# CHAPTER 6

# DISCUSSION

## 6.1 Missing data

Loss of ASS commonly happens when using the ASS in water quality monitoring works. As mentioned in chapter 2, to compensate the loss of samples it is better to set extra samplers. However, this will increase the cost of the sampling program. Fulner (1971) and Roby *et al.* (1978) in their studies have also indicated the loss of samplers. Several extra samplers should be set at different depths especially in the sites where there is highly fluctuating water levels. In small streams, samplers must be placed out of danger of receding water levels, usually pools or areas with sluggish flow. Another problem that was encountered was the collapse of stream bank onto the samplers leading to burial. This happened at site ST 1 during wet season (see chapter 3). In each of the sites, sorting time was also increased due to the sediments and debris. Buried samplers collected a fauna differing from that of elevated samplers which collected drifting organisms. Buried samplers also altered the control of original substrate type and surface area.

## 6.2 Data transformation.

ANOVA is the statistical analysis method that enable the comparison of variances. Therefore to perform the statistical analysis, in this study researcher collected replicate samples for each treatment. Although, in order to perform ANOVA, the data should be normally distribute and there should not be significant difference between two variances.

Figure 13 and table 8 indicate that the raw data are not normally distributed and the variances are not equal. AS such, the raw data had to be transformed into several transformation methods such as Log n, Log10 and Square root. . However, only Log n

transferred data revealed there is no significant difference between variance. Therefore all statistical analysis performed after data were transformed to Log n.

## 6.3 Data standardization

Since the different sampling methods had different surface areas in order to standardize, the researcher converted abundance of animals into one square meter. Comparing the ASS with conventional methods which are based on different surface areas may result in under or overestimation of abundance. Because macroinvertebrates show patchy or clumped distributions rather than even distribution, it is difficult to standardize to unit area. Especially in the case of the Ekman grab, which had a small surface area (0.0225 $m^2$) the abundance may under or overestimated after standardization. Further considering Ekman grab, most of the samples are based on volume rather than surface area. But when calculating the abundance per unit area we do not consider the volume of the sample. This may affect the results for the Ekman grab sampler especially in muddy habitats where Annelids and Molluscs are highly abundant. For an example in this study in site SC 1 which had a thick layer of mud the Ekman grab samples contained more Annelids and Molluscs than were found using other sampling methods (Appendix table C 7- C 8).

## 6.4 Abundance and taxon richness of macroinvertebrates.

The highest number of animals per square meter in Ekman grab samples in dry season attributed to substrate availability. In dry season, most of the silt sedimented on the bottom. Considering ASS, WMC recorded highest number of animals in wet season. In the field, the WMC sampler caught large amount of drifting leaves and detritus on the wires of the cage. This leaf rich environment obviously attracted many macroinvertebrates providing extra niches. Further, highest abundance of macroinvertebrates in wet season can be explained by colonization of drifting animals.

Hynes (1975) suggested that the drift is composed of two distinctive faunal elements. the first consist of organisms carried away passively in any condition of illumination or current flow. The second group in the fauna is the true drift appeared to be influenced by variety of factors, such as abundance of animals, competition etc.. In the rainy season, there is a higher possibility to occur the first condition.

The second high abundance of animals recorded by the site IC 1 in wet season. In site IC1, no Hydropsychidae were found in the dry season, whereas 77 individuals were found in the wet season per unit sampler (Appendix A1-A2). Most of these Hydropsychidae considered to be drifted animals colonized in ASS. Site IC 1 located in irrigation canal and it passes through many agricultural lands leading contamination of pesticides with water. This supposition is strengthened by other similar findings such as Tuyor (1994), where he indicated that, pesticides and losses of microhabitat through siltation are the two primary factors that enhanced the drift of macroinvertebrates in lotic system.

The highest abundance of animals in site SC 1 in all sampling methods except MP sampler, can be explained by it's nature of the substrate. The substratum of the site SC1 mostly consists of mud due to abundant aquatic plants which has slowed-down the flow rate allowing high sedimentation. In addition, most of the silt was settled on ASS. This silt has been a suitable habitat for Annelids, and in this site they accounted for more than 70% from all ASS.

The reasons for the lack of regular abundance change patterns between sites in WB sample can not be explained. This may be due to some site specific factors. Unlike WMC or MP samplers, WB samplers do not provide a firm attachment place for some animals, and this may be a reason why some sites show low abundance of animals in the wet season.

The lower abundance of animals in conventional methods, especially in the Ekman grab, in all sites during the wet season suggest the flush off of the bottom

substrate. But this explanation is not valid for the stream sites since these sites sampled using Surber sampler. Because of the low water level and consequently aggregation of animals in small areas may collect high number of animals in dry season from Surber sampler.

## 6.5 Coefficient of variation (CV) in ASS

The CVs of the present study ASS lie in the range of 0.12 - 0.74. CV varies widely in reported studies on ASS. The CV ranged from 0.109 (Dickson *et al.*, 1971- limestone filled basket) to 0.849 (Dickson and Cairns, 1972- plastic webbing). One reason for the fluctuation of the CV among the sites is the accumulation of debris on ASS and microhabitat changes.

