# SOLUTIONS TO REDUCE WATER POLLUTION AT METAL CRAFT VILLAGE OF THANH THUY COMMUNE, THANH OAI DISTRICT, HANOI CITY

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## SUMMARY

The metal craft village in Thanh Thuy commune produces a variety of products, but the machines and production processes are outdated. All metal craft production wastewater is discharged directly to Nhue River, the section flowing through Thanh Thuy commune, thus polluting surface and ground water. Research results show that surface water in the area is seriously polluted by Zn, in which 80% of the samples have a Zn content exceeding the permissible limit from 23.3 to 74 times, and 100% of the samples contain COD exceeding the allowed limits by 1.6 to 3.2 times, the metals of Mn, Fe, and Cr show signs of pollution in some local ponds and lakes. Groundwater is seriously polluted by metals such as Zn and Fe, in which 100% of the groundwater samples have Fe contents exceeding the permitted limit from 2.25 to 17.71 times, 100% of the groundwater samples have Zn contents exceeding the permissible limit from 1.3 to 8.3 times, and other pollutants are at high risk of pollution. In order to improve the water quality, the study has proposed some integrated solutions that combine many management, planning, and techniques measures, and environmental education. Particularly, the study focuses on solutions for cleaner production and waste generation prevention at sources by implementing good internal management, replacing raw materials; optimizing the production process; and on-site recovery and reuse. In addition, local authorities should select locations to build wastewater treatment systems, and implement communication solutions to raise awareness of local people on environmental and water protection.

**Keywords: Cleaner production, groundwater pollution, mechanical trade village, surface water pollution.**

## 1. INTRODUCTION

Metal craft village in Thanh Thuy commune (administratively belonging to Thanh Oai district, Hanoi) is a long-standing craft village with a variety of mechanical products. According to a survey of the Department of Natural Resources and Environment of Hanoi City and a report of the People's Committee of Thanh Thuy commune, Thanh Thuy commune Metal Craft Village is one of the famous craft villages that attracts many households participating in the production (167 out of 202 households producing mechanical needles) (Vietnam environment administration, 2014; The People's Committee of Thanh Thuy commune, 2018).

In spite of contributing to the development of local economy, mechanical craft activities have caused environmental pollution, especially water pollution. Sources of waste water generation are from production processes such as cooling, cleaning - metal plating, cleaning equipment and factories. Wastewater contains dust, rust, grease and some toxic chemicals including HCl, NaOH, Cr, Ni, $Fe^{3+}$, $CN^-$, $Zn^{2+}$, $Cr^{3+}$, $Ni^{2+}$ (Nguyen Manh Hung, 2014). Outdated manual production technology, lack of uniformity, and limited environmental awareness are main causes of environmental pollution. In this vilalge, most wastewater is untreated and discharged directly into rivers, ditches and sewers. Consequenly, the water sources of Thanh Thuy commune's mechanical trade village has been increasingly polluted (The People's Committee of Thanh Thuy commune, 2018). Facing the above situation, finding a suitable solution to reduce water pollution in the area is of great significance to the authorities and local people. This study conducts a review of the situation of water pollution and the basic causes, thereby proposing solutions to reduce water pollution at the metal craft village in Thanh Thuy commune.

## 2. RESEARCH METHODOLOGY

### 2.1. Methods of investigation and survey

To understand the production process, sources of wastewater, and status of environmental protection implemented at production facilities and localities, the research team interviewed 05 offficers in the People's

Committee of Thanh Thuy commune to collect information about the households producing metal mechanical products, then selected 10 typical production households to investigate in detail, including 7 households processing mechanical and 3 households clad metal. Interviewees are households who produce mechanical products. The contents of the investigation include: directly surveying production facilities; finding out the sources of wastewater; investigating raw materials and chemicals used for each stage; learning about labor protection and environmental protection measures; investigating points of wastewater discharge into basin; and, finally, finding out what measures people are taking towards cleaner production.

**2.2. Water sampling and analysis**

- **Sampling subjects:** To assess the situation of water pollution in the study area, the research team took and analysed six (06) wastewater samples from metal mechanical production. In addition to proving that the water quality in the commune was affected by metal mechanical production, the team took and analysed 10 samples in total of surface and groundwater samples in Thanh Thuy commune. The information on the samples is shown in table 1.

**Table 1. Sample symbols and water samples in Thanh Thuy commune**

| No. | Model | Characteristics and location of sampling mẫu |
|---|---|---|
| 1 | NT1 | Wastewater in Rua Ha village |
| 2 | NT2 | Wastewater in Thanh Thuy commune |
| 3 | NT3 | Wastewater at Nguyen Van Vuong household |
| 4 | NT4 | Wastewater at Nguyen Minh Thong household |
| 5 | NT5 | Wastewater at Nguyen Thị Quynh household |
| 6 | NT6 | Wastewater at Nguyen van Tuan household |
| 7 | NM1 | Surface water in the pond near the cultural house of Rua Thuong village |
| 8 | NM2 | Surface water in the pond near the cultural house of Du Tien village |
| 9 | NM3 | Surface water in Nhue river next to Rua Ha village |
| 10 | NM4 | Surface water in Nhue river next to Rua Thuong village |
| 11 | NM5 | Surface water in Nhue river next to Rua Thuong village |
| 12 | NN1 | Groundwater at Nguyen Van Vuong household |
| 13 | NN2 | Groundwater at Nguyen Van Cuong household |
| 14 | NN3 | Groundwater at Nguyen Minh Thong household |
| 15 | NN4 | Groundwater at Nguyen Van Vi household |
| 16 | NN5 | Groundwater at Nguyen Huong Lan household |

