IMPACT OF GOLF COURSES ON WATER QUALITY OF BUI RIVER IN HEADWATER CATCHMENT

Nguyen Thi Luong[1], Bui Xuan Dung[2]
[1,2]*Vietnam National University of Forestry*

SUMMARY

This study was conducted to examine water quality of the Bui river under the impact of the Phoenix Golf Course using two main methods: macroinvertebrate community through $BMWP^{VIET}$ and ASPT scoring systems, along with physical and chemical parameters characteristics (pH, TSS, DO, COD, BOD_5, NO_3^-, PO_4, total coliforms) at three locations: upstream, in the stream passing through the golf course, and downstream. Measurements were taken in 4 different periods: on a sunny day without using fertilizers and pesticides, one day after applying fertilizers and pesticides, after applying fertilizers and pesticides on a rainy day, and using fertilizers and pesticides on a sunny day. The results show that: (1) pollution level decreases dramatically from upstream to downstream (from 6.4 to 4.2) based on $BMWP^{VIET}$ method; (2) The concentrations of pollutants increased significantly from upstream to downstream. Almost parameters exceeded B1 standard, only pH, total nitrogen and total coliform range in B1 standard limit based on Vietnam water quality Standard. WQI also depicted that water quality decreases from upstream to downstream. This paper also suggests some solutions to reduce the influence of the golf course on water quality and aquatic ecosystem of Bui River catchment including improved pesticide management and riparian buffer zones.

Keywords: $BMWP^{VIET}$, golf course, Lam Son, macroinvertebrate, pollution, water quality.

I. INTRODUCTION

In the past, golf courses were not so popular in Vietnam. However, in the recent years, more golf courses began to take form in the whole country with 144 golf course projects in 39 provinces and another 35 golf courses operating along the country. Nevertheless, in long term, golf courses have a lot of negative impacts to environment such as reducing the natural vegetation cover, forest fire, damaging natural resources or causing changes in topography. Furthermore, a major focus of discussion regarding known or suspected ecological impacts of golf courses has been water quality, typically focusing on chemical toxicology (Wheeler & Nauright, 2006).

There were some previous studies predicting that when golf courses using fertilizers and pesticides regularly, these chemicals can dissolve into surface water and ground water following application and cause a lot of effects to water quality (Hindahl et al. 2009). In addition, the quantities of fertilizers applied to the turf grasses of golf courses are roughly the same as that used on crop fields, and it is even more seriously when they used these chemical nutrients regularly (Klein, 1990). Therefore, up to 84% of the nitrogen fertilizers applied to turf grass may leach to groundwater with the average hovering between 5% and 10% (Petrovic, 1990).

Bui river belongs to Lam Son commune, Luong Son district, Hoa Binh province which is the main source providing water for Lam Son commune and it also passes through the Phoenix Golf Course. In recent years, there are some articles and previous studies mention impacts of this golf course on water quality. For instant, Yen et al. (2009) showed that the concentrations of nitrate and phosphorous upstream water where had not impact of Phoenix Golf Course were lower than ones of

water in downstream after passing this golf course. Otherwise, Oanh (2015) also investigated that golf course decreased water quality of Bui river through the physical and chemical parameters. Nevertheless, there are very few scientific survey and report on chemical effect in golf course in Lam Son Province which use for reference and guidance. However, Golf course impact on other water parameters (such as biological index) and different period was not showed clearly. This study therefore was conducted to solved these problem and provide information for further research.

II. STUDY SITE AND METHODOLOGY

2.1. Study site

Bui river belongs to Lam Son commune, which is located in the Northwest of Luong Son district, Hoa Binh province. It is about 46 km North from Hanoi center (fig. 2.1). This river passed through the Phoenix Golf Course, which was established in 2005 with total area of 311.7 ha, in which 17 ha belong to the golf club and hotel, and 250 ha to turf grass systems. In each year, this golf course uses 76 – 81 tons fertilizers (Delta – Coated, Delta – Top and NPK) as well as 41280 liter pesticides (Agrodream"D"; Agrodream "M" and Anvil 5SC) for taking care of the turf grasses and uses 15000 m^3 water for irrigating.

