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Research Article

Environmental pollution caused by textile dyeing and finishing factories in Binh Tan District, Ho Chi Minh City

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ABSTRACT

The production activities of some small textile dyeing factories inadvertently cause some significant impacts on environmental quality. In this study, we take samples and analyze them to monitor the quality of water, air, and solid waste generated at 5 complete dyeing factories in Binh Hung Hoa ward, Binh Tan District, Ho Chi Minh City, Vietnam. We then assessed the environmental status of the finishing plants and their impact on the habitat of the surrounding residential area. The results show that industrial emissions and wastewater produced at these factories seriously violate standards such as dust and CO in the flue gas and color, Cu, BOD_5, COD, TSS in wastewater. Specifically, at the outlet pipe of the factory (1), the CO concentration is 14.6 times higher than the National Technical Standard on industrial emissions (QCVN 19:2009/BTNMT). In the production wastewater, the concentration of Cu metal exceeds the standard by 1.5 times. The long-run will seriously affect aquatic life and human health at the plant and surrounding area. BOD_5, COD, and TSS are 71, 63.07, and 63.16 times higher, respectively, compared to the National Quality Standard for Surface Water (QCVN 08:2015/BTNMT). However, air quality around the factory almost met the standard, which is due to the good air dispersion in this area. Furthermore, pollutant concentrations were higher in the dry season and lower in the rainy season. The situation of solid waste generation in the area is also assessed. Here, solid waste of small and insignificant volume, mainly collected as domestic waste, is not classified and is collected and treated by the Ho Chi Minh City Urban & Environment Company in accordance with regulations. Finally, several solutions have been proposed to reduce pollution and improve the environmental condition of this area.

Key words: textile, air pollution, wastewater, working environment

INTRODUCTION

The textile dyeing industry has the oldest history in the world. It plays a crucial role in the economy of each country, including Vietnam. The manufacturing operations of this industry use a lot of harmful chemicals, especially synthetic dyes. The environmental impact caused by the activities of this industry is mainly untreated dyeing wastewater entering the receiving source. The dyeing process alone contributes to 15-20% of the total amount of wastewater generated. It has caused many environmental and health impacts. Dyes contain high levels of toxic compounds such as sulfur, nitrate, formaldehyde, acetic acid, soap, chromium compounds, and heavy metals such as copper, arsenic, lead, cadmium, mercury, nickel and cobalt, and some other auxiliary chemicals. It is also the cause of the high toxicity of textile dyeing wastewater[1]. It is toxic to aquatic microorganisms, depletes the amount of dissolved oxygen in the water, prevents the transmission of light into the water, and reduces the self-cleaning ability of the water. About 40% of the colorants used in the world are composed of organic substances containing chlorine - a carcinogenic compound. Besides the impact on the aquatic environment, some volatile compounds and organic solvents used in the dyeing industry also have direct impacts on human health[2,3]. The properties of dyeing wastewater are color, turbidity, total suspended solids, biochemical oxygen demand (BOD), and chemical oxygen demand (COD). Their pollution composition is very diverse, their load is large and unevenly distributed among countries and regions[4]. Therefore, dyeing industry wastewater is required to be treated before being discharged into the environment, which is mandatory in most countries around the world today. On the other hand, what needs to be considered for the operation of this dyeing industry is air pollution. Exhaust gas generated from boiler operation and finished product drying processes. The environmental impacts of this industry are mainly volatile organic compounds, hydrocarbons, formaldehyde, NO_x, SO_x, CO_x, temperature, odor, and noise[5]. Pollutants have to be treated before being released into the environment to limit air

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pollution, prevent global warming, and ensure human health.

In Vietnam, the textile industry accounts for a very high proportion of annual GDP. Ho Chi Minh City (HCMC) is a major industrial, commercial, cultural, and tourist center in Vietnam where environmental pollution has increased due to industrial, agricultural, transportation, and living activities. The same situation is shared by some provinces in the southern region. Every year, the textile and garment industry discharges an average of 70 million m^3 of wastewater into the environment. But only about 45% of the total amount of wastewater has been treated (although the treatment level is still not thorough). The rest is discharged directly into sewers or drainage ditches.

The environmental condition around areas where small dyeing factories operate is dire. According to the assessment of many environmental experts, for fabric dyeing establishments located outside export processing zones and industrial zones, if they do not thoroughly treat the waste source, it will lead to serious pollution problems for the environment. Fabric dyeing and finishing are the most polluting stages when using dyes and chemicals, consuming a lot of water, generating a lot of wastewater with organic pollution concentrations (BOD, COD), toxic heavy metals, suspended solids, and very high color. It causes water pollution due to the poisonous properties of dye ingredients. Emissions of the dyeing industry are released into the environment as vapor, Cl, SO_2, CO, CO_2, NO_x, ... seriously affect human health. Most dyes are toxic, and some have the potential to cause cancer. Chlorine gas released from the washing process has an irritating effect on the respiratory tract and eyes. Chlorine can cause sudden death from respiratory arrest and syncope, pulmonary edema, and chemical burns at high concentrations. Although the authorities have detected and sanctioned many polluting textile and dyeing establishments, the risk of environmental incidents due to the operation of these establishments is still unpredictable. Some typical examples of the problem of water pollution caused by wastewater from textile factories and dyeing villages are Phuong La, Thai Thuong (Thai Binh), Van Phuc, Chuong Duong (Hanoi), Tuong Giang (Bac Ninh), Dong Yen (Quang Nam) or from textile dyeing establishments along Tham Luong canal, Binh Chanh district (HCMC). These are urgent and significant issues for the current management authorities.

The operation of many small establishments in Ho Chi Minh City is relatively discreet. The operating capacity of these production factories is low. Commonly, the products are supplied to small-scale garment companies in the area. Usually, these factories do not have a license to operate. In that case, it's expired. The location of factories and warehouses is quite sketchy. Around the textile dyeing factories are scattered sacks, chemical tanks, dyes. Environmental pollution due to industrial production is particularly the main concern. What is even more concerning at the moment is the existence of small dyeing establishments located around residential areas. It is also an essential aspect that has to be studied and proposed suitable solutions.

In this study, we research the current status of environmental pollution in residential areas around dyeing and finishing factories in Binh Hung Hoa Ward, Binh Tan District, Ho Chi Minh City. There are many dyeing factories located in the study area. From the survey results, we conduct an assessment according to the actual environmental status. Solutions are proposed to treat and improve environmental quality in the study area. This study provides important and meaningful data into the environmental management system in Ho Chi Minh City to support future environmental management and treatment.

