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Water Quality and Identification of Organisms Found at the Intake Water Area of South Bangkok Thermal Plant

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ABSTRACT

The water quality of samples taken from the intake water area of South Bangkok Thermal Plant showed the pH range of 7.01-7.37 and temperature range of 27.3-29.7°C throughout the year. Dissolved oxygen (DO), however, was rather fluctuated, being high (7.10-8.6 mg/l) in the dry season and dropped to a low level (4.78-6.5 mg/l) in the rainy season. On the contrary, the amount of chloride which indicated water salinity was low (22-75 ppm) in the rainy season but gradually increased from 310 ppm to the highest value of 11,000 ppm in the dry season resulted in the changing from brackish to marine condition in January.

Types of organisms at this area was found corresponding to the chloride level in water. There were 3 main groups of marine invertebrates, i.e., muddy tube fan worms, calcareous tube fan worms, and a hydroid (*Bougainvillia pyramidata*). The co-existence and high proliferation of these 3 organisms in the dry season greatly contributed to the contamination of the screen plate and obstructed the inflow of water supply to the cooling system of the power plant. Changing the water salinity at the intake water area could make it unfavorable for the growth of marine organisms and, hence, an alternative method of controlling the fouling organisms and avoid the use of chemical while maintaining a good environment condition in the area.

Key words: power plant, cooling system, planktonic organisms, salinity, Chao Phraya river

INTRODUCTION

The estuary of the Chao Phraya River is the junction of freshwater and seawater where brackish to marine conditions are found depending on the flow and surge of the sea at that area all-year-round. Therefore, it is a suitable habitat for diverse microscopic organisms ranging from free-swimming to suspended phytoplankton and zooplankton. Phytoplanktons are mainly diatoms and other microscopic algae while marine zooplanktons represent virtually every group of animals, both as adults and developmental stages. However, the animal constituents of freshwater plankton are more limited in number. Plankton, especially marine plankton, is the primary important aquatic food. The photosynthetic phytoplanktons, i.e., diatoms, dinoflagellates, minute flagellates, and cyanobacteriums form the primary trophic level and serve as food for larger animals (Ruppert and Barnes, 1994). On the other hand, most of the sessile animals are invertebrates in the marine environment. They are the sponge of Phylum Porifera, hydroids and coral of Phylum

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Cnidaria, and polychaetes of Phylum Annelida. When they settled on hard substrate and became unwanted, they were called fouling organisms.

South Bangkok Thermal Plant is located on the bank of the Chao Phraya River, Samutra Prakarn Province, Thailand. Water supply for the cooling system of the plant is obtained from the river and passed through the filter systems before use. The intake water area or the reservoir for the water supply is facing the river with 3 large sublimed walls where water pumps are installed and the water is pumped to the screen tower for waste and deposit removal. After that, the water is chlorinated and filtered before entering the cooling system. The accumulation of fouling organisms at the filter system could cause the lower amount of water flow, raising the temperature of the cooling system and will automatically shut down the power. The obstruction of the filter screen has been a major problem especially during the dry season when the tide is high. Primary investigation was done to figure out the cause of this problem. A large amount of hydroids was found on the filter screen which chlorine gas was used to eliminate them. However, hydroids still persist and larger amount of chemicals is further needed. Subsequently, the chemical treatment of water intake could cause water pollution in the river. The thorough investigation on the types of organisms as well as their fluctuated amount during the seasonal change is necessary to determine a proper biocontrol of their growth. The aim of this project is to determine the water quality at the intake water area as well as identify these organisms which could lead to a suitable treatment with least effect on the environment.

MATERIALS AND METHODS

1. Determination of water quality

Temperature, pH and dissolved oxygen of water samples collected from the intake water area of South Bangkok Thermal Plant were monthly determined from December 1999 to November 2000 using the laboratory multiparameter, HACH, senION 378, respectively, while the amount of chloride was determined by Agentometric Method.

2. Collection and identification of organisms

2.1 Planktons were collected from the front part of intake water area of South Bangkok Thermal Plant using plankton net (maze size 40 μm) at the level of 0.5 meter below the water surface. Each swooping was done for the distance of 3 meter long. The planktons were identified according to Charubhun and Charubhun (1997), Corliss (1979), Lee *et al*. (1985), Margulis *et al*. (1990), Todd *et al*. (1996), Wongrat (1998), and Wongrat (1999). The specimens were photographed, and the number was estimated.