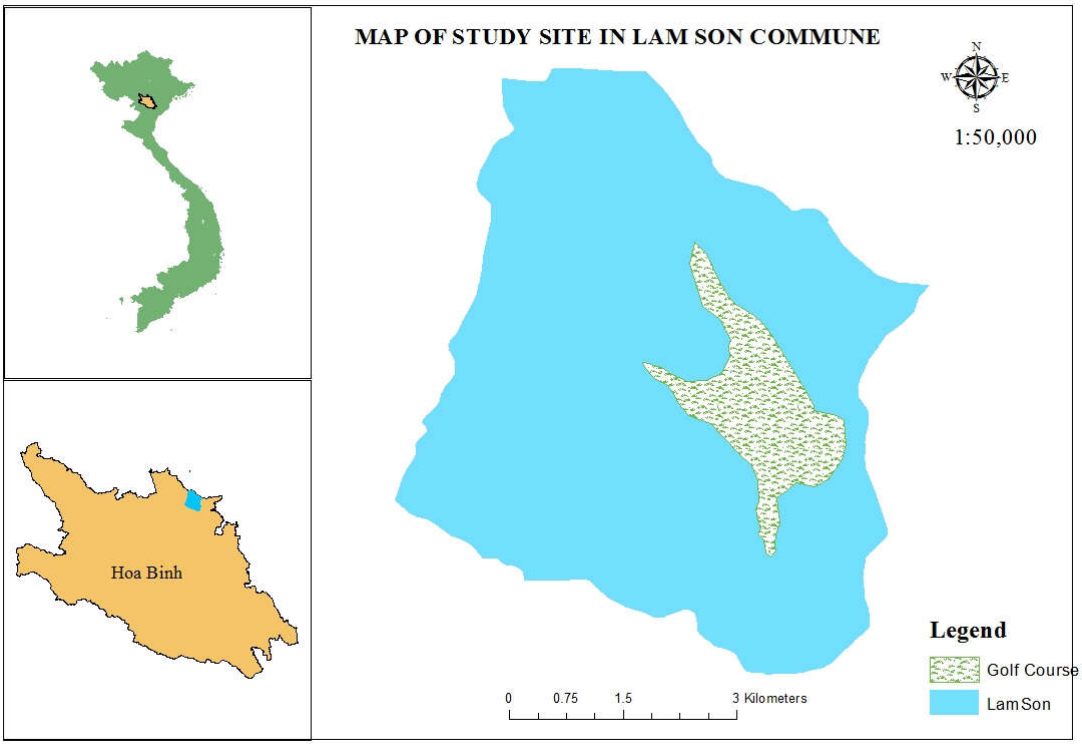

Figure 2.1. Location of study site in Lam Son commune

2.2. Methodology

2.2.1. Experiment design and collect data

Physical and chemical water samples and macroinvertebrate samples were collected at the same locations: upstream, inside the golf course and downstream area in four periods (fig. 2.2). Because this is have only land use of golf course, water quality of Bui was impacted by their activities (fig. 2.2).

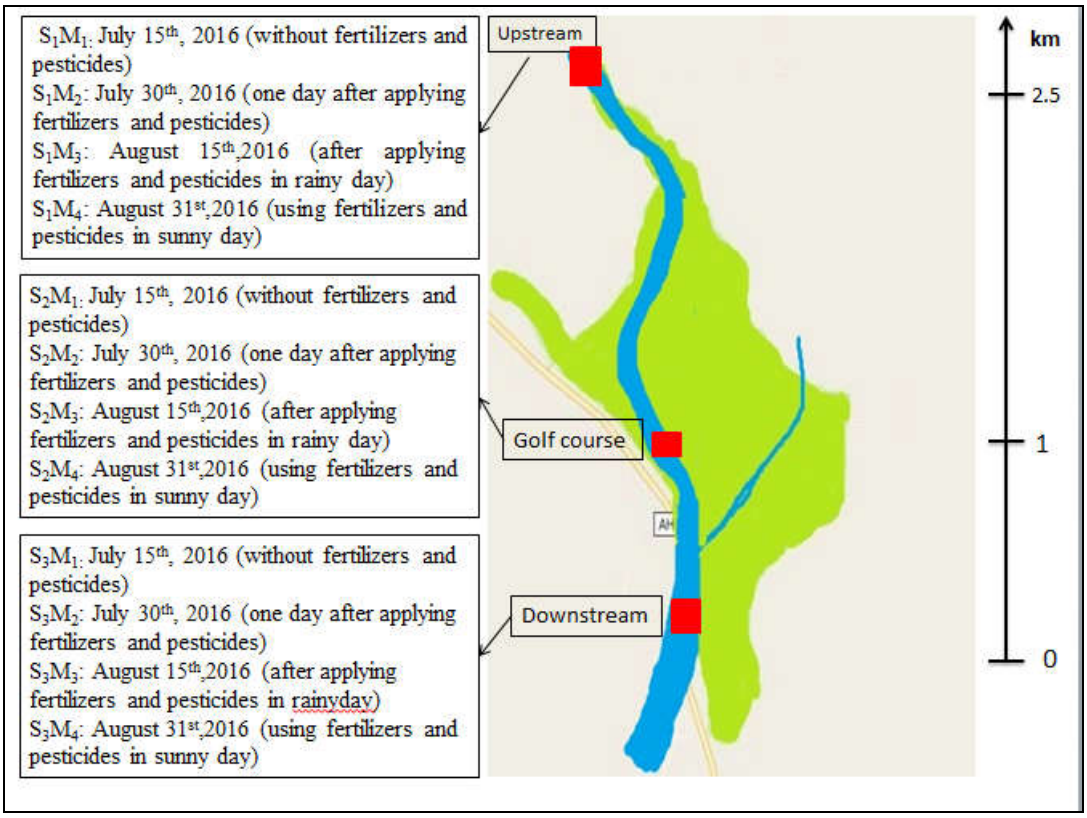

Figure 2.2. Water samples location in study site

Water samples were collected according to current standards in Vietnam TCVN 5996 1995: Water quality- Sampling - Guidance on sampling on rivers and Streams at three locations in four different periods (fig. 2.1).