MATERIAL AND METHODS

Research location

Binh Tan is an urban district in Ho Chi Minh City, Vietnam. Binh Tan District was established on November 5, 2003, based on separating 3 communes: Binh Hung Hoa, Binh Tri Dong, Tan Tao, and An Lac town in Binh Chanh district according to Decree 130/2003/ND-CP of the Vietnamese Government. Binh Tan District is one of the two largest districts in Ho Chi Minh City and also the most populous district in the city. Binh Tan district has an area of 52.02 km^2, a population of 784,173 people, a population density of 15,074 people/km^2. Binh Hung Hoa ward has an area of 449 hectares, population in 2012 was 59,886 people (Figure 1a). In this ward, two canals are running through the 19/5 Canal and the Nuoc Den Canal. From 2009 up to now, environmental pollution caused by economic and industrial activities has significantly affected people's lives. According to records from the local environmental management department, the current state of environmental pollution comes from dyeing factories operating along two canals and two canals that run along route 26/3, canal 19/5 are heavily affected by untreated wastewater from some dyeing factories that are discharged into the dispersed source. Five dyeing factories have completed their operation and directly discharged wastewater into this canal (Figure 1b-c). The environmental pollution status of the surrounding residential areas and at these factories was selected as the study area.

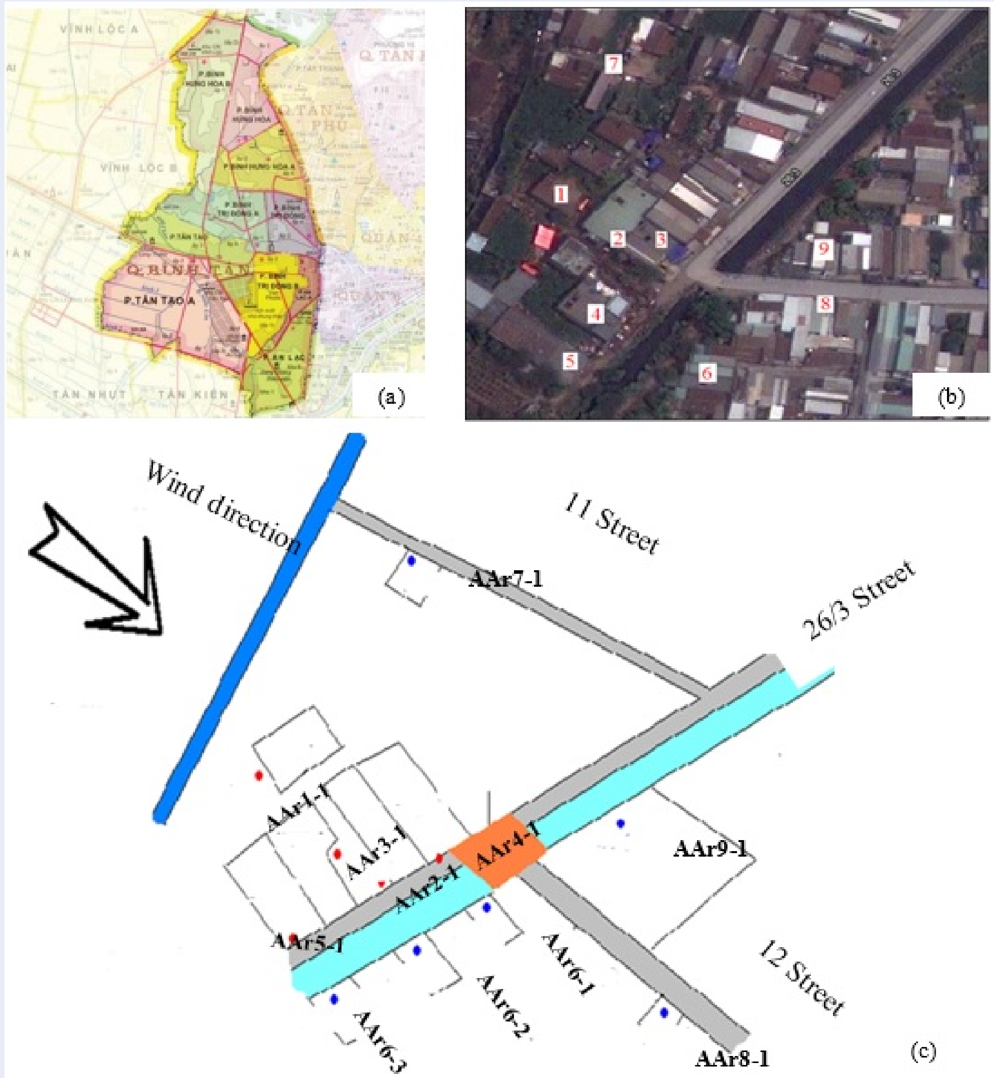

Figure 1: Research location

Data collection

The research database was collected at 5 finishing dyeing factories and surrounding residential areas in the ward (Figure 1b) during the rainy season (May) and dry season (September). Sampling is conducted twice a year at each factory, including two periods: the first in the dry season and the second in the rainy season. The current status of air and surface water in the survey area was collected and analyzed (Table 1). In residential areas, in the surrounding air, the concentration of dust, chlorine vapor, CO, SO_2, NO_x, and noise is analyzed; for surface water at channel 19/5, 5m from discharge point upstream, pH, COD, BOD, TSS, color, grease, and Cu concentration were analyzed. At the dyeing factory, ambient air and boiler exhaust gas are analyzed for indicators such as CO, SO_2, NO_x, dust, chlorine vapor, and noise; Wastewater produced at the dyeing factory is analyzed for pH, TSS, color, Cu, SO_4^{2-}, COD, BOD_5, and grease. In addition, the control sample on ambient air quality was taken in a residential area in Binh Tri Dong B ward, Binh Tan district. An overview of the production status of 5 finishing dyeing factories is described in detail in Table 2. Products at these factories are all fabrics. The main dyeing method of these establishments is the direct dyeing of fabrics. The dyeing line uses sulfur dyes and reactive dyes with volume ranging from 50 - 70 kg/month, detergents (1-2.5 kg/month), and color auxiliaries (11-16 kg/month) month). Production water is exploited and used from underground

Table 1: Environmental indicators analyzed in the residential area and at dyeing and finishing factories