- **Parameters to be analysed**: Because the village mainly produces metal mechanical items, wastes containing many metals. Therefore, the main parameters for evaluating water quality are: temperature, pH, TDS (mg/l), DO (mg/l), TSS (mg/l), COD (mg/l), Zn (mg/l), Fe (mg/l), Cr (mg/l) and Mn (mg/l).

**Table 2. Methods to analyze water quality in laboratory**

| No. | Indicators | Methods |
|---|---|---|
| 1 | $t^0$ | TCVN 4557:1988 (ISO 10523:2008) |
| 2 | pH | TCVN 6492:2010; |
| 3 | TDS | SMEWW 2540 C:2005 |
| 4 | DO | TCVN 7325:2004 |
| 5 | TSS | TCVN 6625:2000 (ISO 11923:1997) |
| 6 | COD | TCVN 6491:1999 (ISO 6060:1989) |
| 7 | Zn | TCVN 6193:1996 (ISO 8288 :1986) |
| 8 | Fe | TCVN 6177:1996 (ISO 6332:1988) |
| 9 | Cr | TCVN 6222:2008 |
| 10 | Mn | TCVN 6002:1995 (ISO 6333:1986) |

**2.3. Data analysis**

Water samples were analyzed in an environmental analysis laboratory at the Department of Forest Resources and Environment Management (Vietnam National University of Forestry). The analysis time is April 2019. After completing field investigation, field data is processed. In addition, analysis results of water samples are compared with environmental standards corresponding to each type of water to assess the level of water pollution. Based on data integretation, the research group detemined subjective and objective reasons resulting in the pollution of water sources at the study site. Finally, solutions were designed and proposed in order to deal with the current water pollution. These sollutions are towards cleaner production combined with management measures, techniques, and environmental education.

**3. RESULTS AND DISCUSSION**

**3.1. Wastewater from the metal craft production in Thanh Thuy commune**

***3.1.1. State of mechanical production at Thanh Thuy commune***

*Production scale:* In Thanh Thuy commune, there are 2270 households distributed in 6 villages (Gia Vinh, Rua Ha, Rua Thuong, Tu Am, Du Tien and Du Du), in which 1223 households in 5 villages are involved in mechanical production, especially in 2 villages of Rua Ha and Rua Thuong. The number of laborers working in mechanical engineering is 3131, out of 5227 laborers in the whole commune (accounting for 60% of the laborers of the whole commune).

*Products:* The products of the village vary depending on the orders and needs of the market, such as components for electrical equipment, sanitary equipment, bicycle accessories, motorbikes, fan, construction steel, steel wire, steel plates, staples, hinges, deadbolt, flower door, and folding door.

*Yield:* It is estimated that the craft village produces about 30,200 tons of products annually. 72% of the village's products are consumed in provinces throughout the country such as Hanoi, Hung Yen, Hai Duong, Thai Binh and Hai Phong and 28% are exported to foreign countries such as China, Taiwan, etc.

*Raw materials:* The main raw materials are iron and steel with a quantity of 18250 tons/year. In addition, production materials including industrial iron and steel waste are collected in many places. Iron and steel scrap, such as automobile hulls, old ship hulls, scrap from household appliances, and discarded manufacturing facilities and old machinery.

*Chemicals:* In the production process, the following chemicals have been used to wash raw materials and metal plating products: ZnO, $Zn(CN)_2$, NaCN, $Na_2S$, surfactant, glossing agent, $H_2SO_4$, HCl, NaOH.

In addition, on average, each day the village also uses a significant amount of water (about $25m^3$) to cool the post-rolling products and the device, and wash the equipment.

*Sources of wastewater generated from mechanical production*

The information on the sources and impacts of production wastewater was obtained through field investigation, observation, and interview. Sources, characteristics, and impacts of wastewater are summarized in the following table 3.

According to the survey results, the village generates 120 $m^3$ of production wastewater per day. Wastewater generated from plating facilities is a typical source of water pollution of craft villages due to its heavy metal and grease content.