Day 1: July 15th, 2016 (without fertilizers and pesticides)

Day 2: July 30th, 2016 (one day after applying fertilizers and pesticides)

Day 3: August 15th, 2016 (after applying fertilizers and pesticides in rainy day)

Day 4: August 30st, 2016 (using fertilizers and pesticides in sunny day)

Macroinvertebrate samples were collected by pond net after taking water samples. Invertebrate samples were collected by the method of Nguyen Xuan Quynh et al (2004) by pond net then all of the specimens were preserved in 70% alcohol (fig. 2.3).

Figure 2.3. Pond net to collect macroinvertebrate samples

2.2.2. Laboratory sample processing

The water samples were analyzed according to current standards in Vietnam TCVN 5996-1995: Water quality- Sampling - Guidance on sampling on rivers and Streams:

Table 2.1. Methods to analyze water samples

Water quality indicators	Method
pH	Hana pH measurement directly in the field.
Total Suspended solid (TSS)	Filter and weight in lab.
Dissolved Oxygen (DO)	Modified Winkler, treated with $MnSO_4$, H_2SO_4 in lab
Biological oxygen demand (BOD_5)	Pipetted into a BOD bottle containing aerated dilution water.
Chemical oxygen demand (COD)	Redox titration, oxygen is used to oxidize the organics to carbon dioxide and water
Total nitrogen (NO_3^-)	Titrimetric
Total Phosphorous (PO_4^{3-})	Ascorbic Acid
Total Coliform	Fecal coliform confirming test

2.2.3. Data analysis

Table 2.2. Methods to analyze data

Indicator	Method
WQI	America Water quality index (WQI) method (Srivastava and Kumar 2013)
Diversity index	Shannon Wiener Diversity method (https://www.easycalculation.com/statistics/learn-shannon-wiener-diversity.php)
$BMWP^{VIET}$ and ASPT	Biological monitoring Working Party method (Nguyen Xuan Quynh, 2004)

III. RESULTS AND DISCUSSION

3.1. Impact of Phoenix golf course on Physical and chemical parameters

3.1.1. Evaluating water quality in Bui river based on Vietnam's water quality standard

a. pH

pH levels of water quality in Bui river during four periods and different locations change from 7.3 to 8.6 (fig. 3.1). This fluctuation is small and all values belong to allowable limit of standard B1 (for aquatic life).

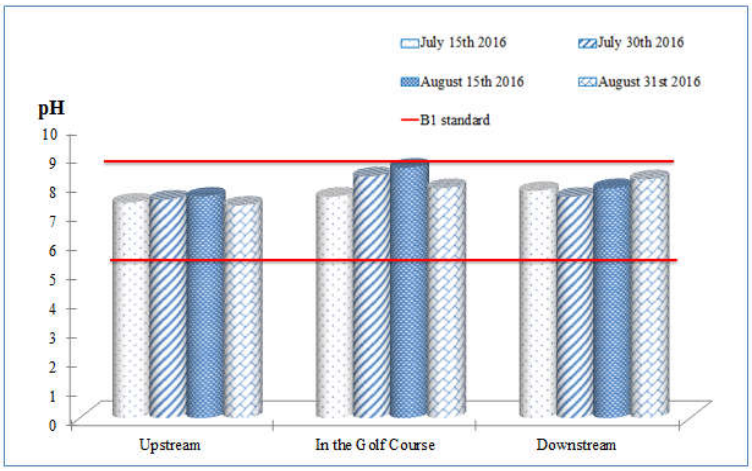

Figure 3.1. pH fluctuation in four periods at three different locations

b. Total suspended solids (TSS)

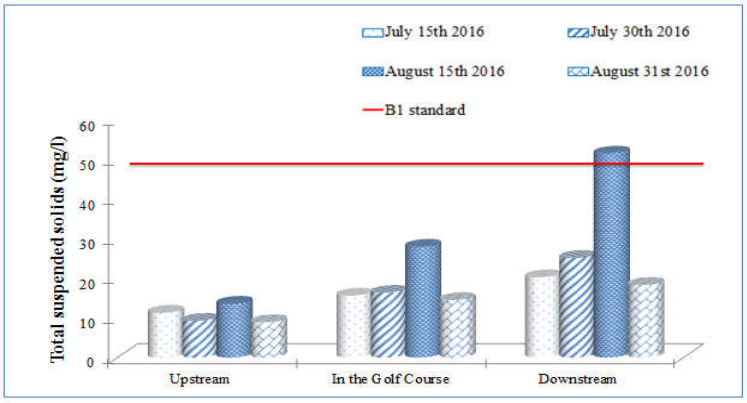

Figure 3.2. The amount of TSS in four periods at three locations

Total suspended solids of Bui river water increased significantly from upstream to downstream, especially after rainy day, the concentration exceeded the B1 limit (fig. 3.2).

c. Chemical oxygen demand (COD)

The concentrations of COD are increased remarkably from the upstream to downstream and exceeded B1 limit in the location inside the golf course and downstream after turf grass was applied fertilizers and pesticides (fig. 3.4). With these values, water quality in downstream and in the stream passed through the golf course is not acceptable for agriculture and aquaculture.

Figure 3.3. COD concentration in four periods at three different locations

d. Biological oxygen demand (BOD)

The concentration of BOD increased dramatically from upstream to downstream along Bui river (fig. 3.4). In rainy day, it exceeded B1 standard with the highest values, which is more than 30 mg/l.