Sample symbol	Sampling locations	Parameter	Evaluation criteria
Residential			
Ambient air (AAr)	In residential areas around dyeing and finishing factories	CO, SO_2, NO_x, dust Cl_2 Noise	QCVN 05:2009/BTNMT QCVN 06:2009/BTNMT QCVN 26:2010/BTNMT
Surface water (SWr)	Surface water quality in Canal 19/5 at a point 5m upstream from the discharge source	pH, COD, BOD, TSS, Colour, Cu, grease	QCVN 08:2008/BTNMT
Production factory			
Ambient air (AAs)	In front of the factory, 8m from the dyeing area	CO, SO_2, NO_x, dust Cl_2 Noise	QCVN 05:2009/BTNMT QCVN 06:2009/BTNMT QCVN 26:2010/BTNMT
Emissions (Es)	Emission of dyeing factory	CO, SO_2, NO_x, dust, air-outflow, temperature	QCVN 19:2009/BTNMT
Wastewater (Ws)	The quality of wastewater produced at dyeing factories	pH, TSS, colour, Cu, SO_4^{2-}, COD, BOD_5, grease	QCVN 13:2008/BTNMT

water sources, the amount of water used ranges from 26 - 40 m^3/day. The boiler uses firewood fuel, the volume is about 50 - 72 m^3/month.

Analysis

In this study, all concentration samples were measured by instant digital instruments. Temperature, humidity, and wind speed were measured by the TESTO digital meter (Germany) to conduct measurements. The noise was measured using a model 2700 instrument (Quest - USA). Air samples were taken by using APEX SERIES (Casella - UK) and sampler model SL-20 Sibata (Japan). Dust was determined by the gravimetric method. Sampling was carried out using a HI-Q (USA) instrument with a flow rate of 750L/min. Dust samples were collected on a glass fiber filter with a filter paper diameter of 100 mm, a filter pore diameter of 0.3 μm, then followed by sample quantification using a Sartorius analytical balance with a sensitivity of 1×10^{-5} gr (Germany). Vapors and gases were sampled by absorption method and analyzed by colorimetric method on a Shimadzu UV Visible Spectrophotometer (UV mini-1240 - Shimadzu corporation - Kyoto, Japan). Water samples were sampled and analyzed for pollution indicators such as pH, TSS, color, Cu, SO_4^{2-}, COD, BOD_5, and grease according to current Vietnamese standards. The results of the analysis of environmental indicators are compared with Vietnamese standards on air quality (QCVN 05:2009/BTNMT, QCVN 06:2009/BTNMT), industrial emission-quality (QCVN) 19:2009/BTNMT), noise (QCVN 26:2010/BTNMT), and environmental quality of surface water (QCVN 08:2008), textile dyeing wastewater (QCVN 13:2008).

RESULTS AND DISCUSSION

Air quality

In dyeing and finishing factories

In the study area, all 5 production factories use wood-burning boilers in the dyeing process, leading to some typical pollutants in the exhaust gas composition. Some factories have concentrations of dust and SO_2 ((factory (1) and (3)) exceeding the permissible limits when comparing them with current standards on industrial emission standard (Table 3). The analyzed emissions include dust, SO_2, CO, NO_x, flow, and temperature. In the dry season, due to the dry conditions of the weather, the flow rate and the concentration of pollutants in the exhaust gas at the site are higher than in the rainy season. Dust concentration at the factory (1) in the dry season is 1.4 times higher than the permitted standard, this value is also nearly 3 times higher than that in the rainy season at this factory. The concentration of CO in the exhaust gas is the heaviest and most noticeable pollution indicator. At all survey sites, the CO concentration exceeded the allowable standard from 6.3 to 14.6 times. The amount of CO concentration released into the surrounding air

Table 2: Production situation of 5 dyeing and finishing factories in the study area

Factories	Dyes	Detergents	Color aids	Water	Firewood
	(kg/month)	(kg/month)	(kg/month)	m^3/day	m^3/month
Tuan Dinh (1)	59	1.2	14	26	50
Dat Vu (2)	50	1.0	11	31	59
Thai Nguyen (3)	70	2.5	16	40	72
Chin Do (4)	62	2.1	12	35	61
Hoa Nguyen (5)	58	1.0	15	29	53

is quite large. The concentration of CO in the exhaust gas in the dry season and the rainy season at the source is described in detail in Figure 2. When compared with Vietnamese standards on industrial waste, the CO concentration is extremely high. The largest CO emission points are factory (1) and factory (3) in the dry and rainy seasons, respectively. The amount of CO appearing due to incomplete combustion when using wood-burning boilers is very high at the factories. In addition, due to their small scale and manual operation, these factories have absolutely no treatment or emission control system before being discharged into the environment, so the concentration of pollutants at the chimney is very high, which seriously violates Vietnam's standards on industrial emissions. Clearly, there is a strong relationship between the emission concentration at the source and the air quality around dyeing and finishing factories. The emission of dust, CO with high concentrations into the surrounding air leads to significantly polluted air. This can be obviously found in the results of the field sample analysis of air quality around the factory. However, if the results are compared with Vietnamese standards for ambient air quality, only dust concentrations at the factory (1) and (3) exceed the allowable levels in the dry season (Figure 3). The load from the exhaust gas from the wood-burning boiler exceeds the allowable level, so it affects the dispersed source. Moreover, factories located in the same area are very close to each other (< 20 m), there is a high possibility of mutual influence. Factors such as dust, SO_2, CO, NO_x, Cl_2, humidity, noise, wind speed, and temperature are all within the allowable limits in both seasons, except for the rather small excess of dust. The possibility of affecting the surrounding residential environment of industrial emissions from boilers is quite possible. The reason for this is that the boiler flue gas is located above, the polluted air area near the ground usually starts from 4-20 times the height of the chimney from the foot of the exhaust pipe. The influence of emissions from these factories will be more evident when surveying pollution factors in surrounding residential areas. Microclimate factors in the dry season also have certain effects on the diffusion of pollution into the air. Microclimate factors in which air velocity (wind speed) is the factor that has the greatest influence on the spread of pollutants in the air. Temperature and humidity affect pollutant distribution. In the rainy season, the concentration of substances in the air also decreases because rain cleans the air. Measurement results of microclimate factors in the rainy season with higher humidity than in the dry season. Air pollutants such as suspended dust will combine with moist air to form larger, heavier particles and quickly settle to the ground, or in moist air, creating conditions for microorganisms to thrive, cling to into the suspended dust particles that fly further or fall to the ground. The speed of air circulation will disperse pollutants into the air environment. Therefore, in the rainy season, the environment is less polluted than in the dry season.

