). This is a potential water source for agricultural use in the current climate of climate change and environmental pollution. It meets water demands and partially meets the nutritional requirements of crops, saving between 5% and 10% of annual fertilizer costs.

With the numerous benefits of wastewater reuse, the government and authorities must implement policies that encourage the expansion of the wastewater reuse system in Yen Binh Industrial Park, encourage investment in construction, and raise residents' environmental protection awareness.

Additionally, the circulation of treated wastewater for reuse in industrial production facilities that do not require ultrapure water, such as those that manufacture building materials, iron, and steel, is feasible and warrants further investigation.

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