Figure 3.4. Values for BOD in four periods at three different locations

e. Dissolve oxygen (DO)

Figure 3.5. DO level of Bui river in 4 periods at 3 locations

Similar to COD and BOD concentration, DO is decreased gradually when golf course used pesticides and fertilizers in rainy day, this concentration lies below B1 standard, which can cause stressful to aquatic ecology (fig. 3.5).

f. Total nitrogen ($N\text{-}NO_3^-$)

Unlike other concentrations, although the values of total nitrogen increased significantly from upstream to downstream, especially after the golf course applied fertilizers and pesticides, it does not exceed B1 limit (fig. 3.6).

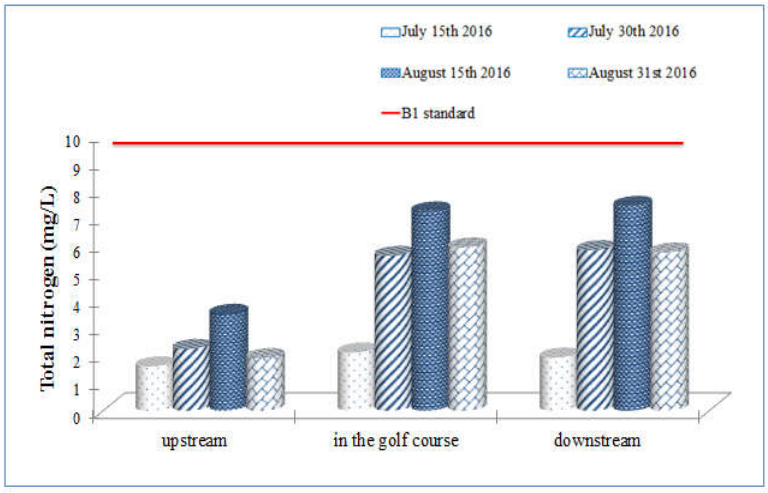

Figure 3.6. Total nitrogen of Bui river in 4 periods at 3 locations

g. Total phosphorus ($P\text{-}PO_4^{3-}$)

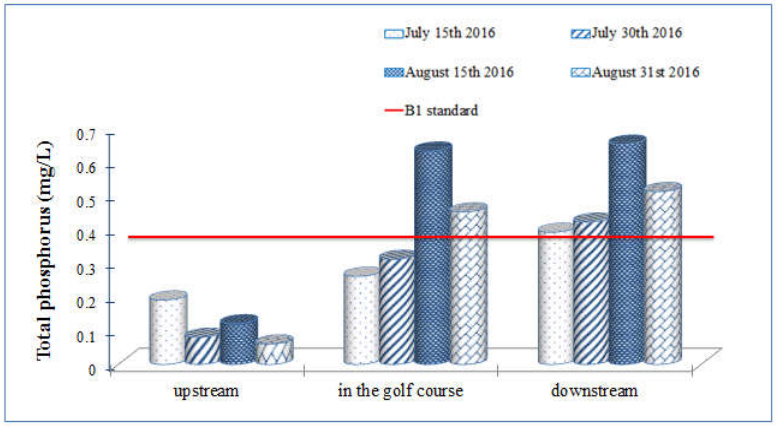

Figure 3.7. Total phosphorus of Bui river in 4 periods at 3 locations

From the figure 3.7, we can see that, two areas inside the golf course and downstream area were affected by applying fertilizers and pesticides, the concentration of phosphorus increased significantly and exceeded B1 standard.

h. Total coliform

The figure 3.8 below indicates the significant increase of total coliform bacteria from upstream to downstream of Bui river surface water. In general, total coliform in 4 periods at 3 locations are lower than the limits of B1 standard (which is lower than 7500 MPN/100 ml).

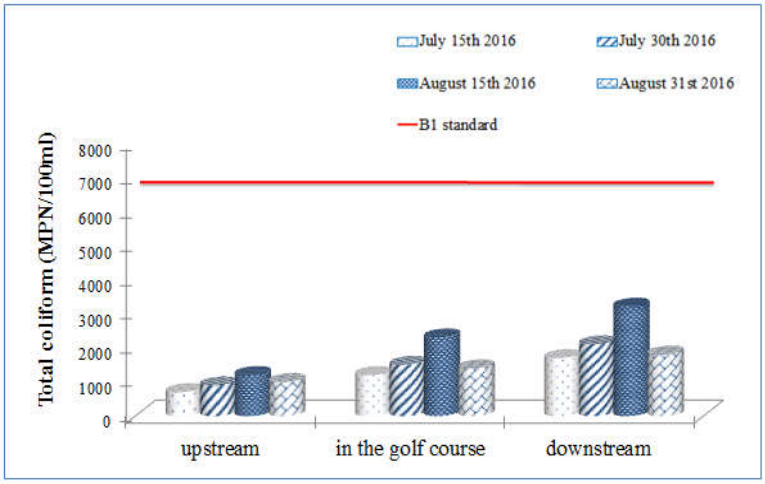

Figure 3.8. Total coliform of Bui river in 4 periods at 3 locations

i. Summary

Phoenix golf course in operation and maintenance can cause increase organic waste in water and lead to a significant difference of water quality parameters from upstream to downstream (fig. 3.9). Almost physical and chemical parameter of water increased significant from upstream (no impact) to golf course and to downstream. This suggests that golf course have changed water quality of Bui river such as physical and chemical indicators of water at the study site. More impact of golf course was showed in increasing of TSS, BOD, COD, DO and $P\text{-}PO_4^{3-}$.

