

WATER QUALITY ASSESSMENT USING BENTHIC MACROINVERTEBRATES IN SAIGON RIVER AND ITS TRIBUTARIES, VIETNAM

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ABSTRACT

This study to enhance the discussion about the usefulness of benthic macroinvertebrates for water quality assessment in Saigon River and its tributaries. Data from 16 sites were used as a representative example for Saigon River and its tributaries in the area of basin over 4,500 km², the length through provinces of Tay Ninh, Binh Phuoc, Binh Duong, and Ho Chi Minh City of about 280 km. The data covered the period of dry and rainy seasons in 2015, the survey sampled 16 sites (32 events) of the Saigon River and its tributaries selected. To implement this evaluation, the analyses were based on MRC methods and classifications these improved by the scientific group.

The analysis of general characteristics of benthic macroinvertebrates and bio-indices were used to examine the spatial patterns of water quality and biological groups. The value of good water quality was recorded in the sites far from industrial parks, crowded citizen areas, big cities (SG1 and SG2) while the sites in near urban Ho Chi Minh City and Thu Dau Mot Town or industrial areas (the section of Saigon River from SG6 to SG13) where had the value of worse water quality because of the more human activities. Especially, there was not any animal that was collected in the site SG7 because of too heavy pollution. The results demonstrated that these organisms could be applied to describe the ecological health in the Saigon River and its tributaries.

Keywords: Saigon River and its tributaries, benthic macroinvertebrates, water quality, ecological health.

1 INTRODUCTION

The Saigon River is a river located in southern Vietnam that rises near Phum Daung in Southwestern Cambodia, flows South and South-Southeast for about 230 kilometres and empties into the Nha Be River, which in its turn empties into the East Sea some 20 kilometres Northeast of the Mekong Delta. The Saigon River is joined 29 kilometers Northeast of Ho Chi Minh City by the Dongnai River [1]. The Saigon River is very important to Ho Chi Minh City as it is a one of the main water supply as well as the host Saigon Port. The policies for socio-economic development and land-use change have impulsed the economic growth of Tay Ninh, Binh Phuoc, Binh Duong, and Ho Chi Minh City, but the water pollution have a tendency to increase. These consequences of environmental pollution are thus far from inevitable [2].

In order to contribute the water resources management and improve the water quality monitoring in Saigon River and its tributaries, besides the physiochemical measurements, the using of aquatic organisms for the ecological health monitoring has been applied more and more because of many their advantages. Saigon River was chosen to assess the impact of socio-economic development and land-use change on water quality and ecological health. This work will support for scientists and managers in field of ecology, resources and environment, who can applied these studies for the ecological health monitoring in the provinces of Tay Ninh, Binh Phuoc, Binh Duong, and Ho Chi Minh City. The objectives of the research were to (i) study on the benthic macroinvertebrates for water quality assessment in the Saigon River and its tributaries; (ii) evaluate the changes of water quality in the Saigon River and its tributaries.

2 MATERIALS AND METHODS

2.1 Study area

Based on the characteristics of socio-economic development, water bodies, flows, environmental variables, and ecological conditions, 16 sampling sites for the main river and canals in Saigon River were selected as representative of the basin for a sampling program (*Figure 1*).

