

Ecological Studies on Togyo Reservoir in Chulwon, Korea VI. The List of Phytoplankton and Periphyton

Kyung Lee* and Sook-Kyung Yoon

Department of Life Science, The Catholic University of Korea, Puchon 420-743, Korea

The composition of phytoplankton and periphyton community in Togyo reservoir was investigated. A total of phytoplankton was composed of 150 taxa, belonging to 6 phyla, 8 classes, 15 orders, 5 suborders, 31 families, 71 genera, 106 species, 14 varieties, 1 form and 29 unidentified species. The observed number of diatoms and green algae were much higher than others. Within diatoms the pennate diatoms appeared more than centric diatoms and solitary forms or colonial forms appeared more than filamentous forms in green algae. A total of epipelagic algae was composed of 125 taxa, belonging to 3 phyla, 3 classes, 6 orders, 3 suborders, 13 families, 30 genera, 87 species, 29 varieties, 2 forms and 7 unidentified species. The diatoms appeared much more than others. Among those, the pennate diatoms dominated the centric diatoms in species number observed. A total of epilithic algae was composed of 114 taxa, belonging to 4 phyla, 4 classes, 11 orders, 3 suborders, 22 families, 38 genera, 79 species, 8 varieties, 1 form and 26 unidentified species. The observed number of diatoms and green algae were much higher than others. Within diatoms the pennate diatoms dominated the centric diatoms in species number observed. The dominance of pennate diatoms of the diatom community in the epipelagic algal community and the epilithic algal community could be assumed that was due to the presence of raphe structure of pennate diatoms.

Key Words: periphyton, phytoplankton, Togyo reservoir

INTRODUCTION

In freshwater ecosystem there are some components of the biotic community. Among those, primary producer is more important component of the biotic community rather than secondary producer and carnivore because of the first one of the lowest trophic structure of aquatic ecosystem. Due to the habitat of primary producer they could be divided into the phytoplankton and the periphyton (or benthic algae), and the periphyton could be also divided into epiphytic algae which may grow on plant leaves and stems, epilithic algae which may grow on stones and rock surfaces, epizoic algae which may dwell on animal, for example, copepods, fish or even on whales, epipelagic algae which may grow on sediment surface, for example, mud surface and psammion which may grow or attached to sand grain (Round, 1973).

Since Han *et al.* (1995) revealed the general features of Togyo reservoir for the further ecological studies, some ecological studies have been made (Lee *et al.* 1996; Lee *et*

al. 1998; Han *et al.* 2002; Lee *et al.* In submitted). However the checklist of phytoplankton and periphyton community have not been reported but only the epipelagic algae among the periphyton community has been studied (Lee *et al.* 1997).

The aim of this study is to elucidate the composition of the phytoplankton and periphyton community in Togyo reservoir which is situated within the Civilian Passage Restriction Line close to Demilitarized Zone (DMZ) and therefore which has not been influenced by human activities or agricultural and industrial wastes from surrounding areas.

MATERIALS AND METHODS

Phytoplankton samples were collected monthly from April 1995 to May 1996 and periphyton samples (epipelagic algae) were collected monthly from April to December 1996 and also periphyton samples (epilithic algae) were collected monthly from May to December 1996 and from May to July 1999. Among the suitable substrata of periphyton communities, we could not collect the sufficient specimen for the epiphytic algae, the epizoic

*Corresponding author (lkay@catholic.ac.kr)