2.2 Fouling organisms were collected from the concrete wall of the water intake reservoir by scuba divers. The specimen were identified according to Day (1967), Fauchald (1977), Hayward and Ryland (1990) Kozloff (1990), Ruppert and Barnes (1994), Sterrer and Sterrer (1986) and Ushakov (1955). The specimens were photographed and recorded.

RESULTS AND DISCUSSION

1. Water Quality

The average pH of water samples at the intake water area of South Bangkok Thermal Plant was found to be 7.25, having the lowest value of 7.01 in December and highest value of 7.67 in May (Table 1 and Figure 1). Although the ability of nutrient utilization of organisms depends on the pH condition, the pH range of 6.5-9 was found to be suitable for plankton growth (Daungsawat and Somsiri, 1985). The pH condition at this area (7.01-7.37) is considered favorable for phytoplankton, zooplankton, as well as other aquatic organisms all-year-round.

There are 3 official seasons in Thailand; winter (November to February), summer (March to June), and the rainy season (July to October). However, little fluctuation of climate temperature throughout the year (27.3-35°C) has made it more practical to classify the weather according to precipitation, i.e., the rainy and the dry season. Water temperature of the samples was also found to be in the range of 26.9-29.8°C which is also considered suitable for most aquatic organisms.

Dissolved oxygen (DO), on the other hand, was not found to be stabilized throughout the year. DO value was quite high in the range of 7.1-8.6 mg/l in the dry season with the maximum amount in March. It was drastically dropped to the range of 4.78-6.5 mg/l in the rainy season, having the lowest value in September (Table 1 and Figure 1). However, the lowest DO found in the area (4.78 mg/l) was still above the minimum standard DO required (3 mg/l) for living organisms (Daungsawat and Somsiri, 1985).

The most interesting water parameter was found to be the amount of chloride in water samples. From June to October, the amount of chloride was as low as 22-75 ppm. It started to elevate in November (310 ppm) and reached the highest

Table 1 Water quality at the intake water area of South Bangkok Thermal Plant from December 1999 to November 2000.

	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov
Chloride (ppm)	1,750	11,000	8,750	8,212	7,300	1,275	75	22	25	50	50	310
pH	7.01	7.26	7.29	7.39	7.32	7.67	7.25	7.32	7.21	7.20	7.26	7.25
DO (mg/l)	7.66	8.4	8.45	8.6	8.15	7.65	7.7	7.7	6.5	4.78	5.6	7.10
Temp. (°C)	26.9	26.8	27.7	29.7	29.5	29.8	29.6	29.8	29.8	29.7	29.8	27.6

