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A Comprehensive Analysis on the Dynamics of Biodiversity and Bitan-ag Creek Watershed Interactions: Ecosystem Approach for Rehabilitation

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Abstract

The study dealt with the dynamics of biodiversity and watershed interactions of Bitan-ag Creek in Cagayan de Oro City, Philippines mainly for rehabilitation. Specifically, this study assessed a) the diversity of agroforest species in the watershed and their ecological status and economic importance; b) the composition of phytoplankton species diversity in the watershed as biological indicator for water pollution; and c) the condition of the soil in the upper and middle stream sections in the watershed. Standard protocols were followed in the methodology in measuring diversity of species, phytoplankton species composition and in performing soil tests.

General findings include identification of forty one floral species in the urban landscape and watershed of the Cagayan de Oro City, classified as economically important (e.g. Crysophyllum cainito, Sandoricum koetjape), endemic (e.g. Muntingia calabura, Macaranga bicolor), and rare species (e.g. Lygodium circinnatum, Pneumatopteris nitidula). The phytoplankton communities were dominated by genus Nitzchia and Navicula in the middle stream section, and Microsystin auruginosa and Nitzchia species in the lower stream section. These species are pollution-tolerant and are known to release red-tide causing toxins which are major causes of fish kills. Soil tests showed a very good range of soil pH values (6.8 – 7.36), which are appropriate for agriculture and cash crops. For both the middle and upper stream sections, the Nitrogen Phosphorus Potassium (NPK) content was moderately high and appropriate for crops.

Keywords: biodiversity; watershed interactions; rehabilitation

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1. Introduction

Biodiversity is one of the foundations of healthy and functioning ecosystems, which form the basis for human livelihoods (Amoroso *et al.*, 1999). Rich soils, clean air and water, abundant forests – the complexity of nature and the myriad species it supports are essential to maintain stable and thriving societies (Miller, 2000). One important aspect in understanding the ecosystem landscape is plant species composition. Species vary in their general characteristics, abundance, distribution, trophic requirements or ecological role; therefore it is important to understand the most important species and their role for designing strategies for conservation and restoration. It is a fact that there are species performing very important roles in their respective habitat, and if its population decreases, there would be a marked effect on other species (SEAMEO-SEARCA & RAWOO NDARC, 2000). This study on biodiversity assessment of upper Camaman-an, Cagayan de Oro City, and the plankton analysis in an urban creek in Cagayan de Oro City were conducted in the context of their ecological roles.

There are six identified creeks in Cagayan de Oro City, Philippines. Bitan-ag Creek is part of the local ecosystem-biodiversity landscape and is the longest and most polluted of all the creeks. This creek passes through Barangay Camaman-an, down to Agora, Lapasan. These are urban barangays in Cagayan de Oro City which show trends of growing human population. In the words of one resident, the creek used to be a small stream with flowing potable freshwater. The current condition of the creek is the result of anthropogenic activities, namely the introduction of factory effluents and city sewerage effluent. This further increases the pollution in Macajalar bay, affecting the marine ecosystem.

Biodiversity of species associated with the creek watershed provides the basis for a functioning ecosystem, buffering change and conferring resilience over all levels of biological organization. Miller (2000) stated that many direct and indirect benefits of biodiversity include all the resources and processes required for human existence, including oxygen production, pollination, global climate control, water filtration and storage by wetlands and soil conservation and fertility. These are all benefits of the biological diversity on Earth.

While loss of biodiversity in the Bitan-ag Creek may have partially contributed to higher incidence of flooding, soil erosion, clogging of drainage, encroachment of marine water on freshwater systems, among others, this study was a suitable and timely endeavor due to the urgency of appropriate rehabilitation measures in the aforementioned area as well as in the tributaries of the watershed. The study aimed to support research on restoration measures involving the use of vegetation, engineering structures, or a combination of both.