In residential area

The influence of industrial emissions due to the operation of wood-fired boilers on the ambient air quality in residential areas around the finishing dyeing factories is described in Table 4. The control sample was also taken in a residential area of another ward of Binh Tan district, where there were no other industrial factories. The results showed that the ambient air quality index in the residential areas around the dyeing and finishing factories was higher than that of the control sample. Specifically, the concentrations of dust, SO_2, and CO were all significantly higher when compared with the 3 control sample locations in a residential area in Binh Tri Dong B ward (Figure 4), especially SO_2 and CO indexes. Although the ambient air quality in the residential areas around the dyeing factories is within the allowable limits, when compared with the control sample, there is a very clear difference in pollutant concentration and the ability

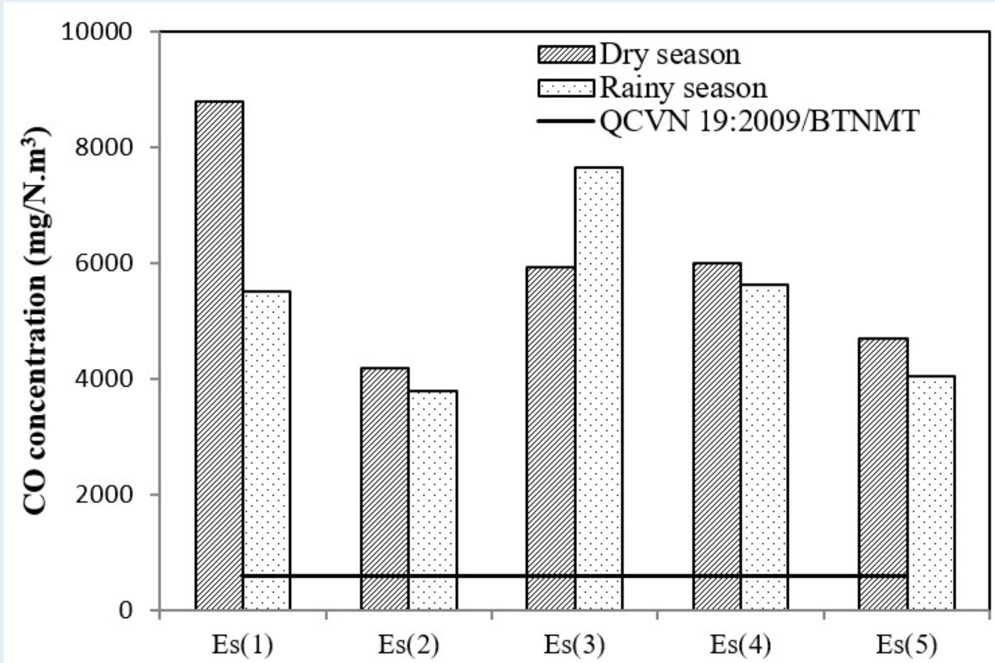

Figure 2: Concentrations of CO emissions at boiler chimneys at dyeing and finishing factories during dry and rainy seasons

Table 3: The pollution current of industrial emissions at dyeing and finishing factories

	Dust (mg/Nm^3)	SO2 (mg/Nm^3)	CO (mg/Nm^3)	NOx mg/Nm^3)	Air-outflow (m^3/h)	Teamp. (^{o}C)
Dry season						
Es (1)	**346**	**910**	**8783**	205	2126	151.5
Es (2)	175	724	**4180**	129	1195	158.1
Es (3)	259	825	**5917**	125	3061	169.2
Es (4)	225	782	**6004**	213	2087	155.9
Es (5)	237	**901**	**4702**	247	1954	162.6
Rainy season						
Es (1)	121	898	**5500**	126	2013	157.2
Es (2)	138	892	**3785**	136	1219	149.6
Es (3)	203	**911**	**7649**	179	3007	161.5
Es (4)	167	802	**5621**	183	1845	156.2
Es (5)	145	873	**4047**	201	1640	154.8
QCVN 19:2009/BT-NMT	240	900	600	600	-	-

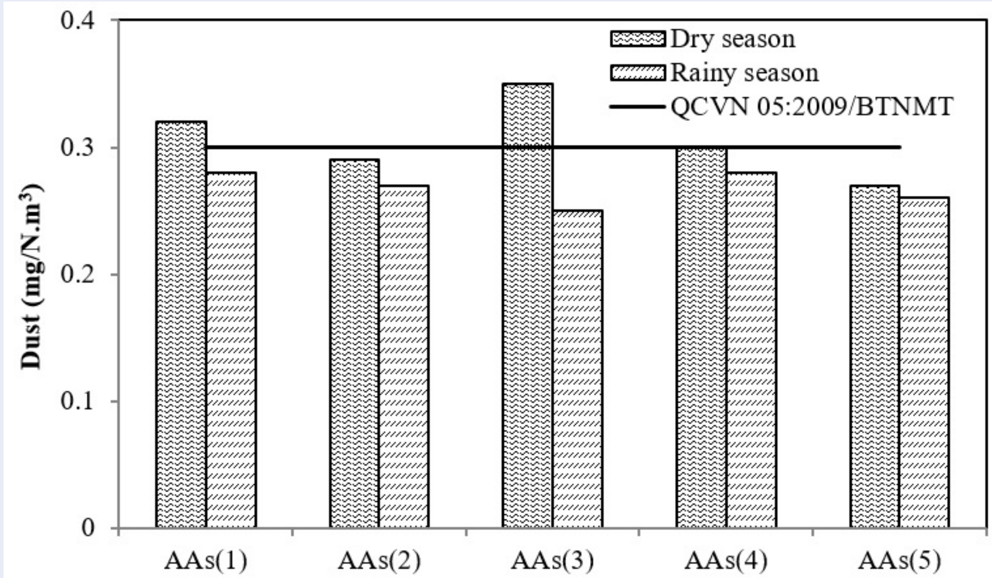

Figure 3: Dust concentration in front of the dyeing and finishing factories (8 m away from the dyeing area) in the dry and rainy seasons