Table 1. The list of phytoplankton in Togyo reservoir in 1995 and 1996

Phylum Cyanophyta	Family Peridiniaceae
Class Myxophyceae	Genus <i>Peridinium</i>
Order Chroococcales	<i>Peridinium cinctum</i>
Family Chroococcaceae	<i>Peridinium inconspicuum</i>
Genus <i>Chroococcus</i> (소구체 속)	<i>Peridinium</i> sp.
<i>Chroococcus dispersus</i>	Family Ceratiaceae
<i>Chroococcus gitanteus</i>	Genus <i>Ceratium</i> (뿔말 속)
<i>Chroococcus minor</i>	<i>Ceratium hirundinella</i>
<i>Chroococcus</i> sp.	
Genus <i>Dactylococcopsis</i>	Phylum Chrysophyta
<i>Dactylococcopsis</i> sp.	Class Xanthophyceae
Genus <i>Gomphosphaeria</i>	Order Heterococcales
<i>Gomphosphaeria</i> sp.	Family Characiopsidaceae
Genus <i>Merismopedia</i>	Genus <i>Characiopsis</i>
<i>Merismopedia tenuissima</i>	<i>Characiopsis</i> sp.
Genus <i>Microcystis</i>	Family Gloeobotrydaceae
<i>Microcystis</i> sp.	Genus <i>Gloeobotrys</i>
Genus <i>Synechococcus</i>	<i>Gloeobotrys limneticus</i>
<i>Synechococcus eximus</i>	Family Centritractaceae
Order Pleurocapsales	Genus <i>Centritractus</i>
Family Pleurocapsaceae	<i>Centritractus belanophorus</i>
Genus <i>Xenococcus</i>	Class Bacillariophyceae
<i>Xenococcus acervatus</i>	Order Centrales
	Suborder Coscinodisceneae
Phylum Cryptophyta	Family Thalassiosiraceae
Class Cryptophyceae	Genus <i>Aulacoseira</i> (대롱돌말 속)
Order Cryptomonadales	<i>Aulacoseira ambigua</i>
Family Cryptomonadaceae	<i>Aulacoseira granulata</i>
Genus <i>Cryptomonas</i>	<i>Aulacoseira granulata</i> v. <i>angustissima</i>
<i>Cryptomonas</i> sp.	Genus <i>Cyclotella</i> (단추돌말 속)
	<i>Cyclotella comta</i>
Phylum Euglenophyta	<i>Cyclotella meneghiniana</i>
Class Euglenophyceae	<i>Cyclotella pseudostelligera</i>
Order Euglenales	<i>Cyclotella</i> sp.
Family Euglenaceae	Family Coscinodiscaceae
Genus <i>Euglena</i> (유글레나 속)	Genus <i>Coscinodiscus</i> (채돌말 속)
<i>Euglena</i> sp.	<i>Coscinodiscus</i> sp.
Genus <i>Phacus</i>	Family Rhizosoleniaceae
<i>Phacus</i> sp.	Genus <i>Rhizosolenia</i> (관돌말 속)
Genus <i>Trachelomonas</i>	<i>Rhizosolenia eriensis</i>
<i>Trachelomonas dybowskii</i>	Suborder Biddulphineae
<i>Trachelomonas lefevrei</i>	Family Biddulphiaceae
<i>Trachelomonas oblonga</i>	Genus <i>Acanthoceras</i> (가시돌말 속)
<i>Trachelomonas pusilla</i>	<i>Acanthoceras zachariasii</i>
<i>Trachelomonas similis</i>	Order Pennales
<i>Trachelomonas volvocina</i>	Suborder Araphidineae
<i>Trachelomonas volvocina</i> v. <i>punctata</i>	Family Diatomaceae
	Genus <i>Asterionella</i> (별돌말 속)
Phylum Dinoflagellata	<i>Asterionella formosa</i>
Class Dinophyceae	Genus <i>Diatoma</i> (막돌말 속)
Order Gymnodiniales	<i>Diatoma</i> sp.
Family Gymnodiniaceae	Genus <i>Fragilaria</i> (김발돌말 속)
Genus <i>Gymnodinium</i>	<i>Fragilaria brevistriata</i>
<i>Gymnodinium</i> sp.	<i>Fragilaria crotonensis</i>
Order Peridinales	<i>Fragilaria construens</i>

(Continued)

Table 1. (Continued)

<i>Fragilaria lapponica</i>	<i>Navicula salinarum</i>
Genus Licmophora (민부채돌말 속)	<i>Navicula capitata</i>
<i>Licmophora ehrenbergii</i> f. <i>grunowii</i>	<i>Navicula meniscula</i> v. <i>upsaliensis</i>
Genus <i>Rhabdonema</i> (토막돌말 속)	<i>Navicula cryptocephala</i>
<i>Rhabdonema minutum</i>	<i>Navicula</i> sp.
Genus <i>Synedra</i> (대바늘돌말 속)	Genus <i>Pinnularia</i> (빗살돌말 속)
<i>Synedra amphicephala</i>	<i>Pinnularia subcapitata</i>
<i>Synedra amphicephala</i> v. <i>austriaca</i>	<i>Pinnularia biceps</i>
<i>Synedra faciculata</i>	<i>Pinnularia</i> sp.
<i>Synedra rumpens</i> v. <i>familiaris</i>	Genus <i>Stauroneis</i> (십자돌말 속)
<i>Synedra rumpens</i> v. <i>scotia</i>	<i>Stauroneis anceps</i>
<i>Synedra ulna</i>	<i>Stauroneis phoenicenteron</i>
Genus <i>Tabellaria</i> (블록배돌말 속)	Family Nitzschiaceae
<i>Tabellaria fenestrata</i>	Genus <i>Bacillaria</i> (웃돌말 속)
<i>Tabellaria flocculosa</i>	<i>Bacillaria paradoxa</i>
Suborder Raphidineae	Genus <i>Nitzschia</i> (등침돌말 속)
Family Eunotiaceae	<i>Nitzschia apicalta</i>
Genus <i>Eunotia</i> (눈썹돌말 속)	<i>Nitzschia acicularis</i>
<i>Eunotia</i> sp.	<i>Nitzschia stagnorum</i>
Genus <i>Peronia</i> (공이돌말 속)	<i>Nitzschia paleacea</i>
<i>Peronia fibula</i>	<i>Nitzschia actinostroides</i>
Family Achnantheaceae	Family Surirellaceae
Genus <i>Achnanthes</i> (땅콩돌말 속)	Genus <i>Surirella</i> (방패돌말 속)
<i>Achnanthes gibberula</i>	<i>Surirella</i> sp.
<i>Achnanthes microcephala</i>	Class Chrysophyceae
Genus <i>Cocconeis</i> (날알돌말 속)	Order Chrysomonadales
<i>Cocconeis placentula</i>	Suborder Ochromonadineae
<i>Cocconeis placentula</i> v. <i>lineata</i>	Family Ochromonadaceae
Family Naviculaceae	Genus <i>Dinobryon</i> (나팔말 속)
Genus <i>Amphora</i> (보리돌말 속)	<i>Dinobryon bavaricum</i>
<i>Amphora coffeaeformis</i>	<i>Dinobryon cylindrica</i>
Genus <i>Anomoeneis</i> (작배돌말 속)	<i>Dinobryon divergence</i>
<i>Anomoeneis sphaerophora</i>	<i>Dinobryon sociale</i>
Genus <i>Cymbella</i> (반달돌말 속)	<i>Dinobryon suecicum</i>
<i>Cymbella cymbiformis</i>	Genus <i>Pseudokephyron</i>
<i>Cymbella lunata</i>	<i>Pseudokephyron</i> sp.
<i>Cymbella minuta</i>	Genus <i>Uroglena</i>
<i>Cymbella silesiaca</i>	<i>Uroglena volvox</i>
<i>Cymbella ventricosa</i>	
Genus <i>Diploneis</i> (도관돌말 속)	Phylum Chlorophyta
<i>Diploneis puella</i>	Class Chlorophyceae
Genus <i>Gomphonema</i> (췌기돌말 속)	Order Volvocales
<i>Gomphonema acuminatum</i>	Family Chlamydomonadaceae
<i>Gomphonema truncatum</i> v. <i>capitatum</i>	Genus <i>Chlamydomonas</i>
Genus <i>Gyrosigma</i> (나선돌말 속)	<i>Chlamydomonas</i> sp.
<i>Gyrosigma spencerii</i>	Order Zygnematales
Genus <i>Navicula</i> (쪽배돌말 속)	Family Desmidiaceae
<i>Navicula radiosa</i>	Genus <i>Closterium</i> (반달말 속)
<i>Navicula viridula</i>	<i>Closterium</i> sp.
<i>Navicula tripunctata</i>	Genus <i>Staurastrum</i> (팔장구말 속)
<i>Navicula tripunctata</i> v. <i>schizonemoides</i>	<i>Staurastrum paradoxum</i> v. <i>parvum</i>
<i>Navicula notha</i>	<i>Staurastrum subtilissima</i>
<i>Navicula subtilissima</i>	Genus <i>Spondylosium</i> (사슬장고말 속)
<i>Navicula fluens</i>	<i>Spondylosium ellipticum</i>
<i>Navicula gottlandica</i>	<i>Spondylosium moniliforme</i>