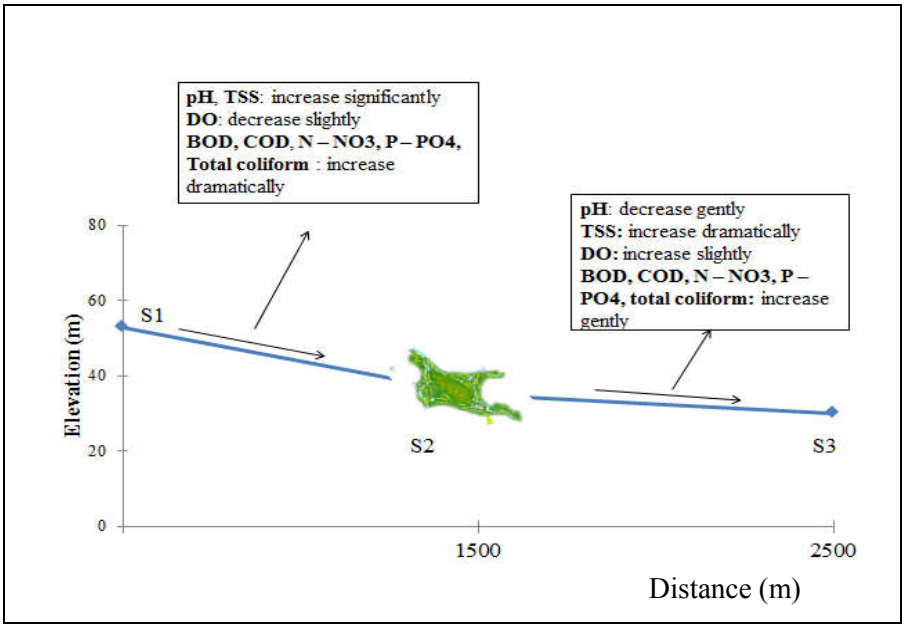

Figure 3.9. The impact of Phoenix Golf Course on water quality of Bui river from upstream to downstream

3.1.2. Evaluating water quality in Bui River based on Water Quality Index (WQI)

After completing the nine tests, the results are calculated by the formula of WQI with missing parameters (Turbidity) (fig. 10).

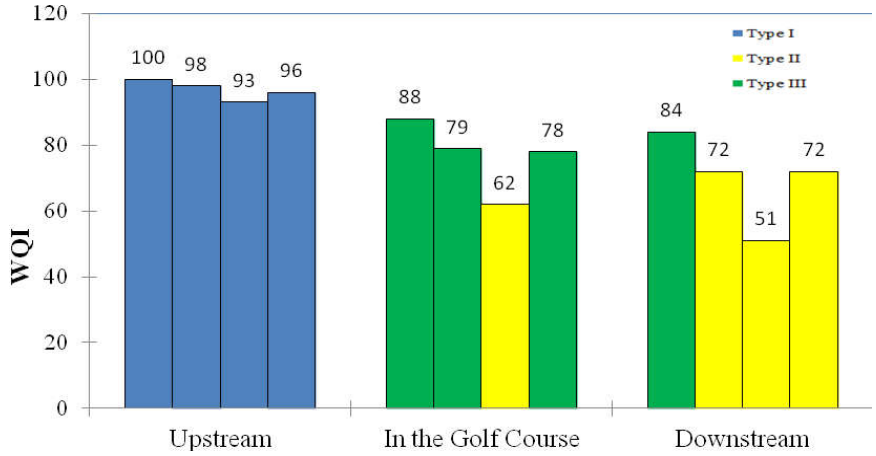

Figure 3.10. WQI values in 4 periods at 3 locations

The WQI values in fours periods at three locations were different. Overall, WQI values decrease dramatically from upstream to downstream (fig. 3.10). In upstream, all WQI values belong to water type 1, range from 91 - >100: good for domestic demand (excellent). In the location of golf course, almost all values belong to water type II: used for domestic demand but need treatment or water quality is quite good; only water sample on August 15th when golf course sprayed fertilizers and pesticides in rainy day, WQI value drops to 62, which indicates for medium water quality, or water used for agricultural purposes. In downstream, almost samples have low WQI score which belongs to water quality of type III: used for agricultural purposes, only water sample on July 15th has WQI gained in water quality of type II.

3.2. Impact of Phoenix Golf Course on invertebrate composition and diversity

3.2.1. Invertebrate composition

A total of 40 species belonging to 26 families were collected from 3 locations of Bui river, in which the phylum of Athropoda occupied the highest quantity with 16 families, 22 species; followed by Mollusca with 14 species, 7 families; the phylum that has smallest number is Annelida with 4 species, 3 families (fig. 3.11).