**Table 3. Source and characteristics of wastewater for mechanical needle production in Thanh Thuy commune**

| Sources/Activities | Characteristics | Impacts |
|---|---|---|
| Facilities producing corrugated iron materials: Surface cleaning stage (soaking, rusting, degreasing) | Waste water contains many chemicals and grease | Polluting the receiving water sources. When released into the receiving waters, most of the oil spreads on the surface of the water and forms a membrane that prevents the diffusion of oxygen into the water, affects the growth of organisms in the water, and reduces the ability of self-cleaning of the receiving waters. |
| Punching facilities: cleaning equipment, cleaning floors, washing workers' hands | Wastewater contains grease and metal rust. | Oil, grease and metal rusts settling to the bottom of ponds and lakes partly accumulate in the sediment and affect the ecological systems here. |
| Plating facility: degreasing, rust removal, whitening, plating and passivation. | Wastewater contains grease and heavy metals. | - Heavy metals can penetrate deep into the receiving waters and contaminate water bodies with long-term consequences.<br>- For ecosystems in the receiving water bodies, heavy metal ions inhibit the development of aquatic animals and plants and reduce the self-cleaning ability of receiving sources. |

### *3.1.2. Characteristics of wastewater from mechanical production*

To assess the characteristics of wastewater from each production step as well as general wastewater of mechanical production processes, the research took samples of wastewater at two (02) plating households, two (02) non-plated production facilities, and two (02) sewage systems of the commune. The analysis results of water samples are shown in the table 4.

**Table 4. Characteristics of wastewater in mechanical trade village of Thanh Thuy commune**

| Samples | Variable | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | t° | pH | Fe | Mn | COD | Cr | Zn | TSS |
| | (°C) | | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l |
| NT1 | 22 | 6.3 | **14.57** | 0.26 | **336** | 0.01 | **35** | 91 |
| NT2 | 20 | 6.2 | **15.49** | 0.19 | 96 | 0.03 | **79** | **352** |
| NT3 | 23 | 6.8 | **87.77** | 0.10 | 48 | 0.01 | **9** | 83 |
| NT4 | 23 | 6.5 | **65.92** | 1.12 | 96 | **0.20** | **11** | 104 |
| NT5 | 21 | 5.8 | **16.10** | **1.26** | 48 | **0.29** | **70** | 62 |
| NT6 | 21.6 | 6.0 | **22.47** | **1.24** | 144 | 0.01 | **94** | 72 |
| **QCVN 40:2011/BTNMT (B)** | 40 | 5.5 - 9.0 | 5.00 | 1.00 | 150 | 0.10 | 3 | 100 |
| **$C_{max}$** | 40 | 5.5 - 9.0 | **6** | **1.2** | **180** | **0.12** | **3.6** | **120** |

***Note:***

*- Samples NT1, NT2: wastewater samples taken at the sewage system of the whole commune;*

*- Samples NT3, NT4: wastewater samples from non - plated base;*

*- Samples NT5, NT6: wastewater samples from plated base;*

*- Column B - QCVN 40:2011/BTNMT: The allowable values of parameters applied for industrial wastewater specified in column B of the national regulations on industrial wastewater;*

*- $C_{max}$: Maximum allowable values of parameters applied for industrial wastewater discharged into receiving waters.*

**Discussion:**

- pH: Data from table 4 shows that the samples have relatively uniform pH values and are in the ranges (5.5 - 9) of the QCVN40: 2011/BTNMT.

- Fe: 100% of analyzed samples have Fe value exceeding the national regulations. The NT3 sample has the highest Fe content which is 11 times higher than the standards.

- Mn: Mn content varies between 0.1 and 1.26 mg/l. There were 2 out of 6 samples containing Mn in excess of the standards, which are NT5 sample (1.26 mg/l) at 1.05 times and samples NT6 (1.24 mg/l) at 1.03 times. The values of remaining samples are within permitted limits.

- COD: COD content fluctuates in the range of 48 - 336 mg/l. The COD value in NT1 sample (taken from the concentrated sewage in Rua Ha village) is the highest exceeding the national regulation 1.87 times. The remaining samples are within the allowed standards.

- Cr: The Cr content fluctuates within the ranges of 0.01 - 0.29 mg/l. In 6 samples, the values of NT4 and NT5 samples (from metal manufacturing households) exceed the permitted standard.

- Zn: The Zn content in wastewater is very high, ranging from 9 to 94 mg/l. Especially, the NT2 sample has a Zn value of up to 94 mg/l while the standard is only 3.6 mg/l, exceeding the threshold by about 26 times.

- TSS: TSS content in wastewater ranges from 62 to 352 mg/l. However, only the value of NT2 sample exceeds the permitted level by 2.9 times. The remaining samples contain TSS within the permissible standards.

To conclude, sources of wastewater in Thanh Thuy commune mostly contains high levels of heavy metals, and most parameters exceed the standards. This wastewater needs to be treated before being discharged into the environment. However, Thanh Thuy currently does not have a system to collect and treat wastewater. All wastewater from the mechanical facilities, especially plating wastewater containing heavy metals without separation, is combined with domestic wastewater running into the concentrated sewers and discharged into Nhue river or canals and ponds in the study area.

### 3.2. Water environment pollution in Thanh Thuy commune

With the current management and treatment of wastewater in the locality, it has greatly affected the quality of the water bodies. To assess the level of water pollution in the study area, groundwater and surface water samples were taken for analysis and evaluation.

#### *3.2.1. Current situation of surface water pollution*

The analysis results of surface water samples in Thanh Thuy commune are shown in table 5.