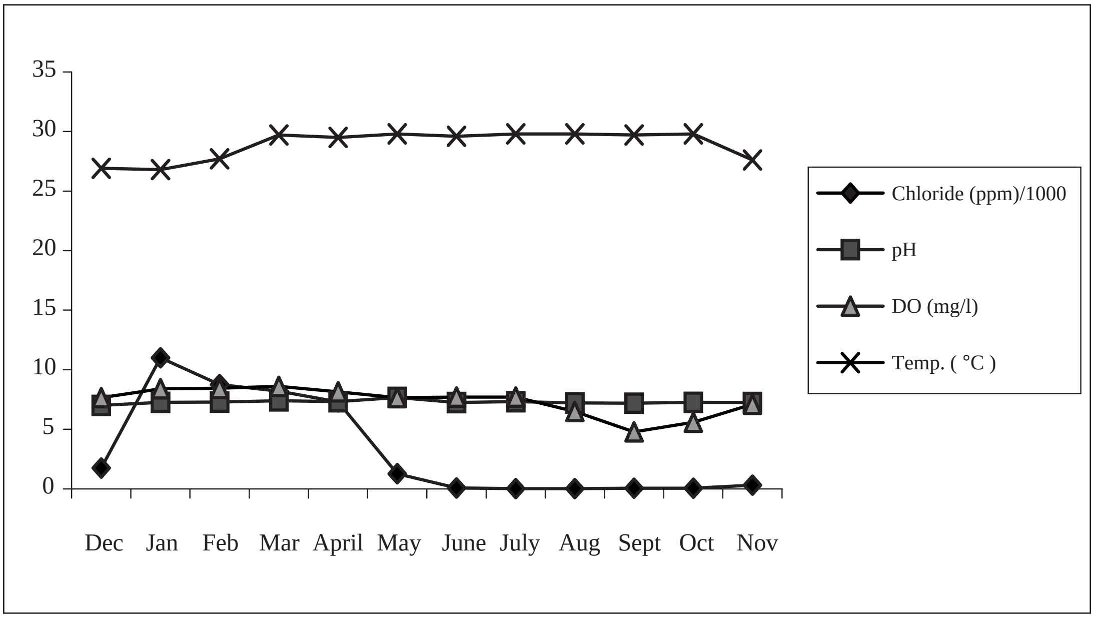

Figure 1 Water quality at the intake water area of South Bangkok Thermal Plant.

value in January (11,000 ppm). Since the amount of chloride is an indicator of water salinity, the water condition at this area is considered brackish during December to May (Table 1 and Figure 1).

2. Planktonic organisms

Planktons found in this area were mainly classified into 31 genera of phytoplankton (2 of Kingdom Monera and 29 of Kingdom Protista) as shown in Table 2, and 47 genera of zooplankton (33 of Kingdom Protista and 14 of Kingdom Animalia) as well as some animal larvae as shown in Table 3. All planktons found during the months of December 1999 to April 2000 were marine planktons which corresponded to the high chloride level in the water (Table 5, Figure 2). Most of the phytoplanktons was in Division Chromophyta (Table 2). *Melosida dubia* was the predominant filament type of diatom in this area while *Oscillatoria* and *Spirulina* were consistently found all-year-round. There were several marine zooplankton of Family *Tintinnopsis*, medusae of *Obelia* and *Eutonina* of the hydroids, comb jelly (*Pleurobrachia*), Muller's larva of flatworm, polychaete larva, Veliger larva of nudibranchs and bivalves and the marine calanoid arthropod (Table 3). However, freshwater phytoplanktons (*Volvox* and *Phacus*) started to emerge during the months of May to December while only a small number of freshwater zooplankton (protozoa and rotifers) were found due to the opened and running pattern of the water in this area. The observed numbers of plankton indicated the limited ability of these organisms (Division Chlorophyta) to live in high salinity condition. They could survive in brackish water for a period of time (December to May) and started to diminish when salinity became high.

Several zooplankton larvae were observed in the water samples. Muller's larva of polyclads belonging to Phylum Platyhelminthes were at high level in January while 5 more types of polyclads were observed in the months of February to June. Early and middle stages of polychaete trochophore larva in the Phylum Annelida were found mostly in January. They were early trochophore stage of *Capitella* and spinoid, middle stage of *Polydora*, and nectochaetea larva of *Nereis*. It is interesting to find polychaete zygotes having thick jelly covering and their subsequent stages of development which confirmed the clear existence of Nerid larva in this area. Veliger's larva of gastropod and bivalve in the Phylum Mollusca were observed but could not be classified into species. Abundant egg sacs of nudibranch (gastropod) were also found on the *Bougainvillia* stick in the months of February to April where 3 types of adult nudibranch were found moving on the branches and fed on *Bougainvillia* polyp. Nauplius, the early stage of marine copepods in Class Crustacea, Phylum Arthropoda, was found in December and February when the water was brackish while nauplius of freshwater *Cyclops* and *Moina* emerged later in the months of July through November when the brackish water had turned more or less to freshwater.

Considering their environmental structure of habitat, freshwater phytoplanktons and zooplanktons were numerously found during the months of May to January while marine organisms were high in diversity during January to April (Table 2, 3 and Figure 2).

There were only 2 genera of sessile protozoa (*Zoothamnium* sp. and *Acineta* sp.) found in this area. Their numbers were consistently stable in the months of January to June (Table 4). However, a large number of varieties of invertebrates were found in fluctuated content depending on the salinity condition. There were 3 genus of Phylum Cnidaria, 4 genus of Phylum Platyhelminthes, unidentified nematodes of Phylum Nematoda, 1 genus of Phylum Nemertea, 10 genus of Phylum Annelida, 4 genus of Phylum Mollusca, 2 genus of Phylum Bryozoa, 2 genus of Phylum Entoprocta, and 2 genus of Phylum Arthropoda. The larvae of these invertebrates were also found in the number corresponding to the adults.