The objectives of the study were the following: (1) to assess the floral diversity species naturally grown and cultivated in the watershed and their ecological uses and distribution; (2) to identify the composition of phytoplankton species in the watershed creek as bio-indicator for water pollution; and (3) to determine the soil condition in the upper and midstream sections of the watershed.

2. Methodology

2.1 The Watershed Research Sites

The whole study area was located at Barangay Camaman-an in the southeastern part of Cagayan de Oro City, Philippines as shown in Figure 1. However, the main stream section of the Bitan-ag creek was reached after a 45 minute hike from Barangay Upper Camaman-an, Cagayan de Oro City on poor roads and steeply sloped terrain. The survey and an ocular inspection of the research site were done through field reconnaissance by the research team.

2.2 Assessment of Biodiversity: Standard Processes and Procedures

The collection of trees, shrubs, herbs, ferns and vines was conducted in the upper stream section, situated in Upper Camaman-an and in the middle stream section in Tierra del Puerto. A total of two 10 x 20 m sampling plots were established for each stream. The plots were laid out and delineated using nylon cords and stakes in each corner. A compass was used to straighten the line of plots and a Global Positioning System (GPS) device was used to determine the exact elevation and location of the sampling plots.

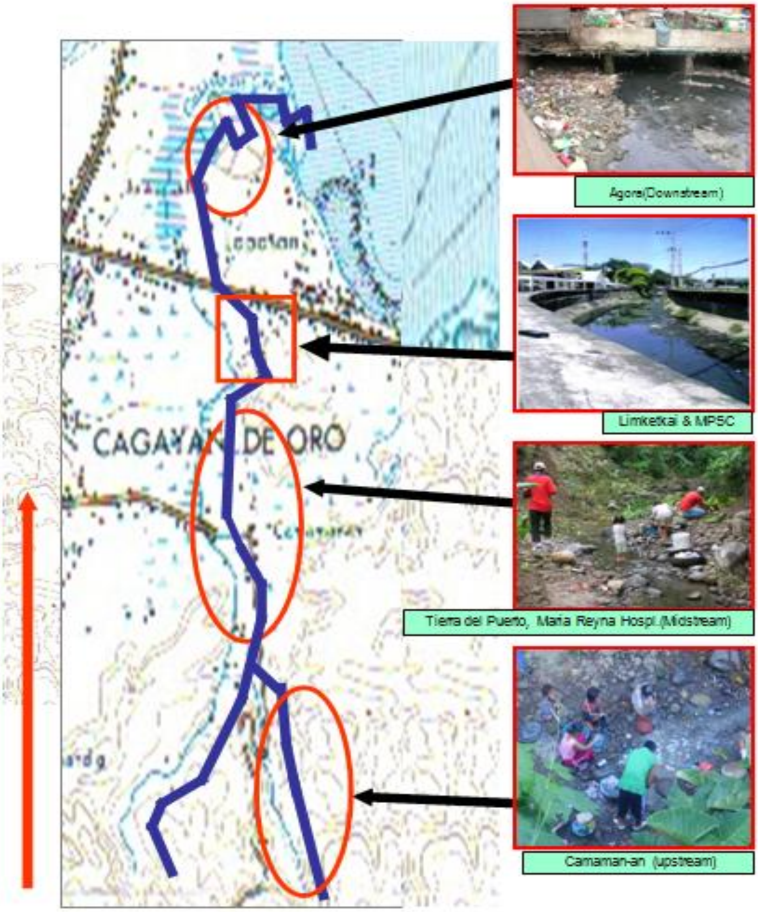

Figure 1. Bitan-ag creek research site

2.3 Plankton Analysis

2.3.1 Sample Collection (Grab Sampling)

The sample bottle was filled with water at the surface (horizontal sampling) in the sampling area and the samples were taken to the laboratory for analysis. The samples were examined using a compound microscope under a high-power objective. The counting was performed in a Sedgewick-Rafter Counting Chamber, and the cells were counted at specified strips designed specifically for the quantitative measurement of the exact number of planktons in a precise volume of a fluid.