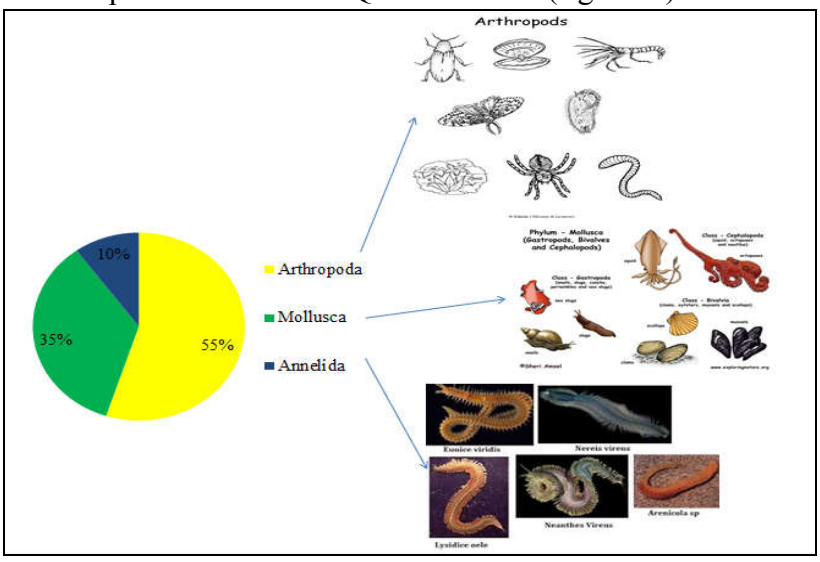

Figure 3.11. The ratio of species composition in 3 sample locations of Bui river

3.2.2. Invertebrate diversity

The results of invertebrate diversity in three locations are illustrated in the following figure 3.12.

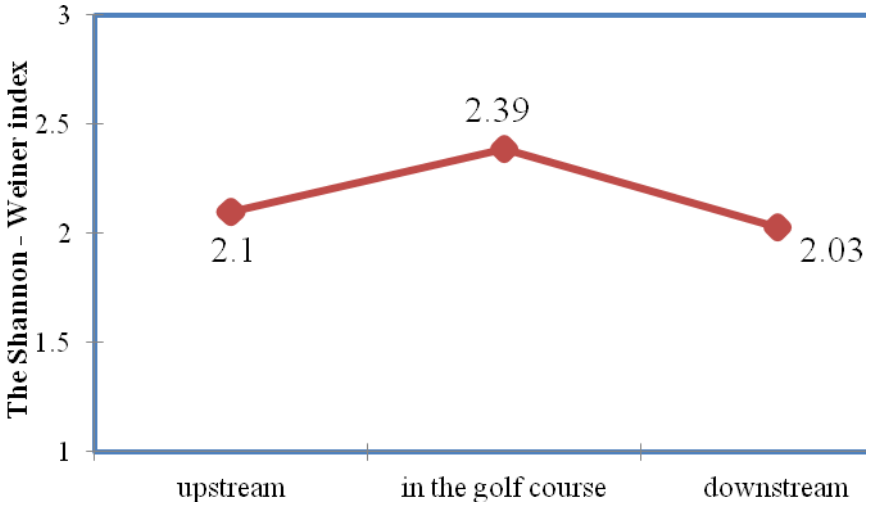

Figure 3.12. The Shannon Wiener index of diversity values at study site

According to the results of figure 3.12, although the location in golf course did not have the highest number of families, it's the location that has highest diversity value which equals to 2.39. Upstream has 2.1 score and downstream has 2.03 score. This values was not significant difference.

To clarify the impact of Phoenix Golf Course to the composition and diversity of invertebrate communities in Bui river, we compared the distribution of invertebrate communities from the upstream to downstream area with natural rules of stream ecology (fig. 3.13).

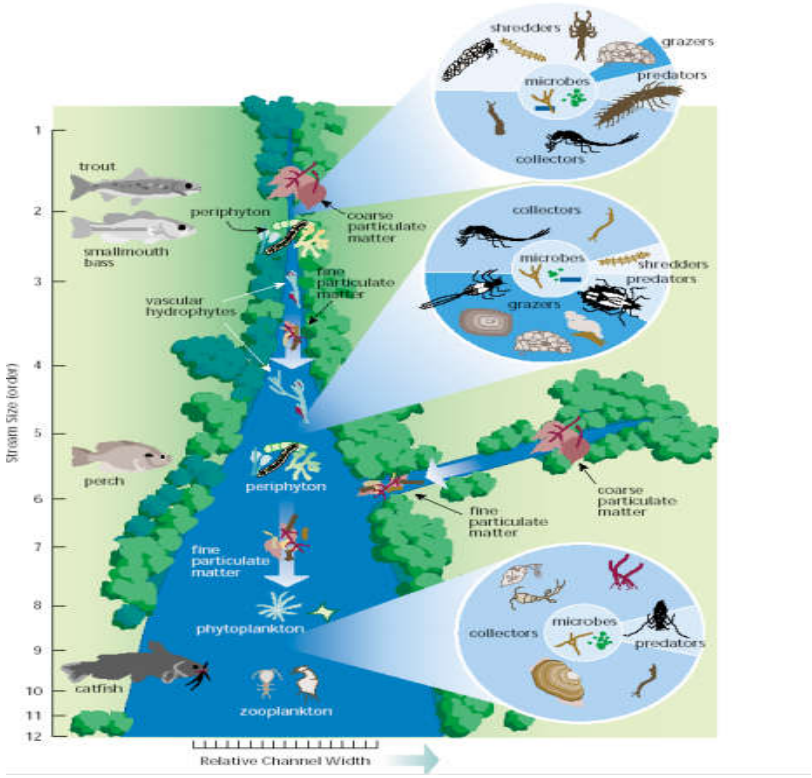

Figure 3.13. The proportion of invertebrate feed groups corresponds to changes in the physical factor in the longitudinal direction (Source: USDA 2001)