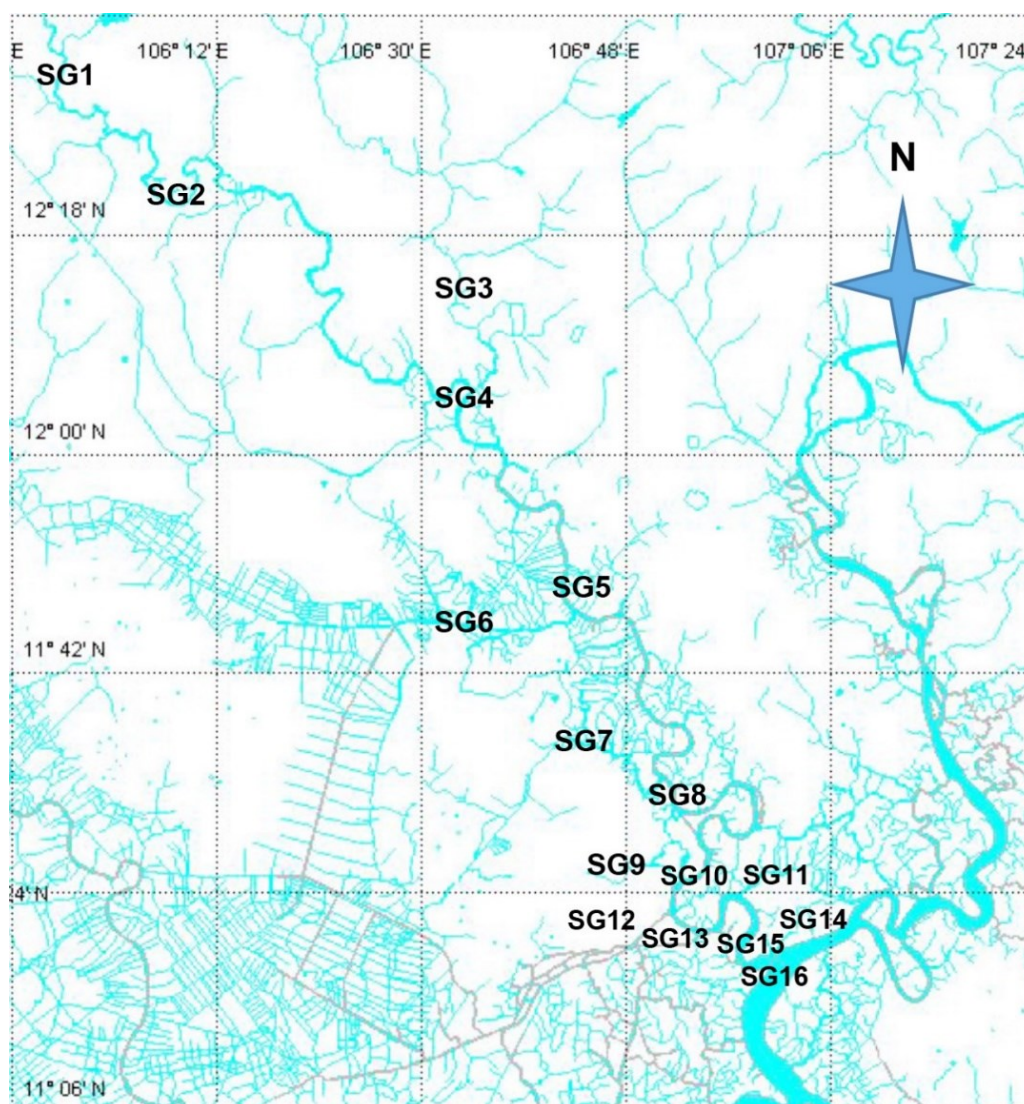


Figure 1. Sampling Sites in Saigon River and its tributaries.

2.2 Sampling and sample processing

The sampling frequencies were taken 2 times of March and September in 2015. Sample locations at each site were selected in each of the right and left parts of the river. Five locations were sampled at each of these parts of the river [3, 4, 5]. According to working experiences in studied area, the middle of river need not be sampled because of without change to collected data.

Prior to sampling, all the equipment to be used was thoroughly cleaned to remove any material left from the previous sampling site. At each sampling location, a composite of four grabs was taken with a Petersen grab sampler, covering a total area of 0.1 m^2 . If the sampler did not close properly because material such as wood, bamboo, large water-plants, or stones jammed its jaws, its contents were discarded and another grab was taken [3, 4, 5].

The composite sample was washed through a sieve (0.3 mm) with care taken to ensure that macroinvertebrates did not escape. The contents of the sieve were then placed in jars and fixed with formaldehyde. Samples were sorted in the laboratory, because there was insufficient time at a site. The sample jar was labeled with the site location code, date, position within the river, and replicate number. The sampling location conditions, collector's name were recorded on a field sheet [3, 4, 5].

All individuals collected were identified and counted under a compound microscope (with magnifications of 40 – 1200x) or a dissecting microscope (16 – 56x). Oligochaeta, Polychaeta, Gastropoda, Bivalvia, and Crustacea were generally identified to species level. Insecta and Insecta larvae were classified only to genus level. The results were recorded on data sheets and specimens are kept at the Ton Duc Thang University, HCMC, Vietnam [3, 4, 5].