2.4 Collection and Preparation of Soil Test Analysis

Soil samples were collected for physico-chemical analysis which include pH, percentage Organic Matter content (OM), percentage Phosphorus (% P), percentage Potassium (% K), as well as soil texture.

2.5 Computation of Diversity Parameters

The assessment of diversity parameters like density, relative density, frequency, relative frequency, dominance, relative dominance, species importance value and Shanon's Index of diversity were computed using the standard formulas as cited by Amoroso *et. al.*, (2006).

3. Results and Discussion

3.1. Floral Species Identified

Table 1 presents the plant species composition along Bitan-ag Creek that are grouped into five categories: trees, shrubs, herbs, ferns and vines. In terms of species richness, a total of forty one floral species were recorded from sampled plots and from a transect walk in Bitan-ag Creek, Cagayan de Oro City. Twenty-two species were trees, seven were shrubs, six were herbs, three were ferns, and three species of vines. The established plots revealed a total of thirty five floral species in the upper stream while the middle stream is composed of thirty floral species. To name a few, tree species identified in the upper stream include *Crysophyllum cainito* (caimito), *Sandoricum koetjape* (santol) while shrubs include *Morinda cetriifolia* (bangkoro), *Melanolepis multiglandulosa* (alim). Examples of herbs species noted in the upper stream are *Chromolaena odorata* (hagonoy) and *Iresini herbstii* (dugo-dugoan). *Lygodium circinnatum* (nito) and *Pneumatopteris nitidula* (maeiden hair) are examples of ferns found in the upper stream. Examples of vines found in the area include *Pandanus cubicus* (pandan) and *Calamus ornatus* (oway). Examples of floral species recorded in the middle stream include: Tree species - *Ficus minahassae* (baliti) and *Acalypa amentacaeae* (bogus); Shrubs species – *Ficus cumingii* (baliti) and *Psidium guajava* (bayabas); Herbs species – *Lantana camara* (baho-baho) and *Amaranthos spesiousos* (kolites); Fern species – *Adiantum capillus-vebeneris* (fern). There was no plot established in the lower stream of the Bitan-ag Creek because the area was mostly occupied by human settlements.

Table 1. Floral species richness in upper stream and middle stream sections of Bitan-ag creek, Cagayan de Oro City

Scientific Names	Common Name	Upper Stream	Middle Stream
A. Trees			
Crysophyllum cainito	Caimeto	x	x
Sandoricum koetjape	Santol	x	x
Ficus septica Burm. F.		x	x
Ficus sp.		x	
Ficus minahassae	Baliti	x	x
Ficus pseudopalma		x	
Acalypa amentacaeae	Bogus	x	x
Muntingia calabura	Datiles	x	x
Cananga odorata	Ilang-ilang	x	x
Spathodea campanulata.	African tulip	x	x
Persia americana	Avocado	x	x
Artocarpus blancoi	Antipolo	x	x
Artocarpus heterophyllus	Langka	x	x
Cocus nucifera	Lubi	x	x
Polyschias nodosa	Malapapaya	x	x
Pterocarpus indicus	Narra		x
Macaranga bicolor		x	
Bambusa sp.	Kawayan	x	x
Mangifera indica	Mangga	x	x
Laportea sp.	Alingatong		x
Pinanga sp.	Palm	x	x
Canna sp.	Centennial plant		x
B. Shrubs (7)			
Morinda cetriifolia	Bangkoro	x	x
Melanolepis multiglandulosa	Alim	x	x
Ficus cumingii	Baliti	x	x
Psidium guajava	Bayabas	x	x
Sterculia sp.	Tambalau	x	
Bauhinia malabarica		x	x
Coffea arabica	Kape	x	x
C. Herbs			
Chromolaena odorata	Hagonoy	x	x
Iresini herbstii	Dugo-dugoan		x
Memusa pudica	Makahiya	x	x
Lantana camara	Baho-baho	x	x
Amaranthos speciousos	Kolites	x	x
Corchorus acutangulus	Saloyot		x
D. Ferns			
Lygodium circinnatum	Nito	x	
Pneumatopteris nitidula	Maidenhair fern	x	
Adiantum capillus-vebeneris			x
E. Vines			
Pandanus sp.	Pandan	x	
Pandanus cubicus	Pandan	x	
Calamus ornatus	Oway	x	
		Total: 35	Total: 30