**Table 5. Surface water quality in Thanh Thuy commune**

| Samples | Variables | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | pH | t° | Fe | Mn | COD | Cr | Zn | TSS | DO |
| | | °C | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | ppm |
| **NM1** | 7.3 | 23.0 | 0.32 | 0.10 | **96** | 0.02 | **35** | **89** | 9.1 |
| **NM2** | 6.7 | 23.4 | 0.62 | 0.11 | **48** | 0.03 | 1 | **83** | 7.6 |
| **NM3** | 7.2 | 22.5 | **1.56** | 0.47 | **48** | **0.07** | **79** | **71** | 4.1 |
| **NM4** | 7.4 | 22.8 | 1.12 | 0.11 | **48** | **0.05** | **101** | 21 | 4.8 |
| **NM5** | 6.8 | 23.0 | 0.95 | 0.13 | **48** | 0.03 | **111** | **83** | 4.6 |
| QCVN 08:2015/BTNMT (B1) | **5.5 - 9.0** | – | **1.50** | **0.50** | **30** | **0.04** | **1.5** | **50** | **> = 4** |

*Note: Column B1 – QCVN 08:2015/BTNMT: Limited values of surface water quality parameters used for irrigation or other purposes with similar water quality requirements (according to the QCVN 08:2015/BTNMT for surface water quality).*

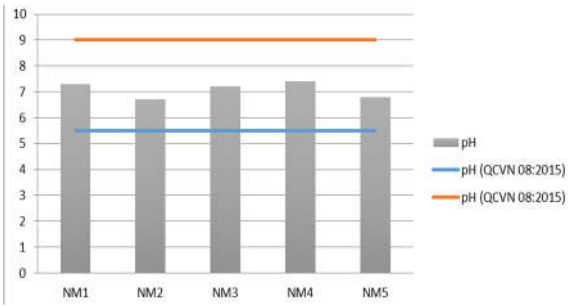


**Fig 1. pH values of surface water samples**

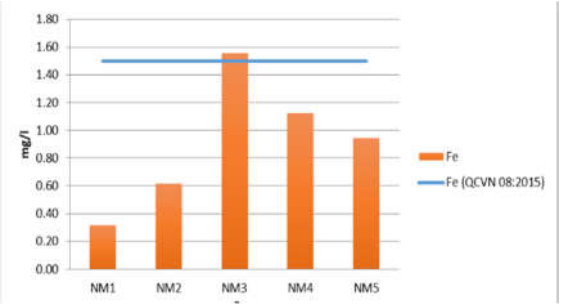


**Fig 2. Fe values of surface water samples**

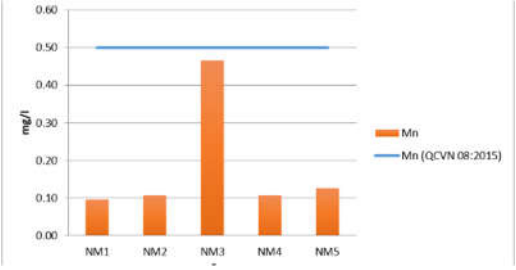


**Fig 3. Mn values of surface water samples**

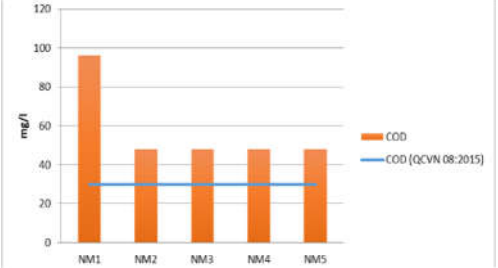


**Fig 4. COD value of surface water samples**

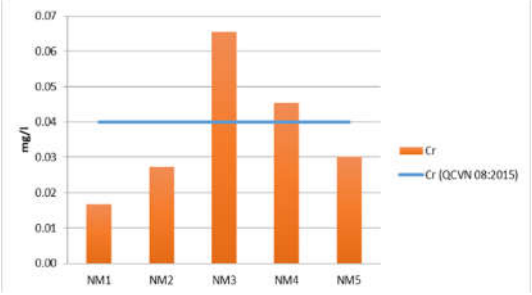


**Fig 5. Cr values of surface water samples**

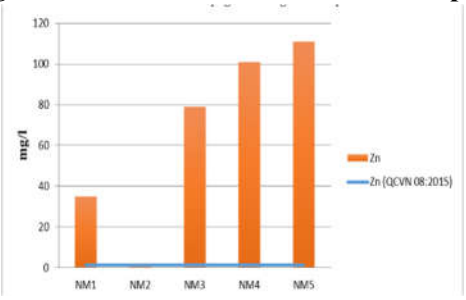


**Fig 6. Zn values of surface water samples**

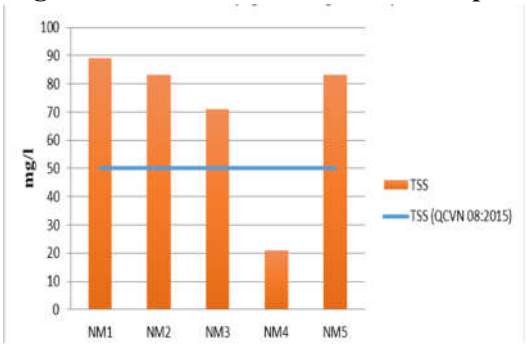


**Fig 7. TSS values of surface water samples**

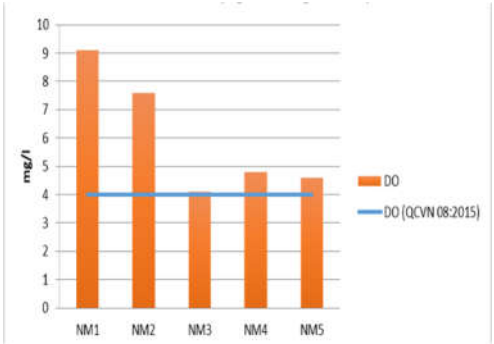


**Fig 8. DO values of surface water samples**

Discussion:

- pH: All samples have pH contents ranging within the allowed limits of QCVN 08: 2015/BTNMT. The analysis results show that the pH in surface water is not affected by production wastewater. These figures also match with the pH results acquiring for wastewater samples ranging between 5.8 and 6.3 that meets the permitted threshold of QCVN40: 2011/BTNMT (Table 4**).**

- Fe: As can be seen in fig. 2, only the content of Fe in NM3 sample exceeds the standard. This sample was taken from Rua Ha village where the number of households involving in mechanical production is highest in the commune. Therefore, the mechanical production wastewater may have affected significantly surface water quality of the river section.

- Mn: It is clear from fig. 3 that the Mn contents of the samples are within the standard ranges of the regulation.

- COD: The graph in fig. 4 shows that 100% of the water samples have much higher COD values than the standards. According to the results of interviews with local people, the surface water quality is increasingly polluted, especially, the water color is darker than before and the smell is very unpleasant.

- Cr: The Cr contents in samples range from 0.02 to 0.07 mg/l. There are 2 samples of NM3 and NM4 having Cr contents exceeding the limits of QCVN 08: 2015/BTNMT.

- Zn: The study area is a Zn-plating village. Therefore, the contents of Zn in surface water are very high (ranging from 1 to 111 mg/l). 80% of the samples have Zn contents that exceeds the standards many times. Particularly, the NM2 sample with low Zn content is due to the sample taken from the pond of Du Tien village, where there is no Zn-plating facility, and the pond is quite far away from the households and does not receive wastewater.

- TSS: Fig. 7 shows that the TSS contents are relatively high in the samples of NM1, NM2, NM3, and NM5 with values of 89 mg/l, 83 mg/l, 71 mg/l, and 83 mg/l respectively. These contents exceed the regulation standards from 1.16 to 1.78 times.

- DO: Data from table 5 shows that limit for DO value regulated in the QCVN 08: 2015/BTNMT is greater than or equal to 4 mg/l. The chart in fig. 8 show that the DO contents of the sample fluctuate unevenly. However, all samples have DO values ranging within the limits allowed by the standard.

**To conclude,** surface water in the study area is polluted by Zn, Cr, TSS, and COD. The sources of water pollution are untreated wastewater from mechanical production and households. Polluted surface water causes loss of landscape, generates, unpleasant odors, and affects the development of aquatic species and agricultural irrigation and drainage, which may affect the health of local people.

### *3.2.2. Current situation of groundwater pollution*

Analysis results for groundwater samples are shown in table 6.

**Table 6. Ground water quality in Thanh Thuy commune**

| Samples | Variables | | | | | | |
|---|---|---|---|---|---|---|---|
| | pH | t° | Fe | Mn | Cr | TDS | Zn |
| | | °C | mg/l | mg/l | mg/l | mg/l | mg/l |
| **NN1** | 6.6 | 22.4 | **88.53** | 0.03 | 0.02 | **9600** | **25** |
| **NN2** | 6.7 | 22.7 | **25.55** | **0.67** | 0.03 | **13640** | **5** |
| **NN3** | 6.8 | 22.8 | **68.08** | 0.19 | 0.01 | **15700** | **17** |
| **NN4** | 6.7 | 22.8 | **12.55** | 0.11 | 0.03 | **6550** | **4** |
| **NN5** | 6.8 | 23.0 | **11.25** | 0.06 | 0.01 | **6550** | **4** |
| **QCVN 09:2015/BTNMT** | **5.5 - 8.5** | _ | **5.00** | **0.50** | **0.05** | **1500** | **3** |

*Note: QCVN 09:2015/BTNMT: Limited values of groundwater quality parameters (according to the National Technical Regulation on Groundwater Quality).*