(Continued)

Table 1. (Continued)

<i>Spondylosium planum</i>	<i>Dictyosphaerium ehrenbergii</i>
Order Chlorococcales	<i>Dictyosphaerium granulatum</i>
Family Micractiniaceae	<i>Dictyosphaerium</i> sp.
Genus <i>Golenkinia</i>	Genus <i>Pseudodictyosphaerium</i>
<i>Golenkinia radiata</i>	<i>Pseudodictyosphaerium minusculum</i>
Family Chlorococcaceae	Genus <i>Raphidocelis</i>
Genus <i>Characium</i>	<i>Raphidocelis sigmoidea</i>
<i>Characium pringsheimii</i>	Family Hydrodictyaceae
Genus <i>Chlorococcum</i>	Genus <i>Pediastrum</i> (훈장말 속)
<i>Chlorococcum</i> sp.	<i>Pediastrum duplex</i> v. <i>gracilimum</i>
Genus <i>Tetraedron</i>	<i>Pediastrum integrum</i> v. <i>priva</i>
<i>Tetraedron minimum</i>	Family Scenedesmaceae
<i>Tetraedron regulare</i> v. <i>torsum</i>	Genus <i>Coelastrum</i>
Family Oocystaceae	<i>Coelastrum microporum</i>
Genus <i>Ankistodesmus</i>	Genus <i>Crucigenia</i>
<i>Ankistodesmus falcatus</i>	<i>Crucigenia crucifera</i>
Genus <i>Chlorella</i> (클로렐라 속)	<i>Crucigenia tetrapedia</i>
<i>Chlorella homosphaera</i>	Genus <i>Scenedesmus</i> (때목말 속)
<i>Chlorella oocystis</i>	<i>Scenedesmus brasiliensis</i>
<i>Chlorella vulgaris</i>	<i>Scenedesmus denticulatus</i>
<i>Chlorella</i> sp.	<i>Scenedesmus minutus</i>
Genus <i>Kirchneriella</i>	<i>Scenedesmus obliquus</i>
<i>Kirchneriella danubiana</i>	<i>Scenedesmus quadricauda</i> v. <i>longispina</i>
<i>Kirchneriella</i> sp.	<i>Scenedesmus secratus</i>
Genus <i>Lagerheimia</i>	<i>Scenedesmus serratus</i>
<i>Lagerheimia</i> sp.	<i>Scenedesmus</i> sp.
Genus <i>Monoraphidium</i> (홀바늘말 속)	Order Ulotrichales
<i>Monoraphidium conbolutum</i>	Family Ulotrichaceae
<i>Monoraphidium contortum</i>	Genus <i>Koliella</i>
Genus <i>Oocystis</i> (알주머니말 속)	<i>Koliella helvetica</i>
<i>Oocystis crass</i>	Genus <i>Ulothrix</i> (주름말 속)
<i>Oocystis erenosphaeria</i>	<i>Ulothrix</i> sp.
<i>Oocystis</i> sp.	Order Oedogoniales
Family Dictyosphaeriaceae	Family Oedogoniaceae
Genus <i>Dictyosphaerium</i>	Genus <i>Oedogonium</i> (붓뚜껑말 속)
<i>Dictyosphaerium chlorelloides</i>	<i>Oedogonium</i> sp.

algae and the psammon, and we also collected the epilithic algae from the artificial substrata: glass slides and unglazed ceramic tiles.