to diffuse pollutants in the air. In the control sample area, the concentration of dust, CO, SO_2 at the points was quite uniform, there was not much difference in space. Particularly for the residential environment under the impacts from dyeing factories, the concentration of pollutant components in the surrounding air is higher. The concentration of SO_2 at the residential site around the finished staining factory was 1.7 times higher when compared with the control sample. On the other hand, at the research sampling sites, there is a very clear difference in the concentration of the same pollutant index at different sampling locations. This shows that the pollutants are spatially diffused. This pollution diffusion is dependent on topographic elevation, sampling location and is most influenced by microclimatic factors such as wind speed, temperature, and humidity. Sampling locations in the residential area of Binh Hung Hoa ward around the dyeing factories are shown in Figure 1c. Based on the diagram and survey results in Table 4, in the dry season, dust concentration gradually decreases in the order AAr6-1 > AAr9-1 > AAr6-2 > AAr8-1 > AAr6-3 > AAr7-1. The CO concentration in descending order is AAr6-2 > AAr9-1 > AAr6-1 > AAr8-1 > AAr6-3 > AAr7-1. SO_2 concentration decreases in the following order AAr9-1 > AAr6-2 > AAr6-3 > AAr7-1. The atmospheric environment around the AAr6-2 sites; AAr9-1; AAr6-1 has higher contaminant concentration values than the other sites. The difference in concentrations of these pollutants is mainly due to topography and geographical location. The closer the sampling location is to the pollution source, the more polluted the ambient air quality will be. For example, the sampling sites at AAr6-1 and AAr6-2 are approximately 30 m apart from the staining bases (only separated via Canal 19/5). Next is the AAr9-1 site, where the distance from the sampling site to the staining factory is about 100m. Of similar distance is AAr8-1 to the plant, which is about 500 m. In the rainy season, the concentrations of pollutants at the sampling locations did not differ significantly. However, most of them saw a decrease in pollutant concentration. The reason is also that emissions from the sources in the rainy season are lower than in the dry season, leading to a decrease in the ability to diffuse pollution into the surrounding air. As a result, pollutant concentrations are also lower. In general, the air quality around the residential areas surrounding the dyeing factory is affected by industrial emissions from the operation of wood-fired boilers. It is necessary to install and design a simple treatment system before releasing waste into the environment.

Water quality

Wastewater

At dyeing factories, wastewater accounts for the majority of both volume and pollutant load. The composition and properties of wastewater are extremely complex, with high concentrations of pollutants, containing many toxic and difficult-to-decompose color

Table 4: The current of the ambient air in the residential area around the dyeing and finishing factories

	Dust (mg/Nm^3)	SO_2 (mg/Nm^3)	CO (mg/Nm^3)	NO_x (mg/Nm^3)	Cl_2 (mg/Nm^3)	Noise (dB)	Warm (%)	Wind speed (m/s)	Teamp. (^oC)
AAr6-1	0.28	0.15	4.0	0.061	n.d	54-56	64-65	0.2-0.8	30.3
AAr6-2	0.26	0.16	4.5	0.067	n.d	55-59	64-65	0.2-0.7	32.1
AAr6-3	0.25	0.12	2.6	0.043	n.d	58-63	62-63	0.2-1.3	30.9
AAr7-1	0.23	0.10	1.9	0.041	n.d	54-58	65-66	0.2-0.7	30.1
AAr8-1	0.25	0.14	3.2	0.055	n.d	59-64	62-63	0.2-0.9	30.4
AAr9-1	0.27	0.17	4.4	0.073	n.d	60-65	62-63	0.3-1.0	30.4
AAr10-1	0.24	0.10	2.1	0.045	n.d	55-57	65-67	0.2-1.2	30.2
AAr10-2	0.27	0.10	1.7	0.040	n.d	53-55	0.3-1.3	67-68	30.6
AAr10-3	0.24	0.12	2.0	0.044	n.d	56-58	0.2-1.2	68-69	30.5
QCVN 05:2009/BT-NMT	0.3	0.35	30	0.2	-	-	-	-	-
QCVN 06:2009/BT-NMT	-	-	-	-	0.1	-	-	-	-
QCVN 26:2010/BT-NMT	-	-	-	-	-	70	-	-	-

Note: "n.d" = no detected, and "-" = no specified

compounds. The indicators of BOD_5, COD, colour are very high. In addition, there is wastewater generated from cleaning machinery and equipment, domestic wastewater, and stormwater runoff. These types of wastewater have relatively lower pollution concentrations when compared to dyeing wastewater. In this study, wastewater samples at dyeing factories were collected at the discharge site located at the factory before being discharged into the public system to drain into the 19/5 Canal. Figure 5 describes the results of the analysis of some pollution indicators in wastewater at factories. When no treatment solution is applied, the wastewater from these factories exceeds the allowable limit for dyeing wastewater. Pollution components are mainly temperature, color, COD index, BOD_5, and heavy metals (Cu). The concentration values of some pollution indicators are shown in Figure 5. All of the analyzed indicators exceed the allowable limit issued by Vietnam from high to very high. Specifically, the color temperature at sampling locations ranges from 9 to 15 times higher than the allowable standard. Colour in dyeing wastewater is an indispensable feature in the assessment of pollution. It is both harmful to the environment and unsightly. The coloration is responsible for the formation of some non-biodegradable compounds in the water. It changes the properties and composition of elements in the aquatic environment. The concentration of organic substances is also very high, which is shown through two indicators BOD_5 and COD. These two indicators have fluctuating concentrations at the sampling points from 7 to 12 times higher than the allowed standard. Organic compounds in textile dyeing wastewater contain many components that are difficult for biodegradation. If the content of these substances is too high, it can lose the self-cleaning ability of the water source. It causes many heavy impacts on the growth and development of the microbial community in the water. Some of their by-products are precancerous, cancerous compounds that are extremely toxic to human health. In addition, it can cause a foul odor, blackening the water due to anaerobic biodegradation. For TSS (total suspended solid), the pollutant concentration value is 14-19 times higher. The content of Cu metal in some positions exceeds the allowable standard from 1.3 to 1.5 times. The temperature in the wastewater is too high, exceeding the permissible limit. This inadvertently

