ASSESSMENT OF USAGE CONDITIONS OF SEPTIC TANKS IN HA NOI AND HAI PHONG

Hoang Thi Thu Huong, Nguyen Thi Anh Tuyet*, Dinh Quang Hung

School of Environmental Science and Technology, Hanoi University of Science and Technology, 1 Dai Co Viet, Ha Noi, Viet Nam

*Email: tuyet.nguyenthianh@hust.edu.vn

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Abstract. The study had been conducted in 2017 - 2018 to generate usage conditions of septic tanks in Ha Noi and Hai Phong through: (1) collecting information on usage condition of septic tanks by interview survey; and (2) obtaining analytical results of wastewater inflowing to and out flowing from the septic tanks selected by interview survey results. The number of target interview surveys was 200 including both type of the septic tanks treating (i) black water only, and (ii) black and grey water. Among the septic tanks surveyed, 20 septic tanks were selected for analysing effluent characteristics. The analyzed parameters included water temperature, pH, BOD\textsubscript{5}, COD, TSS, Total Phosphorous (TP), Total Nitrogen (TN), NH\textsubscript{4}-N, and total coliform. Poor quality of wastewater discharged from septic tanks (BOD\textsubscript{5} = 80 ÷ 1250 mg/l and COD=170÷2110 mg/l) proved the inefficiency of septic tanks in treating black water from the households. The value of BOD\textsubscript{5} showed strong correlation with other wastewater quality parameters, especially with COD\textsubscript{Cr} (R\textsuperscript{2} = 0.962), T-SS (R\textsuperscript{2} = 0.669) and NH\textsubscript{4}-N (R\textsuperscript{2} = 0.905); and also with desludging frequencies (R\textsuperscript{2} = 0.727). Therefor, BOD\textsubscript{5} can be used as an indicator for performance of the septic tanks and desludging frequency of the septic tanks were recommended through the relationship between desludging frequency and effluent quality from septic tank.

Keywords: environmental sanitation, septic tank, black water, grey water, desludging.

Classification number: 3.3.1,3.3.2,3.3.3.

1. INTRODUCTION

On September 2015, the United Nations General Assembly adopted the Sustainable Development Goals (SDGs), which comprise of 17 goals and 169 targets, to address broad-wide ranging issues to be solved in economic, social and environmental fields comprehensively. Among the SDGs, the SDG 6.3.1 is related to the safe level of wastewater treatment. World Health Organization (WHO) has recently formulated the draft proposal on the Protocol for Step-by-Step Monitoring Methodology for Indicators of SDG 6.3.1: proportion of wastewater safety treated [1]. Viet Nam is facing the challenge of trying to keep pace with increasing wastewater pollution associated with rapid urbanization, especially in the large cities. While over 90 percent of households dispose wastewater to septic tanks, only 4 percent of septage is treated. Fecal sludge management was generally poor in most cities [2].
Septic tank is an on-site domestic wastewater treatment facility which is very popular in Viet Nam and many countries around the world. The septic tank is responsible for preliminary or complete cleaning of the black water before it is discharged to the external drainage network or receiving bodies (soil, river, lake) [3]. The principle of the septic tank is to perform sedimentation and anaerobic fermentation process. Septic tanks in Viet Nam usually have 2 to 3 compartments. The septic tank has low treatment efficiency, allows the separation of a part of suspended solids and an insignificant part of dissolved substances in the wastewater, and does not meet the requirements of discharge into the environment. However, septic tanks are still very popular in Viet Nam. Studies show that the performance of septic tanks in urban areas is bad due to improper design, construction, management and use of septic tanks [2]. Effluent from the septic tank remains highly polluted by organic matters, nutrient and microorganisms.

The main objective of this study is to generalize the usage condition of septic tanks in the urban and rural areas of Ha Noi and Hai Phong (Viet Nam) which included the (1) collecting information on usage condition of septic tanks by interview survey; and (2) obtaining analytical results of wastewater inflowing to and outflowing from the selected septic tanks. Data provided better insight relationship among different criteria of septic tank operation. Based on the data analysis, an indicator for septic tank performance was selected. The information is useful for improving design and operation of septic tank as preliminary treatment facility.