Phytoplankton samples were fixed with neutral formalin and periphyton samples were scraped from the surface of the substrata, washed with distilled water, transferred into glass vials, and fixed with neutral formalin. Cleaning of phytoplankton and periphyton samples were by nitric acid or hydrogen peroxide, and mounting was with Naphrax. Identification was made at $\times 1,000$ magnification. The identification of diatoms followed Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b) and that of blue-greens and greens followed Prescott (1962) mainly. On classification system at the level of phyla, we followed the Kingdom

Protoctista by Margulis *et al.* (1990). Within diatoms the classification system was made according to Simonsen (1979) and except for diatoms those were done according to Dillard (1989a, 1989b, 1990, 1991a and 1991b) and Prescott (1962). On the Korean genus name of diatoms was made as in Choi *et al.* (1995) and others except for diatoms were done as in Chung (1968) and Chung (1993).

RESULTS AND DISCUSSION

A total of phytoplankton was composed of 150 taxa, belonging to 6 phyla, 8 classes, 15 orders, 5 suborders, 31 families, 71 genera, 106 species, 14 varieties, 1 form and 29 unidentified species. Phylum Cyanophyta (blue-green

Table 2. The list of epipellic algae in Togyo reservoir in 1996 (Lee *et al.* 1997)

Phylum Cyanophyta	Family Naviculaceae
Class Myxophyceae	Genus <i>Amphora</i> (보리돌말 속)
Order Chroococcales	<i>Amphora copulata</i>
Family Chroococcaceae	Genus <i>Caloneis</i> (오이돌말 속)
Genus <i>Merismopedia</i>	<i>Caloneis ventricosa</i> v. <i>minuta</i>
<i>Merismopedia glauca</i>	<i>Caloneis ventricosa</i> v. <i>truncatula</i>
<i>Merismopedia punctata</i>	<i>Caloneis</i> sp.
Order Hormogonales	Genus <i>Cymbella</i> (반달돌말 속)
Family Oscillatoriaceae	<i>Cymbella affinis</i>
Genus <i>Oscillatoria</i> (흔들말 속)	<i>Cymbella aspera</i>
<i>Oscillatoria tenuis</i>	<i>Cymbella gracilis</i>
	<i>Cymbella japonica</i>
Phylum Chrysophyta	<i>Cymbella minuta</i>
Class Bacillariophyceae	<i>Cymbella minuta</i> v. <i>pseudogracilis</i>
Order Centrales	<i>Cymbella naviculiformis</i>
Suborder Coscinodiscineae	<i>Cymbella silesiaca</i>
Family Thalassiosiraceae	<i>Cymbella tumida</i>
Genus <i>Cyclotella</i> (단추돌말 속)	<i>Cymbella</i> sp.
<i>Cyclotella comta</i>	Genus <i>Diploneis</i> (도관돌말 속)
<i>Cyclotella stelligera</i>	<i>Diploneis elliptica</i>
<i>Cyclotella pseudostelligera</i>	<i>Diploneis finnica</i>
<i>Cyclotella</i> sp.	<i>Diploneis parma</i>
Order Pennales	Genus <i>Frustulia</i> (쪽잎돌말 속)
Suborder Araphidineae	<i>Frustulia rhomboides</i>
Family Diatomaceae	<i>Frustulia rhomboides</i> v. <i>capitata</i>
Genus <i>Asterionella</i> (별돌말 속)	<i>Frustulia rhomboides</i> v. <i>saxonica</i>
<i>Asterionella formosa</i>	Genus <i>Gomphonema</i> (췌기돌말 속)
Genus <i>Synedra</i> (대바늘돌말 속)	<i>Gomphonema acuminatum</i>
<i>Synedra delicatissima</i>	<i>Gomphonema angustum</i>
<i>Synedra rumpens</i> v. <i>fragilarioides</i>	<i>Gomphonema clevei</i>
Genus <i>Tabellaria</i> (블록뼈돌말 속)	<i>Gomphonema globiferum</i>
<i>Tabellaria fenestrata</i>	<i>Gomphonema gracile</i>
<i>Tabellaria flocculosa</i>	<i>Gomphonema sphaerophorum</i>
Suborder Raphidineae	<i>Gomphonema truncatum</i> v. <i>capitatum</i>
Family Eunotiaceae	<i>Gomphonema turris</i>
Genus <i>Eunotia</i> (눈썹돌말 속)	<i>Gomphonema</i> sp.
<i>Eunotia arcus</i> v. <i>bidens</i>	Genus <i>Navicula</i> (쪽배돌말 속)
<i>Eunotia curvata</i>	<i>Navicula capitata</i> v. <i>hungarica</i>
<i>Eunotia diodon</i>	<i>Navicula oppugnata</i>
<i>Eunotia flexuosa</i>	<i>Navicula pupula</i>
<i>Eunotia formica</i>	<i>Navicula pupula</i> v. <i>rectangularis</i>
<i>Eunotia incisa</i>	<i>Navicula radiosa</i>
<i>Eunotia monodon</i>	<i>Navicula rhynchocephala</i>
<i>Eunotia muscicola</i> v. <i>tridentula</i>	<i>Navicula similis</i>
<i>Eunotia parallela</i>	<i>Navicula variostrata</i>
<i>Eunotia pectinalis</i>	<i>Navicula</i> sp.
<i>Eunotia pectinalis</i> v. <i>minor</i>	Genus <i>Neidium</i> (베틀복돌말 속)
<i>Eunotia vanheurckii</i> v. <i>intermedia</i>	<i>Neidium affine</i> v. <i>amphirhynchus</i>
<i>Eunotia</i> sp.	<i>Neidium affine</i> v. <i>longiceps</i>
Family Achnantheaceae	<i>Neidium ampliatum</i>
Genus <i>Achnanthes</i> (땅콩돌말 속)	<i>Neidium bisulcatum</i>
<i>Achnanthes laevis</i>	<i>Neidium productum</i>
Genus <i>Cocconeis</i> (날알돌말 속)	Genus <i>Pinnularia</i> (빗살돌말 속)
<i>Cocconeis placentula</i> v. <i>euglypta</i>	<i>Pinnularia abaujensis</i>
<i>Cocconeis placentula</i> v. <i>lineata</i>	<i>Pinnularia abaujensis</i> v. <i>linearis</i>