Legend: (x) present; ( ) absent

Higher species richness recorded in the upper stream can be attributed to lesser disturbance and minimal anthropogenic activities since human habitation is less observed in the area as compared to the middle and lower streams.

3.2 Floral Species Identified and their Corresponding Economic Importance and Ecological Status

Table 2 is a list of plant species collected along the creek with their respective ecological and economic importance as well as their ecological status (common, endemic, rare or depleted). Most species of plants in the 5 categories were rated common, and very few were rated endemic and rare. In terms of ecological or economic importance, all of the species listed have their respective value (food, medicinal, water indicator, lumber and light construction material or ornamental). A few others serve as food for birds and other fruit-eating mammals.

3.3 Tree Profile in the Upper Stream Stations

Tree profile diagrams are shown in Figures 2 to 5, indicating the types and distribution of height of each species in the 5 x 20 m belt transects. Likewise, all the specimen seen were numbered on the map and other relevant data such as altitude, gradient and crown cover were noted. Figure 2 shows the tree profile diagram in the upper stream section. It can be seen that in the 10 m x 20 m transect belts established, the tree species composition was varied, which may imply that the existing soil conditions still favor the growth of many species.

Figure 3 shows the different heights reached by the tree species growing along the upper stream sections. It can be seen that few trees reached a height of 20 m, and most of these reached 5 to 10 m height. This suggests that trees do not attain maximum height due to human interventions, like extraction of trees for firewood or lumber, or land clearing for crops.

The crown cover of trees as shown in Figure 4 indicates that coconuts are more dominant than the other species identified. This would mean that coconut is favored by the residents along the creek. Figure 5 shows the distribution of trees in the middle stream section of Bitan-ag Creek, which shows the growth of different species as counted and identified in the transect belts established.

Table 2. Floral species of Bitan-ag creek and their corresponding ecological status and economic importance

Species	Common Name	Ecological Uses	Ecological Status
A. Trees			
Crysophyllum cainito	Caimeto	Economically important	Common
Sandoricum koetjape	Santol	Economically important	Common
Ficus septica Burm. F.		Water indicator	Common
Ficus sp.		Water indicator	Common
Ficus minahassae	Baliti	Water indicator	Common
Ficus pseudopalma		Water indicator	Common
Acalypa amentacaeae	Bogus		Common
Muntingia calabura	Datiles	Wildlife food	Common
Cananga odorata	Ilang-ilang	Medicinal	Endemic
Spathodea campanulata.	African tulip	Medicinal	Common
Persia americana	Avocado	Economically important	Common
Artocarpus blancoi	Antipolo	Lumber and Furniture	Endemic
Artocarpus heterophyllus	Langka	Economically important	Common
Cocus nucifera	Lubi	Economically important	Common
Polyschias nodosa	Malapapaya		Common
Pterocarpus indicus	Narra	Economically important	Common
Macaranga bicolor			Endemic
Bambusa sp.	Kawayan	Economically important	Common
Mangifera indica	Mangga	Economically important	Common
Laportea sp.	Alingatong	Wildlife food	Rare
Pinanga sp.	Palm	Ornamental	Common
Canna sp.	Centennial plant	Ornamental	Common
B. Shrubs			
Morinda cetriifolia		Medicinal	Common
Melanolepis	Bangkoro		Common
multiglandulosa	Alim	Economically important	Common
Ficus cumingii	Baliti	Economically important	Common
Psidium guajava	Bayabas	Lumber and furniture	Common
Sterculia sp.	Tambalau	Ornamental	Ornamental
Bauhinia malabarica		Economically important	Common
Coffea arabica	Kape		
C. Herbs		Medicinal	Common
Chromolaena odorata	Hagonoy	Medicinal & ornamental	Common
Iresini herbstii	Dugo-dugoan		Common
Memusa pudica	Makahiya	Ornamental	Common
Lantana camara	Baho-baho	Edible	Common
Amaranthos speciousos	Kolites	Edible, medicinal	Common
Corchorus acutangulus	Saloyot		
D. Ferns		For handicraft making	Rare
Lygodium circinnatum	Nito		
Pneumatopteris nitidula			
E. Vines		Food flavoring	Common
Pandanus sp.	Pandan	For	Common
Pandanus cubicus	Pandan	For furniture	Depleted,
Calamus ornatus	Oway		endemic