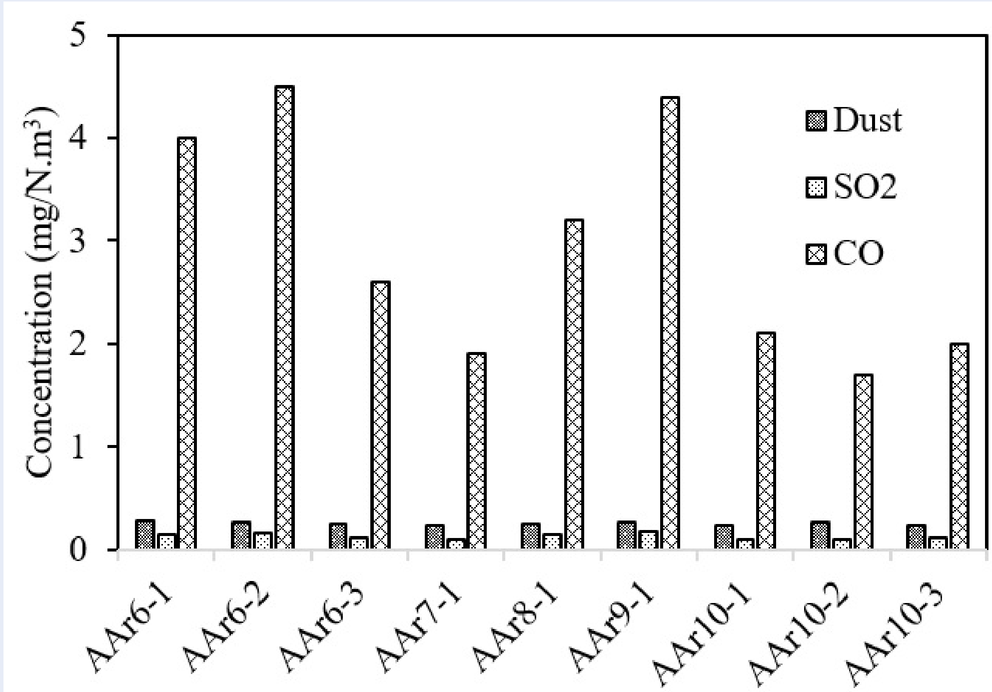

Figure 4: Concentrations of dust, SO_2, and CO in the residential area surrounding the dyeing factory and the residential area of Binh Tri Dong B

kills some beneficial microorganisms during the natural cleaning process of the aquatic environment. Also, it create conditions for some harmful microorganisms to thrive, leading to heavy pollution of the water environment. On top of that, more dangerous diseases will develop and spread to humans and animals. Thus, wastewater from these factories has a heavy pollution level due to the characteristics of the manufacturing industry. If there is no treatment before discharging into the receiving source, in the long run, it will certainly pollute the water environment in the area, which might adversely affect human health and other activities.

Surface water

At the surface water sampling site on 19/5 Canal, 5m upstream, the pollutant content was greatly reduced when compared with wastewater at manholes in production factories (Table 5). However, if these pollution values are compared with Vietnamese standards on surface water quality QCVN 08:2008/BT-NMT, this pollution situation is very serious. In general, in addition to the grease and pH parameters that are within the allowable limits, all other parameters such as BOD_5, COD, TSS, and DO are above the allowable limits.

The current status of the surface water environment at sampling locations on Canal 19/5 is different between the two seasons and these pollution indicators are lower in the rainy season. In the rainy season, the capacity of local factories is nearby reduced by one-third compared to the dry season, so the amount of wastewater entering the 19/5 canal decreases. In addition, the amount of rainwater added to the canal contributes to the dilution of pollutants in surface water, thus reducing the pollutant concentration of the Canal 19/5. Surface water quality through BOD_5, COD, TSS index over the two seasons is shown in Figure 6. The concentration of pollutants in the surface water is much higher than permitted standards, with the highest being 71 times compared with the allowable standard for BOD_5. The dissolved oxygen content in the water at the sampling points is almost equal to 0. This proves that the surface water at this 19/5 Canal is heavily organically polluted. It is likely affected by wastewater from the finishing dyeing factories in the area. In the aquatic environment, there are many aerobic microorganisms capable of oxidizing organic compounds into other substances. They use the oxygen in the water to carry out the oxidation process, resulting in the total consumption of dissolved oxygen in the water. Besides, at the bottom sludge

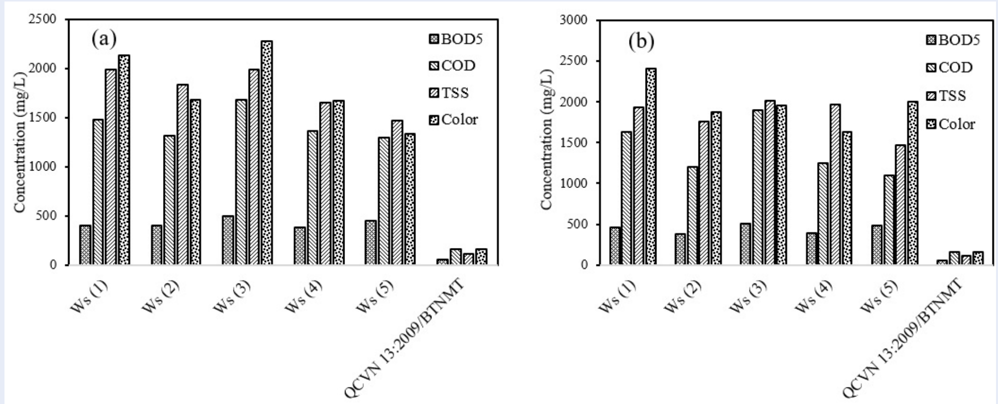

Figure 5: Effluent quality from dyeing factories finished (a) Dry season and (b) Rainy season

Table 5: Surface water quality in Canal 19/5 at a point 5m upstream from the discharge source

	pH	BOD_5 (mg/L)	COD (mg/L)	TSS (mg/L)	Cu^{2+} (mg/L)	DO (mg/L)	Grease (mg/L)
Dry season	7.87	1065	1892	3158	0.62	0	<0.1
Rainy season	7.51	852	1467	3054	0.35	0	<0.1
QCVN 08:2008/BTNMT	5.5-9	15	30	50	0.5	4	0.1

of the canal, anaerobic microorganisms continue to anaerobically decompose pollutants. This leads to a fishy smell and black water in the 19/5 Canal, especially mud. The production wastewater of dyeing factories also contains a concentration of Cu metal exceeding the standard before being discharged to the receiving source. Therefore, the concentration of Cu metal in surface water samples on the 19/5 Canal appears and exceeds the allowable standard in the dry season. Surface water in the 19/5 Canal is also affected by various waste sources. However, at the sampling site in this study, the adverse impact on the surface water quality of nearby finishing factories is quite real. Therefore, it is necessary to have the prompt intervention of competent management agencies to intervene and handle.