## 6.6 Comparison of efficiency of ASS and Conventional methods.

WB sampler showed a higher efficiency than the other two ASS in terms of animals colonized. The WB sampler provides a better refuge place than the other two ASS. Most of the silt and mud are accumulated in the WB which provided some habitats for specific animal groups, especially for Annelids and Chironomids. Cover *et al.* (1978) also stated oligocheates increased in number because of increasing sediments and algal growth on ASS. In addition, Coleoptera tend to feed on grass inside the box. In many occasions researcher observed crabs in side the WB. The presence of crabs can be attributed to their predatory and detritivorous feeding habit.

In this study, the researcher collected 56 animals from WMC filled with stones with 0.19$m^2$ effective colonizing area. Comparing the past studies, Roby *et al.* (1978) collected 102 animals from Wire mesh cage sampler filled with lime stones having 0.247 $m^2$ surface area. Fulner (1971) used basket sample filled with stones having

surface area 0.3m$^2$ and collected 511 animals. However, all of these studies have been carried out in temperate regions.

## 6.7 Natural substrate preference by macroinvertebrates.

Most of the families prefer leaf litter as their habitat. Leaf litter provides a better food source as well as refuge compared to other substrates. The interspaces between leaf litter provide diverse microhabitats by accumulation of silt, mud and sand. Pinder *et al.* (1987) in their study found greatest number of species from gravel and least number from soft sediment. Further they mentioned gravel as a suitable alternative substratum for many of the species which live on aquatic plants, and the interstices inevitably contain a quantity of fine sediment. Site ST4 recorded highest number of animals compared to other three streams in substrate preference study. Site ST4 located at down stream and it is consider to be slightly polluted because of the some pollutant inputs from the vicinity. Less number of families and large number of individuals from each family expected from down stream polluted sites.

## 6.8 Artificial substrate preference by macroinvertebrates.

Some macroinvertebrate families prefer to colonize in a specific type of ASS. Further they show temporal artificial substrate preference. Preference for particular ASS is highly related to their behavior, food habits and available microhabitat within the ASS. For example, Molluscs highly colonized the MP sampler because it gives optimum substrate for attachment compared to other ASS. Further, growth of algae on MP sampler increased the colonization of gastropods providing food sources. The preference for WMC by Trichopterans can be also attributed to their mode of life. Most cased Trichopterans use leaf litter, mud or stones to make their cases. These cases are mostly attached on stones . Annelids showed temporal pattern of colonization in all

ASS. Their abundance was higher in wet season than in dry season for all ASS. This tendency suggests that the accumulation of silt and leaf litter in the wet season provides an optimum habitat for them.

## 6.9 Colonization sequence in ASS

The determination of colonization sequence was partly successful due to increased water level and consequently high flow rate in week 3. Considered if colonization restarted from week 4, the maximum number of animals and taxa richness were recorded in week eight. This colonization period is longer than recorded in earlier studies. Using floating plastic webbing as an artificial substrate, Dickson and Cairns (1972) found a maximum number of species and total organisms in the 5$^{th}$ week. Using multiple plates as artificial substrates, Cover and Harrel (1978) found a high colonization in the 6$^{th}$ week. Roby *et al* (1978) found a high mean number of taxa per sampling unit in the 4th week using a basket with porcelain balls. However, the above studies have been carried out in temperate regions. Colonization sequence and efficiency may be different in tropical regions.

Water level and high flow velocity directly affect the colonization process. In all ASS, most of the families were lost in this critical period. For an example six families and 48 individuals left the WMC in this period. This can be attributed to the drifting of animals to down stream with high flow rate.

## 6.10 Evaluation of water quality using RBP (II) based on macroinvertebrates found in WB sampler and conventional methods.

It can be more accurate and clear if we consider several biological parameters instead of depending on a single parameter in water quality monitoring. Since RBP (II) involves several parameters, it is a useful tool to categorize water bodies according to their impairments.

Overall, RBP (II) performed well in this study, as it separated highly polluted sites such as SC1 and SC2, from rest of the sites. And also, it reflected, dilution of pollutant in the wet season as most of the impaired site in dry season changed to non-impaired condition in wet season.

One defect of this protocol to consider is selection of reference site, because allocation of point scores and final classification depend on the selected reference site. In some instances, for some parameters, reference site may also give lower scores. For an example metrics of taxa richness, BMWP score, ASPT value and number of EPT families recorded lower score for reference site (ST 3) than site IC 1.

## 6.11 Assessment of various indices used in RBP (II) for WB sampler and Conventional methods.

Most of the parameters individually and correctly represented water quality per sites. But some parameters do not represent particular sites. For example site ST4 was slightly impaired and IC1 moderately impaired in dry season. But both sites showed the same number of families. Further, site R 2 has a higher number of families even if it represent slightly impaired condition in the dry season. Generally, it is assumed that, higher the number of families better the water quality is.