Table 2 Frequency index of phytoplankton found at the intake water area of South Bangkok Thermal Plant from December 1999 to November 2000.

	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov
Kingdom Monera												
Division Cyanophyta												
Oscillatoria	++	++	++	++	++	++	++	++	++	+	+	+
Spirulina	++	++	++	++	++	++	++	++	++	+	+	+
Kingdom Protista												
Division Chlorophyta												
Chlamydomonas angulosa	+	-	-	-	+	+	++	++	+	+	+	+
Pandorina morum	+	-	-	-	-	+	+	+	+	-	-	-
Volvox sp.	-	-	-	-	-	-	+	-	-	-	-	-
Spondylomorum	-	-	-	-	-	+	+	+	+	+	-	-
Scenedesmus	-	-	-	-	-	+	+	+	+	-	-	-
Spirogyra	-	+	-	-	-	-	-	-	-	-	-	-
Euglena spp.	++	+	-	-	-	-	++	++	+	+	+	+
Phacus spp.	++	+	-	-	-	-	++	+	+	+	+	+
Trachelomonas spp.	+	-	-	-	-	-	+	+	+	+	-	-
Menoidium falcatum	+	-	-	-	-	-	-	-	-	-	-	-
Entosiphon sulcatum	+	+	-	-	-	-	-	-	-		-	-
Division Chromophyta												
Planktoniella	+	+	+	+	+	+	+	-	-	-	-	+
Melosida	+	++	+++	+++	++	++	++	+	-	-	-	-
Coscinodiscus	-	-	+	+	-	-	-	-	-	-	+	+
Chaetoceros	-	+	+	+	+	+	-	-	-	-	-	-
Rhizosolina	-	-	+	+	+	+	-	-	-	-	-	-
Pleurosigma	-	-	+	+	+	-	-	-	-	-	-	-
Bacillaria	-	-	+	+	+	-	-	-	-	-	-	-
Nitzschia	-	+	+	+	+	-	-	-	-	-	-	-
Microglena ovum	+	-	-	-	-	-	-	-	-	-	-	-
Anthophysis vegetans	++	-	-	-	-	-	-	-	-	-	-	-
Mallomonas litomesa	+	-	-	-	-	-	-	-	-	-	-	-
Ceratium furca	+	+	-	-	-	-	-	-	-	-	-	-
Ceratium fusus	-	+	-	-	-	-	-	-	-	-	-	-
Peridium parallelum	-	+	+	-	-	-	-	-	-	-	-	-

Table 2 (con.) Frequency index of phytoplankton found at the intake water area of South Bangkok Thermal Plant from December 1999 to November 2000.

	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov
Protoperidium excentricum	-	-	++	+	-	-	-	-	-	-	-	-
Protoperidium curtipes	-	++	+	+	+	-	-	-	-	-	-	-
Glenodinium sp.	+	+	-	-	-	-	-	-	-	-	+	+
Cryptomonas ovata	+	-	-	-	-	-	-	-	-	-	-	-

Frequency index : + = low
++ = medium
+++ = high
++++ = abundant

Table 3 Frequency index of zooplanktons found at the intake water area of South Bangkok Power Plant from December 1999 to November 2000.

	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov
Kingdom Protista												
Amoeba proteus	-	+	-	-	-	-	-	-	-	-	-	-
Arcella vulgaris	+	-	-	-	-	+	+	+	+	-	-	-
Arella bathystoma	+	-	-	-	-	+	+	+	+	-	-	-
Difflugia	-	+	-	-	-	-	-	-	-	-	-	-
Centropyxis	-	-	-	-	-	+	+	-	-	-	-	-
Actinosphaerium	-	+	+	-	-	-	-	-	-	-	-	-
Actinophrys	-	-	+	-	-	-	-	-	-	-	-	-
Heterophrys	-	+	-	-	-	-	-	-	-	-	-	-
Raphidiophrys	-	+	+	-	-	-	-	-	-	-	-	-
Holophrya simplex	-	+	-	-	-	+	+	+	-	-	-	-
Prorodon discolor	+	+	+	+	+	+	+	+	-	-	-	-
Coleps hirtus	++	++	+	+	++	+	++	+	+	+	+	+
Trachelocerca	-	-	+	+	-	-	-	-	-	-	-	-
Lacrymaria olor	-	+	-	-	-	-	-	-	-	-	-	-
Amphileptus	+	+	-	-	-	+	+	+	-	-	-	-
Litonotus fasciola	-	+	-	-	-	-	+	+	-	-	-	-
Loxophyllum sp.	-	+	-	-	-	-	-	-	-	-	-	-
Chilodonella	-	+	-	-	-	-	-	-	-	-	-	-
Coelosomatides marina	-	-	+	-	-	-	-	-	-	-	-	-
Paramecium caudatum	+	+	-	-	+	+	++	++	+	+	-	-
Frontonia leucas	-	+	-	-	-	-	-	-	-	-	-	-
Vorticella	-	+	-	-	-	-	-	-	-	-	-	-
Epistylis	-	+	-	-	-	-	-	-	-	-	-	-