Sources: Madulid (2006) and LaFrankie (2010).

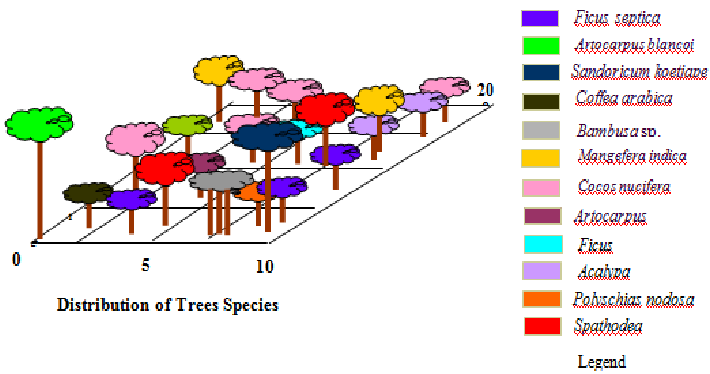

Figure 2. Tree profile diagram in the upper stream section of Bitan-ag creek

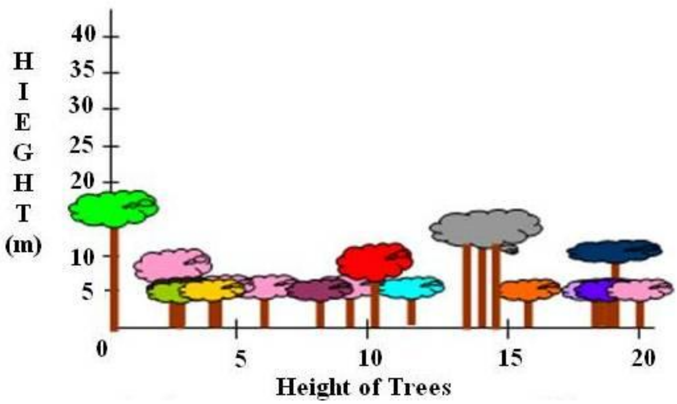

Figure 3. Height of trees in the upper stream section of Bitan-ag creek

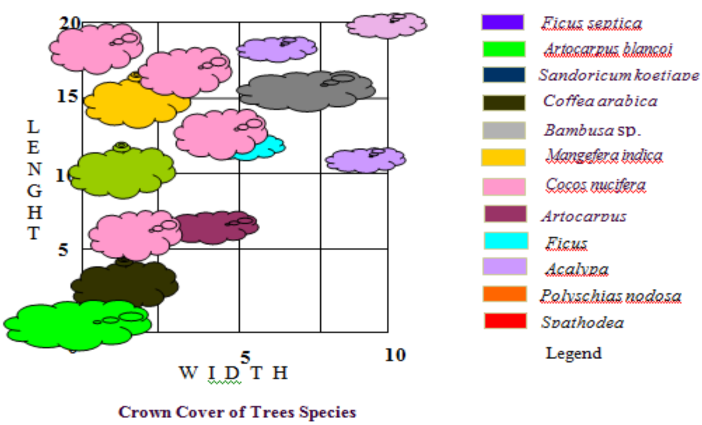

Figure 4. Crown cover of trees in the upper stream section of Bitan-ag creek

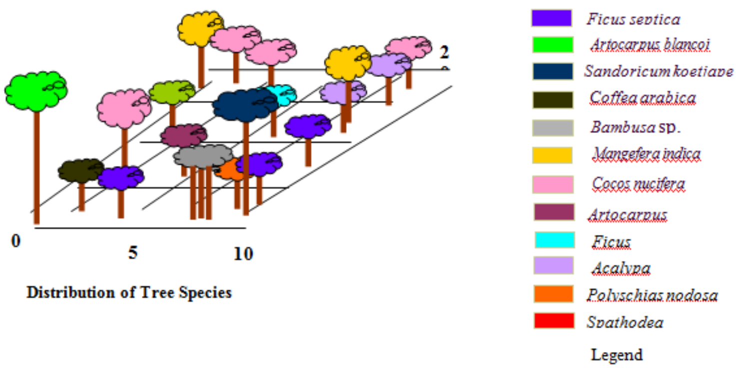

Figure 5. Distribution of trees in the middle stream section of Bitan-ag creek

In terms of tree height, some trees in the middle stream portions were able to grow to 10 to 20 m height, and there are fewer trees in the 5 to 10 m category. This may imply that there were more residents along the creek that cut trees than in the upper stream section, which further supports the hypothesis that trees generally do not attain their maximum growth because of higher population rates in the middle stream portion.

Regarding crown cover of trees in the middle stream, coconut was still dominant, followed by *Ficus* species. The crown cover in general was not as dense as it appears in Figure 4 because coconuts have less wide crowns than most trees identified.

3.4 Findings on Soil Test Analysis in the Upper Stream and Middle Stream Sections

The soil and the soil communities are very important components for the protection of our natural ecosystem. Investigating the soil properties and their relationship to soil microorganisms' diversity will therefore help us move towards truly sustainable land use, thus helping in the protection of the watershed and its natural ecosystem.