In addition to dyeing wastewater, the 19/5 canal is also affected by domestic wastewater from garment, packaging, plastic, and daily life factories. These factors significantly affect the surface water quality of Canal 19/5. It is necessary to expand research and overview assessment of emissions of some other activities in this area to have the most objective assessment leading to the causes of surface water pollution.

Solid waste

A pollutant component that is also of concern and must be treated at dyeing factories is solid waste. The level of solid waste generation at these plants is relatively low and the volume generated is almost the same, mainly domestic solid waste. According to the survey, domestic solid waste generates about 10-15kg/day/factory and production waste from 2-4 kg/day/factory. Hazardous solid waste is mainly chemicals, dyes, and their packaging, rags with hazardous ingredients. The volume of hazardous solid waste generated at these plants fluctuates around 14 kg/month/unit. All this generated solid waste is not segregated at the source. They are scattered everywhere at the factory and are collected as domestic waste. Domestic waste is collected and treated on a daily basis by the Ho Chi Minh City Urban & Environment Company.

Proposing solution

Overall, the environmental quality in this study area is progressing in a bad trend. Proposing solutions to reduce environmental pollution around residential areas with many finishing dyeing factories is essential. Solutions should be practical and implemented in accordance with the specific characteristics of the industry and the location of operations of the factories in

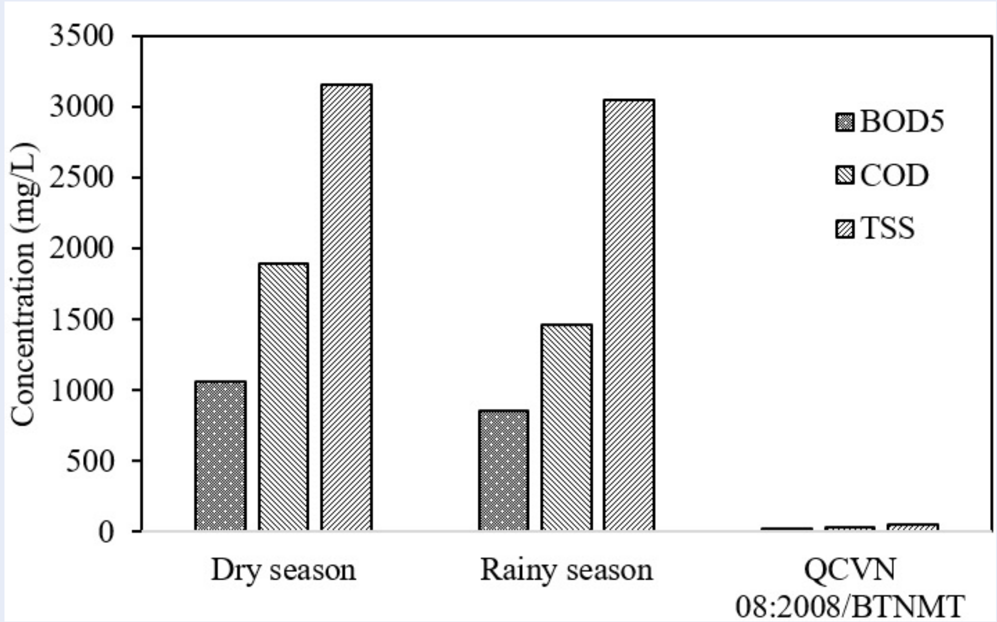

Figure 6: Surface water quality in 19/5 Canal at a point 5m upstream from the discharge source in the dry and rainy seasons.

each specific area, which ensure production activities at the factories.

Managements solutions

For environmental management agencies, it is necessary to develop and implement policies to reduce environmental pollution for establishments causing environmental pollution. In addition, these agencies should also guide the implementation of regulations and policies on environmental protection for establishments and businesses. After that, regular inspection and examination should be carried out and reasonable penalties should be applied for cases of willful or repeated violations of the issued emission standards. Regulatory agencies are also responsible for raising awareness of production factories and people about the importance of the living environment as well as the serious harms caused by environmental pollution.

For production factories, it is mandatory to comply with regulations and policies on environmental protection. Quickly find solutions to current pollution. Plan to apply cleaner production methods by improving processes, increasing equipment maintenance, reusing generated waste, even replacing technological processes to ensure product quality and no negative impact on the environment. Strictly abide by the work of pollution treatment at source, monitoring and control of pollution at source. Raise awareness of workers as well as production factory owners on environment-related issues.

Solutions for production technology

After implementing management solutions, the first prerequisite is to solve the pollution that has been happening. Expeditiously design, build and install pollution treatment works before releasing them into the environment, especially wastewater and exhaust gases. Wastewater can be subjected to mechanical, chemical, and biological treatment methods such as flocculation, Fenton processes, membrane filtration, biological treatment[3]. For industrial exhaust gas, it is possible to design dust collection and filtration devices and have an adsorbent with H_2O or dilute alkaline solution to treat air pollution. Currently, dyeing factories in the study area are small and medium-sized, so they only have equipment such as a misting system to reduce temperature. But these measures are not enough to reduce pollution from heat and noise sources at each factory. Therefore, it is necessary to propose some measures to control pollution caused by the heat and noise of these factories. First of all, it is necessary to periodically check and maintain noise-generating equipment. Arrange heat- and noise-generating devices at locations with the least impact on the environment, or place them in separate places with sound and heat-insulating materials.

Workers operating at the factory should be supported with noise-canceling earplugs and regularly reminded to implement safety measures at the factory. Install fan system, misting system to reduce heat and ensure a ventilated environment at the factory. Finally, increase the area of green trees around the factory, both reducing dust and noise and creating a landscape in the workplace. The solid waste generated at factories needs to be segregated at the source. The harm of hazardous waste is extremely large, so there must be a separate solution according to Decree No. 12/2011/TT-BTNMT of the Ministry of Natural Resources and Environment on Hazardous Waste Management.