Table 3 (con.) Frequency index of phytoplankton found at the intake water area of South Bangkok Thermal Plant from December 1999 to November 2000.

	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov
Spirostomum intermedium	-	+	+	+	-	++	+	+	-	-	-	-
Stentor coeruleus	+	+	-	-	-	-	-	-	-	-	-	-
Stentor polymorpha	+	+	-	-	-	-	-	-	-	-	-	-
Halteria grandinella	+	-	-	-	-	-	-	-	-	-	-	-
Leprotintinnus simplex	+	++	++	++	++	++	+	-	-	-	+	+
Tintinnopsis tocautinensis	+	++	++	++	++	++	+	-	-	-	+	+
Tintinnopsis cylindrica	+	++	++	++	++	++	+	-	-	-	+	+
Tintinnopsis tuberlosoides	+	++	++	++	++	++	+	-	-	-	+	+
Tintinnopsis brasiliensis	+	++	++	++	++	++	+	-	-	-	+	+
Tintinnopsis loricata	+	++	++	++	++	++	+	-	-	-	+	+
Tintinnopsis lohmanni	+	++	++	++	++	++	+	-	-	-	+	+
Tintinnopsis meunieri	+	+	+	+	+	+	+	-	-	-	+	+
Tintinnopsis subacuta	+	++	++	++	++	++	+	-	-	-	+	+
Calpionella sp.	+	++	++	++	++	++	+	-	-	-	+	+
Strombilidinopsis	+	-	-	-	-	-	-	-	-	-	-	-
Uroleptopsis	-	-	-	+	-	-	-	-	-	-	-	-
Euplotes patella	+	+++	-	-	++	+	+	-	-	-	-	+
Aspidisca lynceus	+	+	-	-	-	-	-	-	-	-	-	-
Kingdom Animalia												
Phylum Cnidaria												
Obelia	-	-	-	-	+	+	-	-	-	-	-	-
Eutonina indicans	-	-	-	-	++	+	-	-	-	-	-	-
Phylum Ctenophora												
Pleurobrachia	-	-	-	-	+++	++	-	-	-	-	-	-
Phylum Rotifera												
Rotaria sp.	+	-	-	-	-	-	+	+	+	-	-	-
Keratella	+	-	-	-	-	-	-	-	-	-	-	-
Brachionus plicatalis	+	+	+	+++	+	+	+	+	-	-	+	+
Brachionus caudatus	+	-	-	-	-	-	-	-	-	-	-	-
Brachionus falcatus	+	-	-	+	+	-	-	-	-	-	-	+
Anuraeopsis fissa	++	-	-	-	-	-	-	-	-	-	-	+
Filinia longicaudata	-	-	-	-	-	-	-	-	-	+	-	-
Beauchampia	-	-	-	-	-	-	-	-	-	+	+	+
Phylum Arthropoda												
Bosmina longirostris	-	+	-	-	-	-	-	-	-	-	-	-
Moina	-	-	-	-	-	-	-	-	-	+	-	-
Calanus	+	++	++	+	-	-	-	-	-	-	-	-

Table 3 (con.) Frequency index of phytoplankton found at the intake water area of South Bangkok Thermal Plant from December 1999 to November 2000.