Table 3 shows the eight soil sampling sites that is composed of upper stream and midstream areas in the Bitan-ag Creek with three sites in Camaman-an: Tierra del Puerto, Tipolohan and Dongallo. In each location a sampling site was established, and soil samples were collected for soil tests which included tests for pH, OM and total Nitrogen (N), Phosphorus (P), and Potassium (K).

Table 3. Soil test data of Bitan-ag creek

Field/Area	% OM	% P ppm	% K Ppm	pH
A. Tierra del Puerto Creek Bed Site (Upstream)	3.7 Medium	87 High	500++ Sufficient	6.78
B. Tierra del Puerto Creek Bank Site (Upstream)	0.8 Low	32 High	360 Sufficient	6.81
C. Tierra del Puerto Creek Side, 1m from Water (Upstream)	0.3 Low	26 Medium	320 Sufficient	6.99
D. Tipolohon Site, Creek Bed (Upstream)	0.6 Low	5 Low	200 Deficient	7.34
E. Dongallo Hilltop Area Creek Bank – Culbert (Midstream)	2.7 Medium	22 Medium	139 Deficient	7.12
F. Tipolohon Site, Creek Bank (Upstream)	1.2 Low	15 Medium	616 Sufficient	7.17
G. Tipolohon (Upstream)	2.9 Medium	36 High	413 Sufficient	6.91
H. Dongallo Hilltop Area Creek Bed (Midstream)	2.2 Medium	77 High	500++ Sufficient	7.36

Source: Bureau of Soils Region X, August 2006

The results revealed that the majority of the soil in the upper stream and midstream sections of the Bitan-ag Creek is composed of sandy loam and clay loam soils that are generally considered agricultural soil. The pH values ranged from 6.78 – 7.36 (close to neutral), suitable for agricultural and cash crops. The upper and middle stream sections were also dominated by coconuts, bananas and *Gmelina* species, which serve as an indicator for water quality and soil fertility.