Environmental pollution treatment solutions

The operating capacity of the factories is relatively low, so investing in wastewater and air treatment systems is difficult. The environmental pollution is caused by the operation of the boiler in the dyeing and finishing stages of fabrics. Wastewater and boiler flue gas flows at these factories are relatively small. The location of production factories is located in residential areas. Therefore, installing a treatment system to match the production scale and minimize the effect on the environment, ensuring compliance with current regulations is a trying problem for factory owners. Several pollution treatment solutions at the emission source have been proposed. Specifically, boiler exhaust at production factories is polluted by CO, SO_2, and dust. The emissions need to pass through the cooler into a cyclone or settling chamber dust collector. After that, the absorption with calcium hydroxide solution will treat polluted gas components containing SO_2, NOx, and CO. After going through a simple treatment system, the emissions will meet QCVN 19:2009/BTNMT standard, column B. Production wastewater is contaminated with colorants and some toxic organic substances (high BOD and COD). It is necessary to calculate the appropriate amount of dye to avoid excess to reduce product costs and reduce the amount of wastewater discharged into the environment. Then some small-scale processing should be arranged on-site. First, a coarse filter should be arranged to remove the garbage, cotton residue, and fabric fibers generated during the dyeing process. The treatment process should include flocculation-coagulation, aerobic bioreactor, and settling tank. The flocculation process is capable of handling 50-90% TSS and color. Therefore, its process should be applied in textile dyeing wastewater treatment. Current coagulant chemicals have aluminum or iron. Polymer is a coagulation aid compound, helping the flocculation process take place better, larger flocs, easy to settle. Next, the traditional aerotank can tackle the remaining organic pollutants. The transition between the two processes must include a wastewater neutralization phase for the system to effectively. The ambient residential environment will be improved after solving the problem of environmental pollution at the source.

Environmental pollution has occurred in the residential areas around the finishing dyeing factories. Therefore, minimizing pollution at the source is the first thing to do. It depends on the management policies of the local government agencies and how these policies are implemented in the region. At the same time, workers need to develop and practice environmental protection behaviors. There should be coordination between management agencies and factory owners, together with people around the area to improve the environmental pollution in Binh Hung Hoa ward and Binh Tan district.

CONCLUSIONS

Environmental pollution in the study area has gradually increased in severity, which is clearly shown in the field analysis numbers. The environment at the finishing dyeing factories exceeds the allowable limits of the National Technical Regulation on the quality of textile industry wastewater, industrial emissions, and ambient air quality. The release of pollution at the source will directly affect the quality of life of neighboring residential areas. Surface water quality at Canal 19/5, which is 5 metter from the upstream discharge point, is heavily contaminated with organic matter. Ambient air quality in nearby households has much higher CO concentrations when compared to households in other areas. In the immediate future, it is necessary to immediately set up systems to treat this pollution to minimize pollution and comply with the State's regulations on wastewater, emissions, and solid waste. Because of the small and manual operation scale, these factories should have alternative solutions, cleaner production, raise awareness in environmental protection, and improve product quality as well as the living environment of workers in the factory. Avoid causing adverse impacts on the environment and the lives of residential areas in the area. The grassroots-level management agencies and relevant departments must be responsible for strictly inspecting and monitoring the activities of these emission points and issuing reasonable and highly deterrent fines to solve the problem.

ABBREVIATION

Aar: Ambient air residential
Aas: Ambient air source
BOD: Biochemical oxygen demand
COD: Chemical oxygen demand
Es: Emissions source
GDP: Gross Domestic Product
HCMC: Ho Chi Minh City
SWr: Surface water residential
TSS: Total suspended solids
Ws: Wastewater source

CONFLICT OF INTEREST

There is no conflict of interest regarding this manuscript.

AUTHORS' CONTRIBUTION

Nguyen Nhat Huy outline the research, implementation plan, and complete the manuscript.
Le Truong An and Nguyen Thi Minh Hoa do the analysis, and compose data.
Huynh Duc Thang support to do assist in moving, preparing analytical equipment, and collect of samples.
Nguyen Thi Cam Tien support to process data and prepare the draft manuscript.

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Bài nghiên cứu

Hiện trạng ô nhiễm môi trường do các nhà máy nhuộm hoàn tất tại quận Bình Tân, Thành phố Hồ Chí Minh

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TÓM TẮT

Hoạt động sản xuất của một số nhà máy dệt nhuộm nhỏ lẻ vô tình gây ra một số ảnh hưởng không nhỏ đến chất lượng môi trường. Trong nghiên cứu này, chúng tôi lấy mẫu và phân tích để giám sát chất lượng nước, không khí và chất thải rắn phát sinh tại 5 nhà máy nhuộm hoàn tất tại phường Bình Hưng Hòa, quận Bình Tân, Thành phố Hồ Chí Minh, Việt Nam. Sau đó, chúng tôi đánh giá hiện trạng môi trường của các nhà máy nhuộm hoàn tất và tác động của chúng đến môi trường sống của khu dân cư xung quanh. Kết quả cho thấy, khí thải công nghiệp và nước thải sản xuất tại các nhà máy này đều vi phạm nghiêm trọng các tiêu chuẩn như bụi và CO trong khí thải; màu, Cu, BOD_5, COD, TSS trong nước thải. Cụ thể, tại ống khói của nhà máy (1), nồng độ CO phát thải cao hơn 14,6 lần so với Tiêu chuẩn Kỹ thuật Quốc gia về khí thải công nghiệp (QCVN 19:2009/BTNMT). Trong nước thải sản xuất, kim loại Cu có nồng độ vượt tiêu chuẩn đến 1.5 lần. Điều này về lâu dài sẽ ảnh hưởng nghiêm trọng đến thủy sinh và sức khỏe con người tại nhà máy và khu vực xung quanh. Do đó, chất lượng nước mặt tại các nhà máy và các điểm khảo sát lân cận bị ảnh hưởng đáng kể. BOD_5, COD và TSS lần lượt cao hơn 71, 63,07 và 63,16 lần, so với Tiêu chuẩn chất lượng Quốc gia về nguồn nước mặt (QCVN 08:2015/BTNMT). Tuy nhiên, chất lượng không khí xung quanh nhà máy gần như đạt tiêu chuẩn, nguyên nhân có thể là do khu vực này phân tán không khí tốt. Hơn nữa, nồng độ chất ô nhiễm cao hơn vào mùa khô và thấp hơn vào mùa mưa. Tình hình phát sinh chất thải rắn tại khu vực cũng được đánh giá. Tại đây, chất thải rắn có khối lượng nhỏ và không đáng kể, chủ yếu đã được thu gom như chất thải sinh hoạt, không được phân loại và do Công ty Môi trường đô thị phụ trách thu gom và xử lý theo quy định. Cuối cùng, một số giải pháp đã được đề xuất nhằm giảm thiểu ô nhiễm và cải thiện điều kiện môi trường của khu vực này.

Từ khoá: dệt nhuộm, ô nhiễm không khí, nước thải, môi trường lao động

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