If BMWP score and ASPT values are considered separately, higher values denote better water quality. But contradictory, site R1 shows higher BMWP and ASPT scores than other sites even site R1 is classified as a moderately impaired site. BMWP score is less efficient in this matrices. In the dry season, all of the sites except site SC2 received score six while in the wet season only site SC1 and SC2 received score 2 and zero.

In wet season site IC 2 shows highest numerical values for the most of the metric indices than reference site (ST 3). This is mainly due to the colonization of drifting animals in ASS. Though site IC 2 showed highest scores for indices than reference site ST 3, it was not be regarded as reference site because it did not fulfill some of reference site requirements such as low road and high way density, no known discharge or contaminants in place, low human population etc. (Suwanrat, 1996).

Considering RBP (II) scores for conventional methods , the number of EPT families do not work well. Stream sites which were sampled by Surber sampler show score 6 except site ST4 in the dry season, but sites where the Ekman grab was used as a sampling method received zero score in both seasons. This can be attributed to the sampling inefficiency of the Ekman grab. However, the index of EPT: Chironomids worked more or less precisely due to vast distribution pattern and abundance of Chironomids.

The water quality results obtained from WB sampler and conventional methods differed somewhat in the wet season especially in sites sampled using the Ekman grab. Further this confirmed the sampling inefficiency of the Ekman grab in the wet season. To get representative samples from the Ekman grab, there should be a muddy bottom substrate in the sampling sites. However, in the wet season because of the high flow rate followed by increased water level most of the bottom substrate was flushed away making sampling by the Ekman grab inefficient. However, for the WB sampler, these physical conditions benefited by more colonization of animals. In the wet season most of the drifted animals tend to colonize the WB sampler.

Suwanrat (1996) tested RBP (II) for the same study sites using kick or pond net as sampling methods. Comparing the results of the present study and her study shows some contradictions. For example while in the present study site ST1 (in her study site S2) has been classified as slightly impaired, but she classified it as a non impaired site. This dissimilarity is mainly due to the sampling methods used for collecting macroinvertebrates. Further, this suggests that standardized sampling using ASS. The efficiency and accuracy of sampling by pond nets entirely depends on operator effort, and one can not eliminate the selectivity of habitat when using pond nets. As she met several problems with sampling methods, she recommended use of artificial substrate or dredge in deeper sites instead of pond nets.

Throne (1993) also encountered the same problems in water quality assessment using RBP (II). He used both dredge sampler and artificial substrates (biological filter media). He mentioned the inefficiency of the dredge sampler for collecting macroinvertebrates. In his study, 7 families found in the artificial substrate were not captured by the dredge, but only one family was captured by dredge. He suggested that this inefficiency is mainly due to the absence of natural habitats or the small samples supplied by the dredge or maintenance of hard substratum by the high flow rate. Further he suggests adjustment of some quality point ranges to obtain accurate water quality. For Thailand there is a need to modify some indices to fit local situations. BMWP and tolerance values for family biotic index should be adjusted locally, especially for the families Baetidae and Hydropsychidae.

Clustering of macroinvertebrates found in WB sampler, grouped pollutant tolerant families with pollutant sensitive families. This can be attributed to colonization of drifted animals in WB sampler, provision of diverse microhabitat, and change of original substrate type of WB sampler by sedimentation of silt and accumulation of debris.

Keys used to identify macroinvertebrtes in the present study are mainly based on temperate regions (see chapter 4). So far no complete keys are available for Asia region. This may lead to the misclassification of certain families.

## 6.12 Comparison of results of chemical and biological water quality monitoring

Chemical monitoring was carried out in same study sites in same time period (Napathlung, unpublished data). Most of the sites show same results for biological and chemical water quality monitoring. For an example in wet season, sites ST 1 and ST 3 show extra clean condition from chemical monitoring and from biomonitoring the same sites show Non impaired condition. These extra clean and non impaired terms more or less give same meaning. However, some sites also show contradictory results. For an example in dry season, site IC 1 shows extra clean condition in chemical monitoring while from biomonitoring it shows moderately impaired condition. These two terms in the sense of pollution are very different. This is one of the demerit in chemical monitoring methods. Because in chemical monitoring, time of sample taken is very important and it highly effects to water quality evaluation. Concentration of pollutants in receiving water fluctuates widely and rapidly due to flow rates and physical condition of the water body. But biomonitoring methods does not simply indicate the condition prevailing at the sample taken. The organisms which live in water reveals present as well as past water condition.

The contradictory results from biological and chemical monitoring for site IC 1 could be attributed to the fact that the water flow of the irrigation canal is artificially controlled and if samples are taken at the time of high flow rate pollutant may be diluted or washed away. In such a situation, water quality can be over or under estimated.

Further, chemical analysis only reveal the presence of the substances which the analysis is specifically designed to detect (Abel, 1989). If pesticides analysis is also carried out for the some sites especially irrigation canal sites, water quality assessed by chemical monitoring will show varied results.