	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov
Acartia	+	++	++	+	-	-	-	-	-	-	-	-
Cyclops	+	+	+	+	+	+	+	+	+	+	-	-
Larva stage												
Phylum Platyhelminthes												
Muller's larva	-	++	-	-	-	-	-	-	-	-	-	-
Phylum Annelida												
unidentified trochophore larva	-	+	+	-	-	-	-	-	-	-	-	-
early stage trochophore larva of *Capitella*	-	+	+	-	-	-	-	-	-	-	-	-
early stage trochophore larva of spinoids	-	+	-	-	-	-	-	-	-	-	-	-
middle stage trochophore larva of *Polydora*	-	+	-	-	-	-	-	-	-	-	-	-
nectochaeta larva of *Nereis*	-	+	-	-	-	-	-	-	-	-	-	-
set of larva stage of *Nereis*	-	+	-	-	-	-	-	-	-	-	-	-
Phylum Mollusca												
veliger larva of Prosobranch	-	+	-	-	-	-	-	-	-	-	-	-
veliger larva of Opisthobranch												
veliger larva of bivalve	-	+	-	-	-	-	-	-	-	-	-	-
Phylum Arthropoda												
nauplius of calanoid	+	+	-	-	-	-	-	-	-	-	-	-
late nauplius of calanoid	-	+	-	-	-	-	-	-	-	-	-	-
nauplius of cyclops	-	-	-	-	-	-	-	+	+	+	+	+
nauplius of harpacticoids	-	+	+	-	-	-	-	-	-	-	-	-

Frequency index : + = low
++ = medium
+++ = high
++++ = abundant

3. Characteristic of main sessile organisms

Three sublimed walls around the water intake area at the power plant acted like a hard substrate or artificial coral reef for organism attachment. The walls also serve as a brake to slow down the inflow of water and kept a good circulation. Therefore, this specific area became a suitable habitat for growth especially sessile organisms. There were 3 predominant genus of sessile invertebrates found in this area, i.e, muddy tube fan worm (*Sabella penicillus*) and calcareous tube worm (*Mercierella enigmatica*), both belong to Phylum Annelida, and a hydroid (*Bougainvillia pyramidata*) of Phylum Cnidaria. The muddy tube worms, *Sabella penicillus* (Table 4, Figure 3A-C) usually build large muddy tubes around their body, as the name applied, and use them as their habitat. They quickly proliferated and outgrew all other organisms in the vicinity. The muddy tubes became thick superimpose layers of mud on the wall, being rich in nutrients and attracting all kinds of invertebrates there. The calcareous tube worms, *Mercierella enigmatica* (Table 4, Figure 3D-E) built calcareous tube with operculum to flip the tube close when they withdrawn themselves within the tube. The operculum derived from the feather tentacle of the mouth. These tubes were tightly fit around the worm's body and aggregated in bundles. *M. enigmatica* was a pioneer organism grown at the screen plate which situated at the front of the reservoir and, therefore, became an indicator of high water level. Their tightly aggregation at the screen plate caused a severe water obstruction. The plugged screen had to be removed and the worms were eradicated by flaming. *Bougainvillia pyramidata* (Table 4, Figure 3F-H) aggregated like a branch of hydranth bush. There was a pseudohydrotheca covering the lower hydranth part, each hydranth composed of 6-14 slim tentacles. The reproductive zooid or gonophore (Figure 3H) was oval shape, branching from hydranth and producing a lot of sessile medusa (7 mm in size). They could produce up to 4,450 medusa in 3 days and proliferate by budding. Water temperature ranging between 29.6-31°C is preferable for their growth and reproduction (Hayward and Ryland, 1990). The inflow larva from the sea could attach themselves quite well to the muddy tubes and start proliferation at high speed.

These three genera of sessile invertebrates became attached to the screen plate in sequential order. Calcareous tube worms appeared first in December, abundantly proliferated in January and plugged up the tube wall until April. They were gradually declined and diminished in July (Table 4). Muddy tube worms also appeared in December but were reproductively active in March. Their high density was maintained until May. The competition for habitat between these two types of worm caused their population to decline. *Bougainvillia pyramidata*, however, could co-exist well with muddy tube worms and became synchronizely elevated in number during March to May. Both worms were declined in June leaving the tubes empty afterwards.

Although there were three types of invertebrate heavily occupied this area, only muddy tube worms showed their significant influence on the other organisms by providing favorable habitat of thick soft layers of mud and rich nutrient. The sessile organisms found on the tubes were animals of the Phylum Cnidaria, Annelida, Phoronida, Bryozoa, and Ectoprocta as well as some free-living organisms of Phylum Platyhelminthes, Annelida, Mollusca, and Arthropoda found moving on the muddy substrate.