(Continued)

Table 2. (Continued)

<i>Pinnularia appendiculata</i>	<i>Closterium k tzingii</i>
<i>Pinnularia borealis</i>	<i>Closterium lanceolatum</i>
<i>Pinnularia brevicostata</i>	<i>Closterium lineatum</i>
<i>Pinnularia divergens</i>	<i>Closterium lunula</i>
<i>Pinnularia gentilis</i>	<i>Closterium subscoticum</i>
<i>Pinnularia gibba</i>	Genus <i>Cosmarium</i> (장고말 속)
<i>Pinnularia legumen</i>	<i>Cosmarium binum</i>
<i>Pinnularia karelica</i>	<i>Cosmarium formosulum</i>
<i>Pinnularia maior</i>	<i>Cosmarium globosum</i> f. <i>minor</i>
<i>Pinnularia microstauron</i>	<i>Cosmarium hammeri</i> v. <i>protuberans</i>
<i>Pinnularia subcapitata</i>	<i>Cosmarium laeve</i>
<i>Pinnularia viridis</i>	<i>Cosmarium lundelli</i> v. <i>ellipticum</i>
Genus <i>Stauroneis</i> (십자돌말 속)	<i>Cosmarium raeticum</i>
<i>Stauroneis phoenicenteron</i> f. <i>gracilis</i>	<i>Cosmarium subtumidum</i> v. <i>klebsii</i>
Family Nitzschiaceae	Genus <i>Euastrum</i> (오목장구말 속)
Genus <i>Hantzschia</i> (마름돌말 속)	<i>Euastrum ansatum</i> v. <i>pyxidatum</i>
<i>Hantzschia amphioxys</i>	<i>Euastrum spinulosum</i> v. <i>inermis</i>
Genus <i>Nitzschia</i> (등침돌말 속)	<i>Euastrum turgidum</i>
<i>Nitzschia intermedia</i>	Genus <i>Staurastrum</i> (팔장구말 속)
Family Surirellaceae	<i>Staurastrum dilatatum</i> v. <i>hibernicum</i>
Genus <i>Stenopterobia</i> (지렁이돌말 속)	<i>Staurastrum dispar</i>
<i>Stenopterobia delicatissima</i>	<i>Staurastrum polymorphum</i>
<i>Stenopterobia sigma</i> v. <i>sigmatella</i>	Order Chlorococcales
Genus <i>Surirella</i> (방패돌말 속)	Family Öocystaceae
<i>Surirella angusta</i>	Genus <i>Monoraphidium</i> (홀바늘말 속)
<i>Surirella linearis</i>	<i>Monoraphidium griffithi</i>
<i>Surirella splendida</i>	Family Hydrodictyaceae
<i>Surirella</i> sp.	Genus <i>Pediastrum</i> (훈장말 속)
Phylum Chlorophyta	<i>Pediastrum duplex</i> v. <i>gracilimum</i>
Class Chlorophyceae	<i>Pediastrum duplex</i> v. <i>reticulatum</i>
Order Zygnematales	<i>Pediastrum tetras</i>
Family Desmidiaceae	Family Scenedesmaceae
Genus <i>Closterium</i> (반달말 속)	Genus <i>Coelastrum</i>
<i>Closterium acerosum</i>	<i>Coelastrum proboscideum</i>
<i>Closterium calosporum</i>	Genus <i>Scenedesmus</i> (때목말 속)
<i>Closterium diana</i>	<i>Scenedesmus armatus</i> v. <i>bicaudatus</i>
<i>Closterium intermedium</i>	<i>Scenedesmus armatus</i> v. <i>boglariensis</i>
	<i>Scenedesmus longus</i>

algae) were 10 species, Phylum Cryptophyta (cryptomonads) are 1 species, Phylum Euglenophyta (euglenoids) are 9 species, Phylum Dinoflagellata (dinoflagellates) are 5 species, Phylum Chrysophyta (Class Xanthophyceae: xanthophytes) are 4 species, Phylum Chrysophyta (Class Bacillariophyceae: diatoms) are 68 species, Phylum Chrysophyta (Class Chrysophyceae: chrysophytes) are 6 species and Phylum Chlorophyta (green algae) are 47 species (Table 1). The observed number of diatoms and green algae were much higher than others. But this tendency has been recorded in Korean reservoirs (Han *et al.* 1995; Shin 2003; Kim *et al.* 2003). Within diatoms the pennate diatoms appeared more than centric diatoms and solitary forms or colonial

forms appeared more than filamentous forms in green algae.

A total of epipellic algae (Lee *et al.* 1997) was composed of 125 taxa, belonging to 3 phyla, 3 classes, 6 orders, 3 suborders, 13 families, 30 genera, 87 species, 29 varieties, 2 forms and 7 unidentified species. Phylum Cyanophyta (blue-green algae) are 3 species, Phylum Chrysophyta (Class Bacillariophyceae: diatoms) are 91 species and Phylum Chlorophyta (green algae) were 31 species (Table 2). The diatoms appeared much more than others. Among those, the pennate diatoms dominated the centric diatoms in species number observed. We could probably assume that was due to the presence of raphe structure of pennate diatoms.