2. MATERIALS AND METHODS

2.1. Interview survey

The survey is conducted by door-to-door interviews to the target 200 households with questionnaires. About 120 households had been selected in Ha Noi (60 in urban and 60 in rural areas) and 80 households had been selected in Hai Phong (40 in urban and 40 in rural areas). Criteria for selection the household include:
- Typical urban districts located in the former city area,
- Population,
- Districts where the progress of the urbanization is remarkable.

In each district, 2 communes are selected randomly, based on household lists. From each commune, 3 households were also randomly selected.

The questioner is composed of five sections to get information on: (1) General information of household; (2) Source, amount of use, and way of use of domestic water (3) Septic tank structure, use (black water only or combined black and graywater), operation (desludging frequency), and (4) Type of water body (drainage system) discharged treated wastewater. The interviews were taken by direct question together with interviewers' observation.

2.2. Wastewater sampling and analysis

The targeted wastewater is domestic wastewater treated by septic tank only before discharging to public drainage. Wastewater from industrial, commercial facilities, hospitals and other public services had not been included in this survey.

In field measurement and chemical analysis included water temperature, pH (OAKTON 35632). Wastewater samples were collected and analyzed at the R&D Lab in Environmental Technology (School of Environmental Science and Technology – HUST) by Standard methods:
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COD (TCVN 6491:1999, ISO 6060:1989), BOD₅ (TCVN 6828:2001, ISO 10707:1994), Total Nitrogen (TN) (TCVN 5987:1995, TCVN 6268:1997), NH₄⁺-N (TCVN 5293: 1995), Total Phosphorous (TCVN 6202:1996) and total Coliform [4].

Among the septic tanks surveyed, 20 septic tanks are selected for collecting discharged wastewater sample and analyzing discharged wastewater quality. Both types of the tanks, treating (i) black water only and (ii) black and grey water, are targeted.

The wastewater samples are collected as composite samples during a day at the outlet point of pipe from septic tank. Time-composite sample within 24 hours combining from 04 grab samples at 04 sampling time.

Table 1. Sampling time.

| Sample  | 6 h | 7 h | 8 h | 9 h | 10 h | 11 h | 12 h | 13 h | 14 h | 15 h | 16 h | 17 h | 18 h | 19 h | 20 h | 21 h |
|---------|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|
| 1st grab sample |     |     |     |     |      |      |      |      |      |      |      |      |      |      |      |
| 2nd grab sample |     |     |     |     |      |      |      |      |      |      |      |      |      |      |      |
| 3rd grab sample |     |     |     |     |      |      |      |      |      |      |      |      |      |      |      |
| 4th grab sample |     |     |     |     |      |      |      |      |      |      |      |      |      |      |      |

The implementation process, including quality management, is conducted on the basis of an evolving “working document”, which will ultimately become the final report. All samples are analyzed at the R&D laboratory of INEST that has been certified by VILAS 406 (ISO 17025).

3. RESULTS AND DISCUSSION

3.1. Interview survey

The surveys in Ha Noi and Hai Phong showed that 98 percent of households disposed wastewater to 2-3 compartments septic tanks. In urban areas, currently 76 % households use water saving type of toilet facilities, while this rate was only 59 % in rural areas. The volume of majority septic tanks in Ha Noi was from 4 -10 m³ and in Hai Phong was from 3 - 5 m³ (Fig. 1).

Figure 1. Distributions of estimated volume of septic tanks in Ha Noi and Hai Phong.

The ratios of the households with/without desludging experiences are shown in Figure 2. It is found that the septage in most septic tanks in rural areas (85 % surveyed household in rural Ha Noi area and 76 % in rural Hai Phong area) have never been desludged, although regular desludging is essential to maintain septic tanks. Survey showed that, in urban area, the fecal
sludge from septic tanks in 53\% - 59\% of the households had never sucked. The survey also revealed that 94.6\% of the households equipping septic tanks did not have a custom of regular dislodge, desludging performance were mainly due to problem arisen. The situation however had already improved comparing to situation surveyed 10 years ago in Ha Noi urban areas, when over 80\% of households had never been dislodged [5].

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**Figure 2.** Implementation situation of desludging of septic tanks in Ha Noi and Hai Phong.

Frequency of desludging septic tanks had been investigated with dislodged septic tank and is presented in Fig. 3.