2.3 Laboratory analysis

The identification of benthic macroinvertebrates was based on morphology and taxonomic books such as Polychaeta [6, 7, 8, 9]; Oligochaeta [10, 11]; Gastropoda [11, 12, 13]; Bivalvia [11, 12, 13]; Crustacea [11, 14, 15, 16, 17, 18, 19, 20]; Insecta [21, 22, 23, 24, 25, 26].

2.4 Data analysis

For all sites sampled in March and September of 2015, the following metrics were calculated (which is 1 m^2): (i) taxonomic richness (i.e. number of taxa); (ii) abundance (i.e. numbers of individuals per site); (iii) the Shannon-Wiener Diversity Index (H') [27]; and, (iv) the Simpson Density Index ($1 - D_s$) [28]. The water quality assessment for a range of bio-index values were presented in Table 1.

Table 1. Ranking of bio-index values using benthic macroinvertebrates [2, 29]

No.	H'	$1 - D_s$	Ranking
1	> 3.25	> 0.90	Very light pollution
2	$2.20 - 3.25$	$0.65 - 0.90$	Light pollution
3	$1.40 - 2.20$	$0.40 - 0.65$	Low moderate pollution
4	$0.80 - 1.40$	$0.25 - 0.40$	High moderate pollution
5	$0.10 - 0.80$	$0.10 - 0.25$	Heavy pollution
6	< 0.10	< 0.10	Very heavy pollution

Notes: H' (Shannon-Wiener Diversity Index); D_s (Simpson Dominance Index).

3 RESULTS

3.1 Taxa richness

In total, 32,189 benthic macroinvertebrates belonging to 42 taxa were collected in March and September, 2015 (Table 2). The species of Insecta were dominant in the aquatic communities, these species occurred in almost sites (15/16 sites). In addition, species of Polychaeta, Oligochaeta, Gastropoda, Bivalvia and Crustacea also occurred widely in the studied areas.

Table 2. Communities structure of benthic macroinvertebrates in Saigon River and its tributaries (March and September, 2015)

Classes	No. species	Percentage
Polychaeta	6	14.3
Oligochaeta	3	7.1
Gastropoda	5	11.9
Bivalvia	8	19.1
Crustacea	9	21.4
Insecta	11	26.2
Total	42	100

The species number at site was highly variable, ranging from 0 (Site SG7 in both March and September) to 13 (Site SG2 in March; Sites of SG1, SG2 and SG16 in September) species per site. Generally, the rates of aquatic organisms expressed the specific characteristics of water quality and the soft substrates of mud, clay, sand, debris.

3.2 Abundance

The number of individual macroinvertebrates per benthic site ranged from 0 to 6,184. The changes of dominant species at 16 sites expressed clearly the habitat characteristics of the Saigon River and its tributaries. The density of benthic macroinvertebrates tended to increase too high or to disappear all in near big cities or industrial areas.

3.3 Bio-index analysis

The values of bio-indices for the water quality assessment for the Saigon River and its tributaries were presented in Table 3.

Table 3. Metrics of benthic macroinvertebrate for water quality assessment in the studied sites (March and September, 2015).

Sites	H'	1-D _s	Ranking
SG1	2.56 – 2.69	0.76 – 0.79	Light pollution
SG2	2.02 – 2.26	0.58 – 0.71	Light pollution – Low moderate pollution
SG3	1.39 – 1.77	0.42 – 0.56	Low moderate pollution
SG4	1.20 – 1.58	0.34 – 0.42	Low moderate pollution – High moderate pollution
SG5	0.98 – 1.20	0.27 – 0.34	High moderate pollution
SG6	0.46 – 0.51	0.12 – 0.15	Heavy pollution
SG7	0	0	Very heavy pollution
SG8	0.62 – 0.85	0.18 – 0.21	High moderate pollution – Heavy pollution
SG9	0.15 – 0.35	0.09 – 0.16	Heavy pollution
SG10	0.37 – 0.49	0.10 – 0.11	Heavy pollution
SG11	0.54 – 0.76	0.14 – 0.19	Heavy pollution
SG12	0.08 – 0.14	0.07 – 0.10	Heavy pollution – Very heavy pollution
SG13	0.55 – 0.65	0.18 – 0.20	Heavy pollution
SG14	1.09 – 1.14	0.35 – 0.37	High moderate pollution
SG15	1.49 – 1.91	0.45 – 0.60	Low moderate pollution
SG16	2.36 – 2.46	0.71 – 0.75	Light pollution

Notes: H' (Shannon-Wiener Diversity Index); D_s (Simpson Dominance Index).