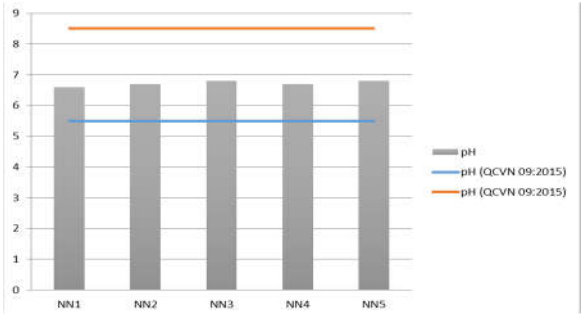


**Fig. 9. TSS value of ground water sample**

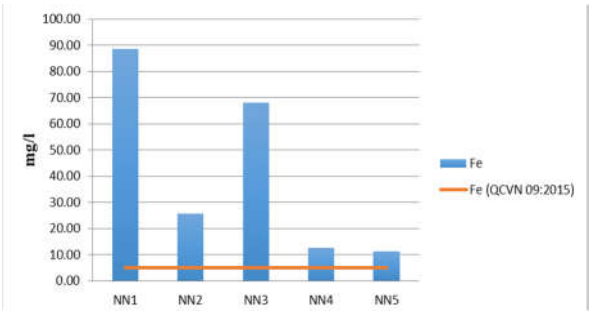


**Fig. 10. Fe value of ground water sample**

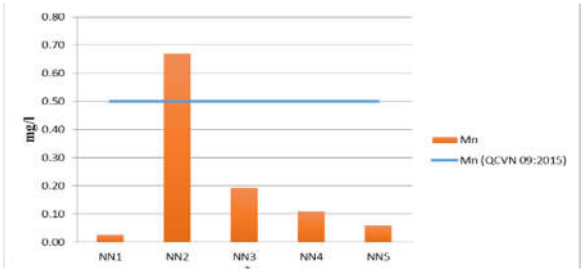


**Fig. 11. Mn value of ground water sample**

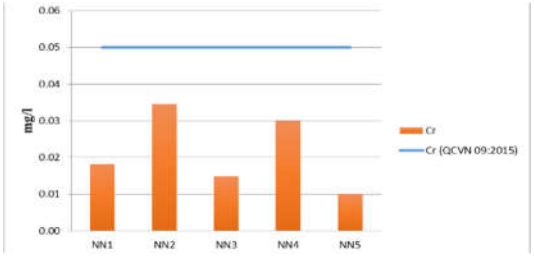


**Fig. 12. Cr value of ground water sample**

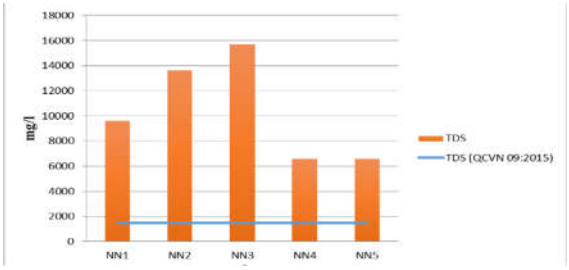


**Fig. 13. TDS value of ground water sample**

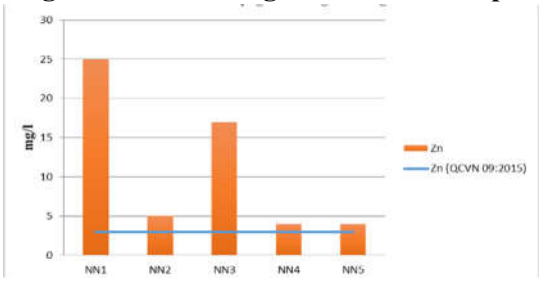


**Fig. 14. Zn value of ground water sample**

**Discussion:**

- pH: 100% of the samples have pH values ranging within the permitted limits (5.5 - 8.5 mg/l) of QCVN 09:2015/BTNMT This shows that production wastewater has not affected the pH in ground water and surface water.

- Fe: The Fe contents of samples range from 11.25 to 88.53 mg/l which exceed the permitted limits of QCVN 09: 2015/BTNMT 2.25 to 17.7 times. The iron contents of two samples of NN4 and NN5 are much less than the remaining samples because the two samples of NN4 and NN5 are two samples of water wells taken from two households in Du Du village, an the area has no production activities and mechanical engineering in Thanh Thuy commune). Samples were also taken in the area of mechanical production activities.

- Mn: The Mn contents of samples vary between 0.03 and 0.67 mg/l. In 6 samples, one has the Mn content exceeding the limits regulated in the QCVN 09: 2015/BTNMT, and that of the remaining samples were within the permitted limits applied for groundwater standards.

- Cr: Cr contents in groundwater of all samples are ranging within the permitted limits of groundwater standards.

- TDS: As can be seen from the Figure 13 that the contents of TDS in groundwater are very high, ranging from 6550 mg/l to 15700 mg/l, which are higher than the standards many times exceeding.

- Zn: The chart in figure 14 shows that 100% of the samples have Zn contents in excess of the limits. The content of Zn in NN1 sample is 25 mg/l, which is the highest among 6 samples, exceeding the standard by 8.3 times. It is clear from the chart that the area affected by production is more polluted than the area without production activities.

To conclude, local groundwater is seriously polluted by metals such as Zn and Fe other parameters are at high risks of pollution. The pollution was mainly resulted from Zn plating process, especially in Rua Ha village. Particularly, these groundwater sources used directly for domestic purposes may have great impacts on local people's health.

***3.2.3. Causes of water pollution in Thanh Thuy commune***

The analysis results of water quality combining with interview information from people and local authorities show that the main cause of water pollution is mechanical production wastewater. A large volume of this source of wastewater with was not treated and discharged directly into the environment. In addition, this wastewater flow contains high levels of pollutants, especially metals. Some reasons for not treating wastewater before discharging into different water bodies are

described as follows.

Firstly, awareness on environmental protection: The local people believe that discharging untreated wastewater into rivers and lakes is inevitably because the mechanic production has become their livelihood for generations. Although they are aware that this action will result in environmental pollution and human health problems, the local people have not had a positive attitude in protecting the environment yet. Consequently, it has not taken drastic actions from the government as well as the local people.

