Water quality in Thanh Luong rice vermicelli and fresh noodle craft village, Thanh Oai district, Hanoi, Vietnam

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Abstract. Traditional production in craft villages has released large amounts of wastes into the environment, which may pose negative impacts on human health and ecosystems. This study was conducted to assess the current state of the water quality in the Thanh Luong rice vermicelli and fresh noodle craft village. Water samples at 12 sites were collected for determination of BOD5 and COD values. Social survey was also performed at 19 production and 30 non-production households. The results showed that BOD5 and COD values in water samples varied from 29 to 2620 mg/l and from 91 to 3600 mg/l, respectively. 100% of wastewater samples with BOD5 and COD values exceeded the regulation limits (QCVN 40: 2011/BTNMT). The highest BOD5 and COD values in wastewater were 37 and 18 times higher than the limits regulated by QCVN 40: 2011/BTNMT, respectively; those in surface water were 23 and 25 times higher than the values set by QCVN 08-MT:2015/BTNMT and 1/2 of the groundwater samples with COD exceeded the QCVN 09-MT:2015/BTNMT. The results of social survey demonstrated the medium effectiveness of the local environmental management (43% of household questionnaires) and low to medium awareness of local community for environmental protection. Solutions for environmental protection in Thanh Luong village have also been discussed in this study.

1. Introduction

Traditional craft villages play an important role in the socio-economic development as a unique culture in rural areas of Vietnam. In 2014, there were 5096 craft villages in operation, of which, 1748 traditional craft villages were certificated [1]. Small-scale production, backward technologies, inadequate infrastructure, limited capital and skilled labor resources, and environmental issues have been major challenges for development of craft villages. Of the 52 handicraft villages reported by Chi (2005), the ratio of severe, moderate, and light pollution was 46, 27, and 27%, respectively [2]. High content of organic matters was reported in wastewater from food processing, husbandry and slaughtering, skill weaving, and dyeing villages [3]. Whereas, recycling, metal fine art, and cooper casting craft villages released high amount of acids, cyanide, and heavy metal [3]. Population growth and expansion of production without wastewater treatment have resulted in an increasing trend of water pollution [3]. Thuy et al. [4] reported that surface water and surface sediment in Trieu Khue recycling village was contaminated with heavy metals. The ammonia content in wastewater from pig farms in Pho Yen district, Thai Nguyen province was 29 folds higher than the limits set by QCVN 08: 2008/BTNMT – Type B1 for surface water [1]. The COD, BOD5, and total nitrogen in recycling villages in Nam Dinh exceeded the permitted limits for wastewater; whereas, the phosphorus and NH3 values were 9–11.9 and 1.29–7.1 times higher than the permitted limits, respectively [1].
Thanh Luong craft village is located in Bich Hoa commune, Thanh Oai district, Hanoi. This village is one of the 80 handcraft villages in Hanoi to be given priority in treatment until 2020, and vision to 2030 [5]. It is famous for making rice vermicelli and fresh noodles. Approximately 80% of more than 400 households in Thanh Luong village involved in producing and trading fresh noodles and rice vermicelli [6]. There are 41 households directly engaged in production [6]. In addition, there are two large concentrated vermicelli production establishments with a capacity of 2 tons/day in the study area. Wastewater has released into the environment without proper treatment, causing negative impacts on the surrounding environment.

This research was conducted to assess the current state of water quality in Thanh Luong village, Bich Hoa commune, Thanh Oai district, Hanoi and propose proper solutions for environmental protection and management of the study area.

2. Materials and methods

2.1. Sampling
Water and wastewater samples were collected at 12 sites in Thanh Luong village and preserved for determination of BOD$_5$ and COD following the proper standard methods (Table 1). At each sampling site, duplicated samples were collected. Wastewater samples were collected at 3 rice vermicelli and fresh noodle households of small, medium, and large production scale. Surface water samples were collected at different locations in the study area including ponds, sewage, and system stream before and after passing through Thanh Luong village.

2.2. Analytical methods
BOD$_5$ and COD values were determined following the TCVN 6001:1995 [11] and TCVN 6491:1999 methods [12], respectively. Sample analysis was performed at VNU University of Science, Vietnam National University, Hanoi. The results of duplicated samples showed that BOD$_5$ and COD at the difference ≤ 10% (BOD$_5$: 6.7–9.8%, COD: 5.9–6.7%).