4 DISCUSSION

4.1 Taxa richness

Benthic macroinvertebrates collected in the Saigon River and its tributaries were characterized for the fresh water, the low brackish water, and the water pollution. Because of the even and flat terrain with very low slop, the tides from East Sea came up to near the Dau Tieng Dam [2, 3], and these records was expressed clearly through the appearances of marine and estuaries species such as families Nephthyidae, Nereidae, Sabellidae (Polychaeta); and families Corophiidae, Anthuridae, Corallanidae, Alpheidae (Crustacea). The species indicated for rich nutrient and organic pollution occurred widely in all sites with high frequency, including the species of *Nephtys polybranchia*, *Micropodarke* sp., *Diopatra neapolitana*; most of species Sedentaria – Polychaeta; and, all species of Oligochaeta and Chironomidae. While, the species of Nereidae (Errantia – Polychaeta); Gomphidae (Odonata); and, Ecnomidae (Trichoptera) were sensitive species with impacts of environmental pollution.

The human activities have influenced strongly on the taxa richness and abundance of benthic macroinvertebrate. The highest taxa richness was recorded in the sites far from industrial parks, crowded citizen areas, big cities (SG1 and SG2) while the sites in near urban Ho Chi Minh City and Thu Dau Mot Town or industrial areas (the section of Saigon River from SG6 to SG13) where had the low taxa richness because of the more human activities. Especially, there was not any animal that was collected in the site SG7 because of too heavy pollution.

The species indicated for acid sulfate water appeared more in sites from SG3 to SG8, including the species of Thiaridae, Viviparidae, Baetidae, Belostomatidae, Philopotamidae, Culicidae, Heleidae.

4.2 Abundance

The changes of abundance and dominant species at 16 sites expressed clearly the environmental characteristics of the Saigon River and its tributaries, and the number of individuals tended to increase in urban and industrial sites, where more organic pollution.

The dominant species composition had the high similarities among the site groups. The oligochaete species of *Limnodrilus hoffmeisteri* and *Branchiura sowerbyi* indicated for the organic pollution were the dominant species in almost sites.

4.3 Bio-indice analysis

Generally, the bio-index values of benthic macroinvertebrates had the homogenous changes in the completely studied area. The values tended to decrease in the urban and industrial sites with high turbidity. The results were suitable for the analysis of benthic macroinvertebrates communities.

The bio-index analysis proved that the biodiversity and stability of benthic macroinvertebrates communities tended to decrease in urban and industrial areas; this expressed the worsening water quality situation in the Saigon River and its tributaries. There is a good result in this monitoring, the water quality in the sites of SG9 (Nhieu Loc – Thi Nghe canal) and SG12 (Tau Hu – Ben Nghe canal) is much better than this five years before. The monitoring results of benthic macroinvertebrates in 2007 – 2010 showed that there was not any animal that was collected in the site SG9 and SG12 because of very heavy pollution [2, 3, 29].

5 CONCLUSION

The analysis of general characteristics of benthic macroinvertebrates and bio-indices were used to examine the spatial patterns of water quality and biological groups. Benthic macroinvertebrates collected in the Saigon River and its tributaries were characterized for the fresh water, the low brackish water, and the water pollution.

The value of good water quality was recorded in the sites far from industrial parks, crowded citizen areas, big cities (SG1 and SG2) while the sites in near urban Ho Chi Minh City and Thu Dau Mot Town or industrial areas (the section of Saigon River from SG6 to SG13) where had the value of worse water quality because of the more human activities. It expressed that the oligochaete species of *Limnodrilus hoffmeisteri* and *Branchiura sowerbyi* indicated for the organic pollution were the dominant species in almost sites. Especially, there was not any animal that was collected in the site SG7 because of too heavy pollution.

The bio-index values tended to decrease in the urban and industrial sites with high turbidity. The results were suitable for the analysis of benthic macroinvertebrates communities. The results demonstrated that these organisms could be applied to describe the ecological health in the Saigon River and its tributaries.

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