The river continuum concept (RCC) predicts that macroinvertebrate assemblages change gradually from headwaters to large rivers downstream (Vannote et al., 1980). To compare with natural rules stream ecology, this study site has the highest diversity value in golf course and lowest value in downstream area. There is a big difference between invertebrate distribution of this study site and natural rule. The reason can be the potential affects of Phoneix Golf Course after applying fertilizers and pesticides to turfgrass. The concentration of nutrient chemicals change can cause the changing in composition of inveterbrate in the stream passing though golf course and downstream. However, the distance from upstream to downstream in the study site is quite small. Therefore, the results is not precise.

3.2.3. Effect of Phoenix Golf Course to water quality in Bui river based on BMWP^{VIET} method.

BMWP scores, ASPT scores of the three locations were calculated and summarized in the following figure 3.14.

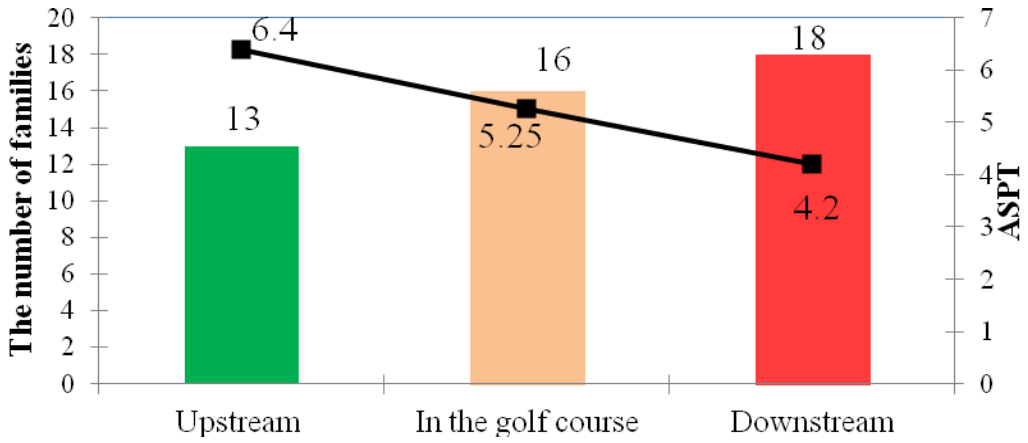

Figure 3.14. The respond of the number of families and ASPT score

Figure 3.14 indicated the respond of the number of families and ASPT score at three locations: upstream, in the stream passing though the golf course, and downstream. From the figure, we can see that, although the location in upstream has lowest number of families, it has highest ASPT score which indicates that water in this location is slightly clean. Meanwhile, sample location in the golf course has lower ASPT score while the number of families is higher. The location that has highest number of families is downstream. There are 18 families, but it has lowest ASPT score which is 4.2 (very high pollution).

3.2.3. Suggestion for Golf Course management

To reduce the impact of Phoenix Golf Course to water quality of Bui river, these findings suggest that the golf course should build the facilities to keep fertilizers and pesticides separately. In addition, the designer of golf course should design some ponds to release of toxics or oxygen – deficient water and install under drain system beneath any portion of the fairways, greens, or tees which are sited on coarse – textured soils or where the depth to bedrock or the water table is less than 1 meter to collect water which may be contaminated with fertilizers or pesticides. Moreover, a golf course should be designed with riparian buffer zones. Ideally, plant buffers with native species provide a triple play of water quality benefits, pleasing aesthetics, and habitat and food sources for

wildlife. Buffers will provide a barrier between grading, filling, or construction activities which ensures that the waterway or wetland is not physically altered by heavy equipment. Leaves, twigs, and other plant parts serve as an extremely important food source for most aquatic ecosystems. Tree trunks and large branches provide vital habitat for fish and other creatures. Streamside forests are the primary contributor of these food and habitat components.

III. CONCLUSION

Based on two main methods: macroinvertebrate community through $BMWP^{VIET}$ and ASPT scoring systems, along with physical and chemical parameters characteristics (pH, TSS, DO, COD, BOD_5, NO_3^-, PO_4, total coliforms) at three locations: upstream, in the stream passing through the golf course, and downstream at different observation periods to check impacts of Golf course on water of Bui river. Main findings of this study were (1) Phoenix Golf Course activities have negative impacts to water quality of Bui river with water quality decreased significantly from upstream to downstream based on Vietnam water quality standard and WQI; (2) BMWP and ASPT method show the decline of water quality at three locations (from 6.4 score in upstream to 4.2 score in downstream); (3). To reduce the effects of Phoenix Golf Course to local environment, the study suggested creating buffer zones, improving pesticides and fertilizers management.