Table 1. Water sampling in Thanh Luong village

| Samples            | Number of samples | Sampling methods | Sample preservation methods |
|--------------------|-------------------|------------------|----------------------------|
| Surface water      | 14                | [7]              | [8]                        |
| Groundwater        | 4                 | [9]              | [8]                        |
| Production wastewater | 6               | [10]             | [8]                        |
| **Total samples**  | **24**            |                  |                            |

2.3. Social survey
Questionnaire was designed to determine the level of production, satisfaction of local households with environmental quality and management in the study area. Random households of either producing rice vermicelli or fresh noodle in the study area were selected for interview. 49 households (19 producers and 30 non-producers) were performed to ensure 90% confidence level and 7% margin of error as calculated by the following equation [13]:

$$n = \frac{z^2 \times p(1-p)}{e^2} \div \left( \frac{z^2 \times p(1-p)}{e^2 N} \right)$$

Where $n$ is sample size or interviewed households, $N$ is the number of households in the study area, $p$ is confidence level, $z$ is value corresponding to desired confidence level, and $e$ is margin of error.
3. Results and discussion

3.1. Wastewater sources

Rice vermicelli and fresh noodle are daily produced. In order to ensure the product quality, the households only use rice as a raw material without adding any by-products or chemicals. Tap water is mainly used for all processes of soaking, milling, grinding, and rice noodles. In addition, the result of questionnaires showed that approximately 32% of households used groundwater to rinse machine tools. The ratios of wastewater generated from fresh noodle and rice vermicelli production in Thanh Luong village are 7.2 and 6.7 liter wastewater per 1 kg of product, respectively (Table 2) [6]. Accordingly, the total volume of wastewater from rice vermicelli and fresh noodle production of the village is 48.24 and 31.15 m³/day, respectively (Table 3).

Most households in the study area use Da River water provided by Ha Dong Clean Water Limited Company for domestic purpose. Many households also use additional rainwater and groundwater. The estimated volume of wastewater generated from domestic use for 1530 people in Thanh Luong village is approximately 183.6 m³/day [6]. Accordingly, the total of production and domestic wastewater in the study area is approximately 263 m³/day.

| Products       | Input materials (kg) | Output products (kg) | Wastewater (liter) | Wastewater generation factor (liter/kg product) | Waste sources                                      |
|----------------|----------------------|----------------------|--------------------|-----------------------------------------------|---------------------------------------------------|
| Fresh noodle   | 100                  | 250                  | 1800               | 7.2                                           | Husk, pickled, pressed dry; cooled.               |
| Rice Vermicelli| 100                  | 270                  | 1800               | 6.7                                           | Husk, pickled, pressed dry; cooled.               |

Table 3. Total amount of wastewater

| Products       | Quantity (kg/day) | Wastewater generation factor (liter/kg product) | Wastewater (m³) |
|----------------|-------------------|-----------------------------------------------|-----------------|
| Fresh noodle   | 6700              | 7.2                                           | 48.24           |
| Rice Vermicelli| 4650              | 6.7                                           | 31.15           |

3.2. State of water quality

The analysis results of wastewater samples showed that BOD₅ and COD values varied in the range of 1070–2640 mg/l and 1790–3600 mg/l, respectively, which were 53 and 24 times higher than the regulated limits [14] (Table 4).

BOD₅ and COD values of surface water fluctuated within 29–1300 and 91–2410 mg/l, respectively. BOD₅ and COD values in 100% surface water samples were higher than those in the regulation [15]. The highest BOD₅ and COD values were at TL9 (where concentrated most wastewater production households) and lowest levels were at TL11 and TL12 (Table 4). The highest values of BOD₅ (1300 mg/l) and COD (3410 mg/l) at central sewer locations (TL9) can be explained by the large amount of wastewater and the low rate of dilution with other surface water sources.
Of the 2 groundwater sampling sites, 1 site (TL1) showed COD value higher than that in the regulation [16]. The highest COD value in groundwater was 83 mg/l, which was approximately 21 times higher than that in the regulation [16] (Table 4). This can be explained by the fact that the groundwater sample at TL1 is close to the contaminated surface water at TL11 (COD = 187 mg/l), leading to the penetration of polluted water into the lower aquifer.

3.3. Satisfaction levels of local people on water environment quality

The survey results of 49 production and non-production households showed that the rate of households feeling unsatisfied, normal, and satisfied with surface water quality was 65, 21, and 14%, respectively. Producers have higher levels of satisfaction with surface water quality than non-producers (Figure 1).