**Figure 3.** Distribution of desludging frequency of septic tanks in Ha Noi and Hai Phong.

The survey of septic tanks use showed that only 20\% of septic tanks used for combined black and grey water. In independent house, septic tanks were used for black water only.

### 3.2. Discharged wastewater sampling and analysis
Sampling and analysis survey were performed in 50 households. Among those 50 facilities, 20 septic tanks are screened for collecting discharged wastewater sample and analyzing discharged wastewater quality.

Criteria considered for the screening process included: (1) Type of house: both types of the households, (i) independent house and (ii) new rise-high condominium / multiple dwelling, are targeted; a public facility is included; (2) Location: both Ha Noi and Hai Phong and in both urban and rural zones; (3) Type of the tanks: both types of the tanks treating (i) black water only and (ii) black and grey water; (4) Frequency of desludging: both cases, (1) No-desludging and Desludging, are targeted; a frequency of desludging was also an important factor.

Figure 4. Relationships between different wastewater quality parameters from septic tanks.

Relationships between each water quality for households (Figure 4) and relationships between desludging interval and effluent water quality from septic tank (Figure 5) are unveiled.
Figure 4 showed strong Pearson correlation of BOD₅ with COD₅₆ (R² = 0.962), T-SS (R² = 0.669), NH₄-N (R² = 0.905) and T-Coliform (R² = 0.627). The weaker correlations with T-N (R² = 0.451) and T-P (R² = -0.140) were observed. However, weak correlation of these parameters was caused by the outlier data points. The outlier showed data at the old multiple dwelling houses, which had never been dislodged. The Spearman correlation with excluding outlier data points from statistical analyses showed the significantly strong correlation of T-N, T-P.

The Pearson correlation proved the relevance of selecting BOD₅ as indicator for performance of the septic tanks. In future works, monitoring the septic tanks can use single BOD parameter to assess the septic tank performance.

Data also show the form of Nitrogen in the septic tanks were mainly NH₄–N. Ammonium was mainly in soluble form and cannot be treated by the septic tank under anaerobic condition. Nitrogen in the solid was digested in the septic tank and also formed an extra ammonia released together with effluents. The situation followed the general characteristics of black water septic tanks [6, 7].

Figure 5 showed the relationship between desludging interval and effluent water quality (BOD₅, COD₅₆) from the septic tank. During statistical analyses, data from the multiple dwelling houses and the houses in which the septic tanks received both black and grey water were excluded. The correlation of COD₅₆ (R² = 0.519), BOD₅ (R² = 0.727) with a desludging interval thus significantly increased.

This phenomenal showed that a longer desludging interval could provide a higher concentration of septage. This trend can be mainly understood as a mixture of a decomposition process of organic matter by anaerobic digestion and an accumulation process of solid matters by settling functions. As the results, concentrations of pollutants in septage increased with an increase in the specific desludging interval. Higher septage concentration due to longer desludging interval should be given attention for septage treatment design. For the future direction of septic tanks and septage management, septage treatment needs to be designed basing on desludging strategy. Besides, proper designs, construction and operation of septic tank can make this a promising facility for on-site wastewater treatment in Vietnamese residential areas [8].

4. CONCLUSIONS

This study generates usage condition of septic tanks in the urban area and local area of Ha Noi and Hai Phong. About 95 % of black water was flushed into septic tanks including public...
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one and 97 % of effluent from septic tanks were discharged into sewer pipes. It should be clear that the septic tanks played major role of management of sanitation in urban areas. In addition, 94.6 % of the households equipping septic tanks did not have a custom of regular dislodge and 68-70 % of the households have never dislodged before. Dissemination of necessity of regular dislodge is considered crucial issues to improve sanitation in urban Ha Noi and Hai Phong.

As the results, desludging frequency of the septic tanks are recommended through the relationship between desludging interval and effluent water quality from septic tank. And the recommended volume of water-saving toilets is determined through the distributions of “water volume per flush in toilet”, “water consumption”, “estimated volume of septic tanks” and “desludging frequency” in the cities. The correlation also proved the relevance of selecting $\text{BOD}_5$ as indicator for performance of the septic tanks. In future works, monitoring the septic tanks can use single $\text{BOD}_5$ parameter to assess the septic tank performance.

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