There were also two types of marine protists, *Zoothamnium* and *Acineta*, co-habitating on the branch of *Bougainvillia pyramidata* in the months of January to August. All the invertebrates in this period were marine organisms (Table 5, Figure 2) which completely disappeared later in the rainy season. *Nemalycastis*, a neroid, was the only marine organism survived in the brackish and freshwater and, therefore, remained in the area until the end of

Table 4 Frequency index of protozoan and invertebrates found at the intake water area of South Bangkok Thermal Plant from December 1999 to November 2000.

	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov
Kingdom Protista												
The Protozoa												
Zoothamnium	-	+	+	+	+	+	+	-	-	-	-	-
Acineta	-	+	+	+	+	+	+	-	-	-	-	-
Kingdom Animalia												
Phylum Cnidaria												
Bougainvillia pyramidata	-	+	+	+++	+++	++	+	-	-	-	-	-
Obelia	-	+	++	+	+	+	-	-	-	-	-	-
Stromphia	-	-	-	-	++	+	+	-	-	-	-	-
Phylum Platyhelminthes												
Coronadena	-	-	-	-	-	-	-	-	-	-	-	-
Stylochus	-	-	-	-	+	-	-	-	-	-	-	-
Notoplana	-	-	+	++	++	+	+	-	-	-	-	-
Prosthiostomum 1	-	-	-	+	++	+	+	-	-	-	-	-
Prosthiostomum 2	-	-	-	-	+	+	+	-	-	-	-	-
Phylum Nematoda												
nematodes	+	+	+	+	+	+	-	-	-	-	-	-
Phylum Nemertea												
Prostoma rubrum	-	-	-	-	-	-	-	-	-	-	-	-
Phylum Annelida												
Eunice	-	-	-	-	-	-	-	-	-	-	-	-
Marphysa	-	-	-	+	+	-	-	-	-	-	-	-
Phyllodoce	-	-	-	++	++	-	-	-	-	-	-	-
Nemalycastis indica	-	-	-	+	+	+	+	+	+	+	+	-
Nemalycastis limnicola	-	+	+	+	+	+	+	+	+	+	+	-
Nereis riisei	-	-	-	-	-	-	-	-	-	-	-	-
Polydora	-	+	++	-	-	-	-	-	-	-	-	-
Spio	-	-	+	-	-	-	-	-	-	-	-	
Capitella capitata	-	-	-	+	-	-	-	-	-	-	-	-
Sabella penicillus	+	+	+	+++	+++	+++	++	+	-	-	-	-
Mercierella enigmatica	+	++	++	++	++	+	+	-	-	-	-	-
Phylum Mollusca												
nudibranch 1	-	-	++	++	++	-	-	-	-	-	-	-
nudibranch 2	-	-	++	++	++	-	-	-	-	-	-	-
nudibranch 3	-	-	++	++	++	-	-	-	-	-	-	-
bivalve	-	-	-	-	++	++	++	-	-	-	-	-
Phylum Bryozoa												
Bowerbankia	-	-	-	+	++	+++	++	-	-	-	-	-
Membranipora	-	-	-	+	++	++	++	-	-	-	-	-

Table 4 (con.) Frequency index of protozoan and invertebrates found at the intake water area of South Bangkok Thermal Plant from March 1999 to November 2000.