Table 3. The list of epilithic algae in Togyo reservoir in 1996 and 1999

Phylum Cyanophyta	<i>Fragilaria crotonensis</i>
Class Myxophyceae	<i>Fragilaria</i> sp.
Order Chroococcales	Genus <i>Synedra</i> (대바늘돌말 속)
Family Chroococcaceae	<i>Synedra acus</i>
Genus <i>Gloeocapsa</i>	<i>Synedra amphirhynchus</i>
<i>Gloeocapsa</i> sp.	<i>Synedra delicatissima</i>
Genus <i>Microcystis</i>	<i>Synedra fasciculata</i>
<i>Microcystis aeruginosa</i>	<i>Synedra rupens</i>
Order Hormogonales	<i>Synedra rumpens</i> v. <i>familiaris</i>
Family Oscillatoriaceae	<i>Synedra tabulata</i>
Genus <i>Phormidium</i> (가죽흔들말 속)	<i>Synedra tenuissima</i>
<i>Phormidium</i> sp.	<i>Synedra ulna</i>
Genus <i>Oscillatoria</i> (흔들말 속)	<i>Synedra ulna</i> v. <i>danica</i>
<i>Oscillatoria angusta</i>	Genus <i>Tabellaria</i> (블록뼈돌말 속)
<i>Oscillatoria tenuis</i>	<i>Tabellaria fenestrata</i>
<i>Oscillatoria</i> sp.	<i>Tabellaria flocculosa</i>
Family Rivulariaceae	Suborder Raphidineae
Genus <i>Calothrix</i>	Family Achnanthaceae
<i>Calothrix braunii</i>	Genus <i>Achnanthes</i> (땅콩돌말 속)
<i>Calothrix fusca</i>	<i>Achnanthes minutissima</i>
Family Nostocaceae	<i>Achnanthes</i> sp.
Genus <i>Anabaena</i>	Family Naviculaceae
<i>Anabaena affinis</i>	Genus <i>Cymbella</i> (반달돌말 속)
<i>Anabaena</i> sp.	<i>Cymbella affinis</i>
Genus <i>Cylindrospermum</i> (올챙이말 속)	<i>Cymbella asper</i>
<i>Cylindrospermum majus</i>	<i>Cymbella cymbiformis</i>
<i>Cylindrospermum stagnale</i>	<i>Cymbella elginensis</i>
Phylum Dinoflagellata	<i>Cymbella gracilis</i>
Class Dinophyceae	<i>Cymbella japonica</i>
Order Peridiniales	<i>Cymbella microcephala</i>
Family Peridiniaceae	<i>Cymbella minuta</i>
Genus <i>Peridinium</i>	<i>Cymbella minuta</i> v. <i>pseudogracilis</i>
<i>Peridinium cinctum</i>	<i>Cymbella silesiaca</i>
<i>Peridinium inconspicuum</i>	<i>Cymbella socialis</i>
<i>Peridinium</i> sp.	<i>Cymbella tumida</i>
Phylum Chrysophyta	<i>Cymbella</i> sp.
Class Bacillariophyceae	Genus <i>Gomphonema</i> (썰기돌말 속)
Order Centrales	<i>Gomphonema acuminatum</i>
Suborder Coscinodiscineae	<i>Gomphonema angustum</i>
Family Thalassiosiraceae	<i>Gomphonema augur</i>
Genus <i>Cyclotella</i> (단추돌말 속)	<i>Gomphonema clevei</i>
<i>Cyclotella comta</i>	<i>Gomphonema globiferum</i>
<i>Cyclotella pseudostelligera</i>	<i>Gomphonema gracile</i>
<i>Cyclotella</i> sp.	<i>Gomphonema parvulum</i>
Order Pennales	<i>Gomphonema sphaerophorum</i>
Suborder Araphidineae	<i>Gomphonema subtile</i>
Family Diatomaceae	<i>Gomphonema truncatum</i>
Genus <i>Asterionella</i> (별돌말 속)	<i>Gomphonema truncatum</i> v. <i>capitatum</i>
<i>Asterionella formosa</i>	<i>Gomphonema turris</i>
Genus <i>Diatoma</i> (막돌말 속)	<i>Gomphonema</i> sp.
<i>Diatoma vulgare</i>	Genus <i>Navicula</i> (쪽배돌말 속)
<i>Diatoma</i> sp.	<i>Navicula bicapitellata</i>
Genus <i>Fragilaria</i> (김발돌말 속)	<i>Navicula cryptocephala</i>
	<i>Navicula dicephala</i>
	<i>Navicula minutissima</i>

(Continued)

Table 3. (Continued)