3.5 Findings on the Composition of Phytoplankton Species in Bitan-ag Creek as Bioindicators for Water Pollution

3.5.1 Phytoplankton Species Identified in the Upper Stream of Bitan-ag Creek

Study revealed a total of four phytoplanktons species present in the upper stream of the creek. These organisms include *Chodatella sp.*, *Pleurosigma* *navicilaceum, Gomphonema sp., and Spirogyra sp.* The organisms observed in the area occur naturally in clean water and are thought to be sensitive to heavy metals and pollution. The dominance of the aforementioned species was an indication that the upper stream of Bitan-ag Creek is still free from pollution.

3.5.2 Phytoplankton Species Identified in the Middle Stream of Bitan-ag Creek

The following phytoplankton species namely: *Gomphonema sp.; Chlorococcum sp.; Pediastrum duplex; Nitzchia sp.; Navicula sp.* were found in the middle stream of the creek. Of the four species noted in the area, the dominant species were the *Nitzchia sp.; Navicula sp.*. These species are believed to inhabit eutrophic waters. The appearance of these microorganisms indicates that the water in the middle stream is polluted.

3.5.3 Phytoplankton Species Identified in the Lower Stream of Bitan-ag Creek

Eight species of phytoplanktons were noted in the lower portion of the creek namely: *Chlorella* sp.; *Microcystis aeroginosa*: *Eunotia exigua; Nizschia sp.; Nostoc; Anabaena sp.; Pleurosigma falx; Prorocentrum compressum. Microcystis aeroginosa* species is known to produce a toxin and was the causative agent of several fish kills. It produces hepatotoxic cyclopeptides (microcystins). *Chlorella* sp. has no known toxin released but is pollution tolerant species. *Eunotia exigua* are tolerant of acidic environments. The presence of this *Nizschia* species indicates that the water is polluted and eutrophic. The appearance of these species would indicate that the water in the lower stream of Bitan-ag Creek is polluted. *Anabaena* species are known to produce hepatotoxins. *Pleurosigma falx* is found in very dirty waters. *Prorocentrum compressum* is toxic if algal blooms occur (red-tide causing dinoflagellate).

The lower stream of Bitan-ag Creek is dominated by *Microcystis aeruginosa*, *Nitzschia* sp., *Procentrum sompressum* and *Nostoc* sp., which are pollution-tolerant species of phytoplankton. These species are also known to release toxins which are the major cause of fish kills.

4. Conclusion and Recommendation

Based on the foregoing findings, this study in Bitan-ag Creek revealed that there are 32 common species. The species identified included 19 economically important species, 10 ornamental species, 4 endemic species, 2 rare species and 1 endangered species. These findings recommend immediate conservation, protection and replanting of agroforest crops in the urban environment.

The composition, population, abundance and distribution of plankton/phytoplankton as bio-indicator of water pollution varies from one stream to the other and also vary horizontally, vertically, seasonally and depends on light availability. This was revealed when *Nitzchia sp.* and *Navicula sp.* of phytoplankton dominated the middle stream and *Microcystis aeruginosa* and *Nitzchia sp*. in the downstream sections. These are pollution-tolerant species and were known to release red-tide causing toxins which are a major cause of fish kills. This recommends another phytoplankton analysis, specifically focusing on abundance and distribution in the downstream section affecting seasonal variations in light availability, temperature and nutrient load as well as herbivory by zooplankton.

The soil tests revealed that from middle stream section going upstream, the soil along the Bitan-ag Creek generally showed a very good range of soil pH values from 6.78-7.36. These values are appropriate for agricultural and cash crops. The percentage of organic matter and the nitrogen content were sufficient, the phosphorus content was moderately high and the potassium content was sufficient. In the downstream portions of the Bitan-ag Creek number of plant species decreased due to high incidence of soil acidity. Hence, it is recommended that periodic soil tests be conducted.

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