ACKNOWLEDGEMENT

This work was supported by the research program of Vietnam National University of Forestry. Otherwise, we gratefully acknowledge the blessings and valuable suggestions from teacher in the laboratory of Faculty of Biology in University of Science to help me classify macroinvertebrate animals, would especially like to thanks to the help provided for by laboratory work at Vietnam Academy of Science and Technology Institute of Chemistry. Many thanks to Ms. Nhan, Mr. Tuc to provide the information of Phoenix Golf Course.

REFERENCES

1. Allan, J. D. (2004). Landscapes and rivers: The influence of land use on stream ecosystems. *Annual Review of Ecology, Evolution, and Systematics*, 35, 257-284.

2. Cohen, S., A. Svrjcek, T. Durborow, and N.L. Barnes (1999). "Water Quality Impacts by Golf Courses." *Journal of Environment Quality* 28(3):798.

3. De Pauw N. and H.A.Hawkes (1993). Biological monitoring of river water quality. *River Water Quality Monitoring and Control*, Aston University Press, pp. 87-111.

4. Eisenberg, D. A., Noss, R. F., Waterman, J. M., & Main, M. B. (2011). *Distribution and habitat use of the big cypress*.

5. Oanh DTQ (2015). *Evaluating effects of Phoenix Golf Course on water quality at headwater catchment of Bui River in Hoa Binh province, Luong Son district Lam Son commune*. Thesis research in Vietnam National University of Forestry.

6. Petrovic, A.M. (1990). The Fate of nitrogenous fertilizers applied to turfgrass. *Journal of Environmental Quality*, 19 (1): 1-14.

7. Quynh NX, Pinder C and Tilling S. (2001). *Classify invertebrate communities often appear in Vietnam.* Vienam National University Hanoi.

8. Srivastava, G and Kumar P. (2013). Water quality index with missing parameters. International *Journal of Research in Engineering and Technology* 2 (4):609–614.

9. USDA (2001). *Stream Corridor Restoration: Principles, Process and Practices*. The Federal Interagency Stream Restoration Working Group, USDA.

10. Yen HT, Duong NT, Hung TV (2008). *Research on the environmental impacts of Long Son golf course, in Lam Son commune*. Scientific research in Viet Nam National University of Forestry.

11. Wheeler, K & Nauright, J. (2006). A global perspective on the environmental impact of golf. *Sport in Society*: Cultures, Commerce, Media, Politics, 9, 427–443.

TÁC ĐỘNG CỦA SÂN GOLF ĐẾN CHẤT LƯỢNG NƯỚC SÔNG BÙI THUỘC LƯU VỰC ĐẦU NGUỒN

Nguyễn Thị Lương[1], Bùi Xuân Dũng[2]
[1,2]Trường Đại học Lâm nghiệp

TÓM TẮT

Nghiên cứu này được thực hiện để kiểm tra chất lượng nước của sông Bùi dưới tác động của sân golf Phượng Hoàng bằng việc sử dụng hai biện pháp chính: sử dụng động vật không xương sống cỡ lớn qua phương pháp tính điểm $BMWP^{VIET}$ và ASPT, cùng với việc sử dụng phương pháp so sánh với TCVN và WQI thông qua chỉ tiêu hóa – lý- sinh (pH, TSS, DO, COD, BOD_5, NO_3^-, PO_4, sinh vật trực khuẩn) ở 3 địa điểm: thượng nguồn, vị trí sông chảy qua sân golf và hạ nguồn. Việc quan trắc được thực hiện ở 4 giai đoạn khác nhau: khi sân golf không sử dụng phân bón và thuốc trừ sâu trong ngày nắng; một ngày sau khi sân golf sử dụng thuốc trừ sâu; ngay sau khi sân golf sử dụng thuốc trừ sâu trong ngày mưa; sử dụng thuốc trừ sâu trong ngày nắng. Kết quả chỉ ra rằng: (1) mức ô nhiễm nước sông Bùi tăng đáng kể từ đầu nguồn đến cuối nguồn (từ 6.4 đến 4.2) dựa trên phương pháp tính điểm ASPT; (2) nồng độ ô nhiễm tăng mạnh từ đầu nguồn đến cuối nguồn, hầu hết tất cả các thông số đều vượt quá chỉ tiêu B1, riêng pH, tổng lượng ni tơ và tổng vi khuẩn trực khuẩn nằm trong giới hạn cho phép của B1 dựa trên phương pháp đánh giá chất lượng nước theo tiêu chuẩn Việt Nam, trong khi đó phương pháp WQI chỉ ra rằng chất lượng nước giảm mạnh từ đầu nguồn đến cuối nguồn. Nghiên cứu cũng đề xuất một số biện pháp nhằm giảm thiểu ảnh hưởng của sân golf đến chất lượng nước và hệ sinh thái dưới nước của sông Bùi như cải thiện việc sử dụng và quản lý thuốc trừ sâu và thiết kế vùng đệm ở ven sông.

Từ khóa: Chất lượng nước, động vật không xương sống, lâm sơn, ô nhiễm, sân golf.

Received : 09/9/2016
Revised : 17/11/2016
Accepted : 23/12/2016