<i>Navicula radiosa</i>	Family Radiococcaceae
<i>Navicula similis</i>	Genus <i>Coenochloris</i>
<i>Navicula</i> sp.	<i>Coenochloris polycocca</i>
Family Nitzschiaceae	Genus <i>Coenococcus</i>
Genus <i>Nitzschia</i> (등침돌말 속)	<i>Coenococcus planctonicus</i>
<i>Nitzschia</i> sp.	Family Oocystaceae
	Genus <i>Ankistrodesmus</i>
Phylum Chlorophyta	<i>Ankistrodesmus affinis</i>
Class Chlorophyceae	Genus <i>Monoraphidium</i> (홀바늘말 속)
Order Volvocales	<i>Monoraphidium contortum</i>
Family Chlamydomonadaceae	<i>Monoraphidium griffithii</i>
Genus <i>Chlamydomonas</i>	Family Hydrodictyaceae
<i>Chlamydomonas</i> sp.	Genus <i>Pediastrum</i> (훈장말 속)
Order Ztgnematales	<i>Pediastrum boryanum</i>
Family Zygnemataceae	<i>Pediastrum duplex</i> v. <i>gracilimum</i>
Genus <i>Mougeotia</i> (판해캡 속)	<i>Pediastrum duplex</i> v. <i>reticulatum</i>
<i>Mougeotia</i> sp.	<i>Pediastrum tetras</i>
Genus <i>Spirogyra</i> (해캡 속)	Family Scenedesmaceae
<i>Spirogyra</i> sp.	Genus <i>Coelastrum</i>
Genus <i>Zygnema</i> (별해캡 속)	<i>Coelastrum proboscideum</i>
<i>Zygnema</i> sp.	<i>Coelastrum</i> sp.
Family Mesotaeniaceae	Genus <i>Crucigenia</i>
Genus <i>Gonatozygon</i>	<i>Crucigenia tetrapedia</i>
<i>Gonatozygon</i> sp.	Genus <i>Scenedesmus</i> (때목말 속)
Family Desmidiaceae	<i>Scenedesmus acuminatus</i>
Genus <i>Cosmarium</i> (장고말 속)	<i>Scenedesmus armatus</i> v. <i>boglariensis</i>
<i>Cosmarium canadinum</i>	<i>Scenedesmus communis</i>
<i>Cosmarium globosum</i> f. <i>minor</i>	<i>Scenedesmus incrassatulus</i>
<i>Cosmarium lundelli</i> v. <i>ellipticum</i>	<i>Scenedesmus longus</i>
<i>Cosmarium obsoletum</i>	<i>Scenedesmus obtusus</i>
<i>Cosmarium subtumidum</i>	<i>Scenedesmus quadricauda</i>
<i>Cosmarium undulatum</i>	<i>Scenedesmus</i> sp.
<i>Cosmarium</i> sp.	Order Ulotrichales
Genus <i>Spondylosium</i> (사슬장고말 속)	Family Ulotrichaceae
<i>Spondylosium ellipticum</i>	Genus <i>Ulothrix</i> (주름말 속)
<i>Spondylosium</i> sp.	<i>Ulothrix subtilissima</i>
Genus <i>Staurastrum</i> (팔장구말 속)	Order Oedogoniales
<i>Staurastrum dispar</i>	Family Oedogoniaceae
<i>Staurastrum polymorphum</i>	Genus <i>Bulbochaete</i>
<i>Staurastrum</i> sp.	<i>Bulbochaete</i> sp.
Order Chlorococcales	Genus <i>Oedogonium</i> (붓뚜껑말 속)
Family Chlorococcaceae	<i>Oedogonium</i> sp.
Genus <i>Characium</i>	Order Chaetophorales
<i>Characium</i> sp.	Family Chaetophoraceae
Genus <i>Tetraedron</i>	Genus <i>Stigeoclonium</i>
<i>Tetraedron minimum</i>	<i>Stigeoclonium mamillosum</i>

A total of epilithic algae was composed of 114 taxa, belonging to 4 phyla, 4 classes, 11 orders, 3 suborders, 22 families, 38 genera, 79 species, 8 varieties, 1 form and 26 unidentified species. Phylum Cyanophyta (blue-green algae) are 12 species, Phylum Dinoflagellata (dinoflagellates) are 3 species, Phylum Chrysophyta (Class Bacillariophyceae: diatoms) are 56 species and

Phylum Chlorophyta (green algae) were 43 species (Table 3). The observed number of diatoms and green algae were much higher than others. Within diatoms the pennate diatoms dominated the centric diatoms in species number observed. This was as same as in the composition of epipellic algal community. In most cases the epilithic diatom community was used as a tool for

the assesment of water quality (Chung 1987; Choi and Chung 1990; Chung *et al.* 1992; Lee and Kim 1996). They also recorded the dominance of pennate diatoms rather than the centric diatoms in the study of diatom community composition.

ACKNOWLEDGEMENTS

The authors are deeply appreciated Park, J.-Y. and Kim, H.J. for collecting samples, and to anonymous referees for reading the manuscript. This work was partially supported by Korean Research Foundation Grant (KRF-98-015-D00231) and by the Catholic University of Korea, Research Fund 2003.