Table 4. BOD$_5$ and COD values in water samples collected in Thanh Luong village

| No | Sampling site | Type of sample | BOD$_5$ | COD | Regulation limits | Regulation |
|----|---------------|----------------|--------|-----|-------------------|------------|
|    |               |                |        |     | BOD$_5$ | COD |                  |            |
| 1  | TL1           | Groundwater    | -      | 81  | 4      |     | [16]              |            |
| 2  | TL3           | Wastewater     | 1800   | 2680| 50     | 150 | [14]              |            |
| 3  | TL4           | Wastewater     | 2640   | 3600|        |     |                   |            |
| 4  | TL5           | Wastewater     | 1070   | 1790|        |     |                   |            |
| 5  | TL6           | Surface water  | 58     | 184 | 15     | 30 | [15]              |            |
| 6  | TL7           | Surface water  | 58     | 215 |        |     |                   |            |
| 7  | TL8           | Surface water  | 58     | 232 |        |     |                   |            |
| 8  | TL9           | Surface water  | 1300   | 2410|        |     |                   |            |
| 9  | TL10          | Surface water  | 872    | 1930|        |     |                   |            |
| 10 | TL11          | Surface water  | 29     | 187 |        |     |                   |            |
| 11 | TL12          | Surface water  | 59     | 91  |        |     |                   |            |

The results of questionnaires demonstrated that most households used tap water for the production process instead of groundwater. The percentage of unsatisfied, normal, and satisfied households with groundwater quality was 57, 25, and 18%, respectively. There was no significant difference between production and non-production households on satisfaction with groundwater (Figure 2).

The level of people's satisfaction with the quality of water environment was low (Figure 2), which reflected the partial awareness of local people about water pollution.

3.4. Current status of environmental management and protection

In 2014, the drainage systems of the village were upgraded to ensure the drainage capacity of 265 m$^3$/day. This capacity is equally to the current total wastewater capacity of 263 m$^3$/day of the village. In particular, wastewater from households is collected by the sewer system (size 70 x 70 cm) before flowing directly to the Hoa Binh River by the centralized sewer system (size 80 x 120 cm) without appropriate treatment measures [6]. The construction of the wastewater treatment system in the craft village has been planned since 2011; however, it has not been implemented. Domestic solid waste will be gathered at the landfill that located in the Northeast of Thanh Luong village before being transferred to waste treatment plant by trucks transporting 0.5 tons. In addition, the garbage in the open-air landfill may affect the landscapes and cause stinks. Especially, the landfill leachates flow down to the Hoa Binh River and neighboring fields in rainy seasons. The result of social survey demonstrated that the only 41% households evaluated that local authorities were paying adequate attention to local production and environmental protection, reflecting the ineffectiveness of the local authorities. This was proved by the percentage of un-satisfaction (33%), medium satisfaction (36%), and satisfaction (31%) with management of the local authorities.
Figure 1. Satisfaction of local people with surface water quality

Figure 2. Satisfaction of local people with groundwater quality

3.5. Solutions for environmental protection and management

The solutions of environment protection of Thanh Luong craft village should focus on: (1) improving the village environment management system and the policy on environmental protection, in which, it is necessary to pay attention to the role of the local management system of the craft village [17], (2) concretizing regulations on environmental protection in trade village conventions, and (3) regularly monitoring, controlling, and timely handling of activities that may result in negative impacts on the environment. In addition, environmental management staffs in craft villages should have a reasonable allowance regime to maintain regular work. It is important to have allowance regime for environmental staffs in handicraft villages on the list of priority to review and treat environmental pollution in Thanh Luong handicraft village [18].

Policies play an important role to encourage environmental protection activities and limit negative environmental impacts. Policies of reward for households that well implement regulations on environmental protection and measures to punish households causing negative impacts on the environment should be taken into account. It is also necessary to have financial support policies to build wastewater treatment system, for example the public–private partnership (PPP).

In addition, knowledge of environmental protection should be transferred to local community through annual training or media such as television and radio. Local authorities also need to increase people's awareness of the impacts of environmental pollution on the landscape, human health, and sustainable development of the village. Therefore, people should actively and positively participate in protection actions as well as limit the negative impacts on the environment. Raising the effectiveness of education and awareness of local people on environmental protection through the dissemination of environmental protection contents should also be implemented.
4. Conclusions
The results of this study showed wide variation of BOD$_5$ and COD values in wastewater and surface water in Thanh Luong village, which exceeded the regulated limits for wastewater (QCVN 40: 2011/BTNMT – Type B) and surface water (QCVN 08-MT:2015/BTNMT). COD value in groundwater was also higher than the regulation (QCVN 09-MT: 2015/BTNMT). Relatively high percentage (43%) of households evaluating the low management efficiency of local authority was also obtained. Installation of proper system for wastewater treatment, enforcement of environmental protection activities, enhancement of management and education effectiveness, and public awareness of environmental protection, socialization of environmental protection should be performed in the study area. High content of organic matters in wastewater, emission of greenhouse gases via the use of coal as fuel, and generation of a large amount of solid wastes from vermicelli production should also be taken into consideration for overall environmental protection and management.

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