Secondly, due to the traditional handicraft production activities, production technology is backward. Although the equipment has been invested, they are still old and patchy. In addition, internal management is ineffective and immediate economic effectiveness is set as the production goal. Therefore, raw materials, fuel, energy, and water are wasted. Consequently, the production processes are generating a lot of wastewater and high concentrations of pollutants in the wastewater.

Thirdly, because production facilities are located in residential areas andthe village space is narrow, there is no sewer system to collect and separate two types of production and domestic wastewater. On the other hand, production households do not treat wastewater themselves due to its high cost. Therefore, production wastewater is mixed with domestic wastewater, all of which are discharged directly into rivers, causing serious pollution. The community considers Nhue River as a place to solve local wastewater. Although there is currently a cluster of craft villages to move production away from households, but the cost of buying premises is too large, only a few households have been moved to the cluster of craft villages.

Fourthly, implementation of regulations on environmental protection in localities is not strict, and sanctions are not strong. Environmental impact assessment and environmental protection planning have not been seriously implemented. People rely on the view that "the whole village is the same, every house produces, every house discharges" so it is difficult to sanction and manage.

### 3.3. Solutions to minimise water pollution due to mechanical production activities in Thanh Thuy commune

#### *3.3.1. Cleaner production solutions to reduce water pollution in craft villages in Thanh Thuy commune*

With the above-mentioned problems, in order to gradually reduce water pollution in particular and protect the regional environment in general, the locality needs to approach cleaner production solutions (prevent waste generation at sources).

The goal of this approach is to prevent generation of waste at the sources by using energy and materials in the most efficient way, meaning that an additional percentage of materials are transferred to the final product instead of being eliminated.

* Good internal management:

Owners of mechanical manufacturing establishments shall manage, supervise, operate and maintain their equipment at the direction of reducing wastage and loss of fuel and energy, specifically:

- Detecting chemical leakage during plating process, and avoiding spillage of chemicals and materials.

- Checking regularly the water valve, and closing the water valve when not in use.

- Maintenancing equipment and machinery during the production process, especially plating process.

- In the punching stage, it is necessary to wash equipment and sanitize the floor... It may be necessary to wipe away the dirt before cleaning to minimize the introduction of pollutants into the sewage source.

* Replacement of materials:

The replacement of materials and chemicals in use with other materials which are more environmentally friendly. Material changes may also include the purchase of better quality

materials to achieve higher utilization. In the process of processing scrap metal (buying corrugated iron from other places, then cutting and cleaning corrugated iron sheets), a considerable amount of water and wastewater containing chemical grease and oil have been used. Therefore, the mechanical facilities can change raw materials, and reduce the purchase of scrap for production. In the metal plating process, it is possible to choose chemicals that are less harmful to the water environment.

* Optimizing production process:

At mechanical metal manufacturing facilities, to ensure production conditions are optimized in terms of consumption of raw materials, water and chemicals, in the plating process, it is necessary to calculate the design of the most reasonable electrodes so that the plating metal can adhere to the plated parts thoroughly, with the highest efficiency, avoiding waste of plating metal (including Zn) into the sewage after plating.

* On-site recovery and reuse:

Owners need to design appropriate stages of economical use of water, circulate water, use limited chemicals, and avoid waste and loss. In the washing stage of corrugated iron sheets, water needs to be reused for later washing. Especially, the wastewater in the final washing stage has little pollutants that can be used for the first wash of the next batch. The clad metals in post-plating sewage can be recovered for other uses or reused.

* Technology change:

Switching to a new and more efficient production technology can reduce resource consumption and reduce wastewater. In stages where materials are required to be washed or parts are cleaned before plating, establishments may use mechanical washing instead of solvent or water.

***3.3.2. Planning the construction of wastewater treatment system in Thanh Thuy commune***

Currently, all domestic and production waste of craft villages are not treated but discharged directly into canals and channels to Nhue River. Therefore, besides the application of cleaner production solutions, it is necessary to build a local wastewater treatment system. According to the information from the local authorities, the suitable area to build the wastewater treatment system for the commune is in Thanh Thuy industrial cluster located in the west of the commune. This location is convenient for the sewage as well as drainage after treatment to the river.

In terms of technical technology of wastewater treatment, in Thanh Thuy commune, plating sewage is the main source of pollution. The galvanizing facilities are often separatedand, not gathered in clusters, consequently, the collection is carried out in each household to avoid causing difficulties for treating common wastewater of the commune. This system will treat two types of wastewater, domestic and production wastewater (mainly treating plating wastewater). Plating wastewater treatment method is the neutralization - precipitation method. This method increases the pH of the wastewater, creates a metal precipitate, and performs aeration to remove $N\text{-}NH_4^+$ in the wastewater. Then the process settles, which entails inorganic and organic contaminants, and heavy metals adsorbed on the surface (Dang Kim Chi, 2005; Thai Thi Thuy An, 2018).