REFERENCES

- Choi J.K., Lee J.H. and Lee K. 1995. Taxonomic studies on diatoms in Korea. I. Classification system and koreanization of classification level. *Korean J. Phycol.* **10**(Suppl.): 1-11.
- Choi J.S. and Chung J. 1990. An assesment of water quality by epilithic diatoms of Namchun water-system. *Korean J. Phycol.* **5**: 173-191.
- Chung J. 1987. An assesment of water quality by epilithic diatoms of Hyungsan River water-system. *Korean J. Phycol.* **2**: 139-146.
- Chung J., Choi J.S. and Lee J.H. 1992. An assesment of water quality by epilithic diatoms of Yangsan-ch'on. *Korean J. Environ. Biol.* **10**: 9-23.
- Chung J. 1993. *Illustration of the Freshwater Algae of Korea*. Academy Publ. Co., Seoul. 496 pp.
- Chung Y.H. 1968. *Illustrated Encyclopedia of Fauna & Flora of Korea*. Vol 9. Freshwater Algae. Samwha Publ. Co., Seoul. 573 pp.
- Dillard G.E. 1989a. *Freshwater Algae of the Southeastern United States*. Part 1. Chlorophyceae: Volvocales, Tetrasporales and Chlorococcales. J. Cramer, Berlin. 202 pp. with 37 plates.
- Dillard G.E. 1989b. *Freshwater Algae of the Southeastern United States*. Part 2. Chlorophyceae: Ulotrichales, Microsporales, Cylindrocapsales, Sphaeropleales, Chaetophorales, Cladophorales, Schizogoniales, Siphonales and Oedogoniales. J. Cramer, Berlin. 163 pp. with 41 plates.
- Dillard G.E. 1990. *Freshwater Algae of the Southeastern United States*. Part 3. Chlorophyceae: Zygnematales: Zygnemataceae, Mesotaeniaceae and Desmidiaceae (Section 1). J. Cramer, Berlin. 172 pp. with 51 plates.
- Dillard G.E. 1991a. *Freshwater Algae of the Southeastern United States*. Part 4. Chlorophyceae: Zygnematales: Desmidiaceae (Section 2). J. Cramer, Berlin. 205 pp. with 52 plates.
- Dillard G.E. 1991b. *Freshwater Algae of the Southeastern United States*. Part 5. Chlorophyceae: Zygnematales: Desmidiaceae (Section 3). J. Cramer, Berlin. 155 pp. with 37 plates.
- Han M.-S., Auh Y.-Y., Ryu J.-K., Yoo K.-I. and Choi Y.-K. 1995. Ecological studies on Pal'tang River-Reservoir system in Korea. 2. Changes in phytoplankton community structure. *Korean J. Limnol.* **28**: 335-344.
- Han M.-S., Lee K. and Yoo K.-I. 1995. Ecological studies on Togyo Reservoir in Chulwon, Korea. I. A field test for *in situ* aquatic net-enclosure mesocosm. *Korean J. Limnol.* **28**: 487-495.
- Han M.-S., Lee H.-R., Hong S.-S., Kim Y.-O., Lee K., Choi Y.-K., Kim S., and Yoo K.-I. 2002. Ecological studies on Togyo Reservoir in Chulwon, Korea. V. Seasonal changes of size fractionated standing crops and chlorophyll *a* of phytoplankton in Kyungan stream of Paldang river-reservoir systems and Togyo Reservoir, Korea. *Korean J. Environ. Biol.* **20**: 91-99.
- Kim M.-K., Park J.-W. and Lee Y.-O. 2003. Seasonal variations of water environment factors and phytoplankton in Nammae Reservoir. *Korean J. Limnol.* **36**: 48-56.
- Krammer K. and Lange-Bertalot H. 1986. Bacillariophyceae 1. Teil: Naviculaceae In: Ettl H., Gerloff J., Heynig H. and Mollenhauer D. (eds), *Süsswasserflora von Mitteleuropa*. Band 2/1. Gustav Fischer, Jena. 876 pp.
- Krammer K. and Lange-Bertalot H. 1988. Bacillariophyceae 2. Teil: Bacillariaceae, Epithemiaceae, Surirellaceae. In: Ettl H., Gerloff J., Heynig H. and Mollenhauer D. (eds), *Süsswasserflora von Mitteleuropa*. Band 2/2. Gustav Fischer, Stuttgart. 596 pp.
- Krammer K. and Lange-Bertalot H. 1991a. Bacillariophyceae 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. In: Ettl, H., Gerloff J., Heynig H. and Mollenhauer D. (eds), *Süsswasserflora von Mitteleuropa*. Band 2/3. Gustav Fischer, Jena. 576 pp.
- Krammer K. and Lange-Bertalot H. 1991b. Bacillariophyceae 4. Teil: Achnanthaceae. Kritische Ergänzungen zu Navicula (Lineolata) und Gomphonema. In: Ettl H., Gerloff J., Heynig H. and Mollenhauer D. (eds), *Süsswasserflora von Mitteleuropa*. Band 2/4. Gustav Fischer, Stuttgart. 437 pp.
- Lee J.H. and Kim Y.J. 1996. Epilithic diatoms and trophic states of dam lakes in the Naktong River system. *Korean J. Environ. Biol.* **14**: 18-28.
- Lee K., Park J.-Y. and Han M.-S. 1996. Ecological studies on Togyo Reservoir in Chulwon, Korea. II. The seasonal changes of phytoplankton community structure. *Korean J. Limnol.* **29**: 241-246.
- Lee K., Yoon S.-K. and Han M.-S. 1997. Ecological studies on Togyo Reservoir in Chulwon, Korea. III. Epipellic algae. *Korean J. Limnol.* **30**: 253-279.
- Lee K., Yoon S.-K. and Han M.-S. 1998. Ecological studies on Togyo Reservoir in Chulwon, Korea. IV. The establishment of periphytic algae on artificial substrate at mesocosm. *Algae* **13**: 461-466.
- Margulis L., Corliss J.O., Melkonian M and Chapman D.J. 1990. *Handbook of Protoctista*. Jones and Bartlett Publishers, Boston. 914 pp.
- Prescott G.W. 1962. *Algae of the Western Great Lakes Area*. Rev. ed. Reprint in 1982 by Otto Koeltz Science Publishers,

Königstein. 977 pp.

Round F.E. 1973. *The Biology of the Algae*. 2nd ed. Edward Arnold, London. 278 pp.

Shin J.-K. 2003. Seasonal dynamics of aquatic environment and phytoplankton in Pyeongtaek reservoir, Korea. *Algae* **18**: 145-156.

Simonsen R. 1979. The diatom system: Ideas on phylogeny. *Bacillaria* **2**: 9-71.

Received 27 November 2003

Accepted 10 December 2003