***3.3.3. Other solutions***

* Raising awareness on environmental protection

In order to improve the responsibility and positive attitude of the community in protecting the environment, different organizations in the commune need to carry out environmental communication and education programs in their localities. Activities may include:

(1) Training to raise environmental protection awareness in production facilities:

- Objects: owners of production facilities;
- Type of education: Training;
- Content: Sources of waste from mechanical production activities, impacts of production wastewater, consequences and waste management.

(2) Communication to protect the environment for the entire population:

- Objects: people in the commune;
- Type of education: The media;
- Topic: Protect the Nhue River;
- Content: The impact of waste on the quality of river and groundwater in the area, preventive measures and remedies.

(3) Communication to protect the environment for students:

- Objects: Students at all levels;
- Type of education: The media, experience;
- Topic: Environmental protection is the protection of our lives;
- Content: Function of the environment, human impact on the environment, environmental protection actions from students.

* Financial support for environmental protection activities:

To implement the above solutions, especially the solution of cleaner production and the construction of wastewater treatment systems, the local people may receive financial support in the following forms:

- Borrowing capital at low interest rates to invest in new production equipment toward cleaner production;
- Regularly inspecting, reminding and handling violations of environmental protection;
- Continuing to implement the scheme on craft village clustering in the commune, transferring production households to the trade village cluster to implement more effective environmental protection measures, and avoiding affecting the daily life of households.

## 4. CONCLUSION

Thanh Thuy commune consists of 2270 households with 1223 households engaging mechanical production. It is estimated that the craft village produces about 30,200 tons of products annually. All mechanical production wastewater is discharged directly to Nhue River and lakes in the commune, thus polluting surface and groundwater. Research results show that surface water in the area is seriously polluted by Zn, 80% of the samples have a Zn content exceeding the permissible limit from 23.3 to 74 times, and 100% of the samples contain COD content. Exceeding the allowed limits by 1.6 to 3.2 times, the metals of Mn, Fe, and Cr show signs of pollution in some local ponds and lakes. Groundwater is seriously polluted by some metals such as Zn and Fe. 100% of the groundwater samples have Fe content exceeding the permitted limit from 2.25 to 17.71 times, and 100% of the underground water samples have the function. Zn contents exceedings the permissible limit from 1.3 to 8.3 times, and other pollutants are at high risk of pollution. The main cause of water pollution in trade villages is due to untreated sewage. In order to improve water quality, the study has proposed some integrated solutions, combining many management measures, planning, techniques and environmental education. These solutions focus on solutions for cleaner production and preventing generation of waste right at the sources such as: good internal management; replacement of raw materials; optimize the production process; and on-site recovery and reuse. In addition, local authorities need to select locations to build wastewater treatment systems, and implement communication solutions to raise awareness of environmental and water protection for local people.

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# ĐỀ XUẤT GIẢI PHÁP GIẢM THIỂU Ô NHIỄM NƯỚC TẠI LÀNG NGHỀ KIM CƠ KHÍ XÃ THANH THÙY, HUYỆN THANH OAI, THÀNH PHỐ HÀ NỘI

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## TÓM TẮT

Làng nghề kim cơ khí tại xã Thanh Thuỳ sản xuất nhiều sản phẩm đa dạng, nhưng máy móc và quy trình sản xuất thì lạc hậu. Tất cả nước thải sản xuất kim cơ khí thải trực tiếp ra sông Nhuệ và các ao hồ trong xã, vì thế gây ô nhiễm nguồn nước mặt và nước ngầm. Kết quả nghiên cứu cho thấy, nước mặt tại khu vực bị ô nhiễm nghiêm trọng bởi Zn, 80% số mẫu có hàm lượng Zn vượt quá giới hạn cho phép từ 23,3 đến 74 lần, 100% số mẫu chứa hàm lượng COD vượt quá giới hạn cho phép từ 1,6 đến 3,2 lần, các kim loại Mn, Fe, Cr có dấu hiệu ô nhiễm tại một số ao, hồ. Nước ngầm đang bị ô nhiễm nghiêm trọng bởi kim loại như Zn và Fe, 100% số mẫu nước ngầm có hàm lượng Fe vượt quá giới hạn cho phép từ 2,25 - 17,71 lần, 100% số mẫu nước ngầm có hàm lượng Zn vượt quá giới hạn cho phép từ 1,3 đến 8,3 lần, các chất ô nhiễm khác đang có nguy cơ ô nhiễm cao. Để cải thiện chất lượng nước, nghiên cứui đã đề xuất các giải pháp mang tính tổng hợp, kết hợp nhiều biện pháp quản lý, quy hoạch, kỹ thuật và giáo dục môi trường. Trong đó tập trung vào giải pháp sản xuất sạch hơn, ngăn chặn phát sinh chất thải ngay tại nguồn như: quản lý nội vi tốt; thay thế nguyên vật liệu; tối ưu hóa quá trình sản xuất; thu hồi và tái sử dụng tại chỗ. Ngoài ra, chính quyền địa phương cần lựa chọn địa điểm để xây dựng hệ thống xử lý nước thải, triển khai giải pháp truyền thông nâng cao nhận thức bảo vệ môi trường và nguồn nước cho người dân địa phương.

**Từ khoá: Làng nghề cơ khí, ô nhiễm nước mặt, ô nhiễm nước ngầm, sản xuất sạch hơn.**

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