	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov
Phylum Entoprocta												
Pedicellina cernua	-	-	+	+	-	-	-	-	-	-	-	-
Barentsia gracillis	-	+	+	-	-	-	-	-	-	-	-	-
Phylum Arthropoda												
Balanus	-	-	+	+	-	-	-	-	-	-	-	-
Gammarus	+	+	+	+	-	-	-	-	-	-	-	-
larva stage												
Phylum Platyhelminthes												
Muller's larva	-	++	-	-	-	-	-	-	-	-	-	-
Phylum Annelida												
unidentified trochophore larva	-	+	+	-	-	-	-	-	-	-	-	-
early stage trochophore larva of *Capitella*	-	+	+	-	-	-	-	-	-	-	-	-
early stage trochophore larva of spinoids	-	+	-	-	-	-	-	-	-	-	-	-
middle stage trochophore larva of *Polydora*	-	+	-	-	-	-	-	-	-	-	-	-
nectochaeta larva of *Nereis*	-	+	-	-	-	-	-	-	-	-	-	-
larva stage of *Nereis*	-	+	-	-	-	-	-	-	-	-	-	-
Phylum Mollusca												
veliger larva of Prosobranch	-	+	-	-	-	-	-	-	-	-	-	-
veliger larva of Opisthobranch	-	-	+	+	+	-	-	-	-	-	-	-
veliger larva of bivalve	-	+	-	-	-	-	-	-	-	-	-	-
Phylum Arthropoda												
nauplius of calanoid	+	+	-	-	-	-	-	-	-	-	-	-
late nauplius of calanoid	-	+	-	-	-	-	-	-	-	-	-	-
nauplius of cyclops	-	-	-	-	-	-	-	+	+	+	+	+
nauplius of harpacticoid	-	+	+	-	-	-	-	-	-	-	-	-

Frequency index : + = low ++ = medium
+++ = high ++++ = abundant

October. The reservoir's condition ultimately changed into freshwater and became unsuitable for all kinds of marine and brackish organisms.

4. Potential control

The sequential inhabitant of these invertebrates and their proliferating cycles has led us to find a suitable eradication method to prevent their settlement. Aside from using mechanical means to remove the sessile organisms accumulated at the screen plate as well as installing a back-up filtering system for alternate use. A subsequent increase of the freshwater supply to the cooling system in the months of February to May when the marine organisms are in the process of proliferation would reduce the salinity and lead to eradication of these organisms. As the amount of chloride is lowered, the marine organisms could not survive in this unfavorable condition and become substituted by the less proliferated groups of freshwater sessile organisms, hence, the concurrent inflow of water to the cooling system.

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Table 5 Species number of organisms and chloride level found at the intake water area of South Bangkok Thermal Plant from December 1999 to November 2000.

	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov
Chloride (ppm)	1,750	11,000	8,750	8,212	7,300	1,275	75	22	25	50	50	310
Freshwater planktons	26	26	9	7	9	17	22	20	14	13	8	10
Marine planktons	10	13	17	16	14	10	5	1	0	0	5	5
Marine invertebrates and sessile protists	4	10	18	22	22	16	14	3	2	0	0	0

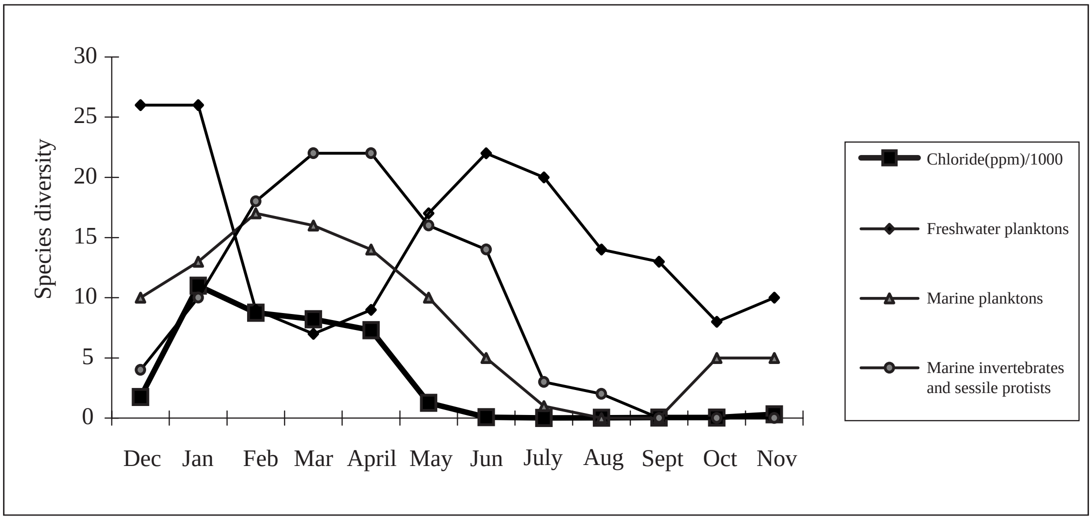

Figure 2 Relationship between chloride level and species diversity of planktonic and organisms found at the intake water area of South Bangkok Thermal Plant.

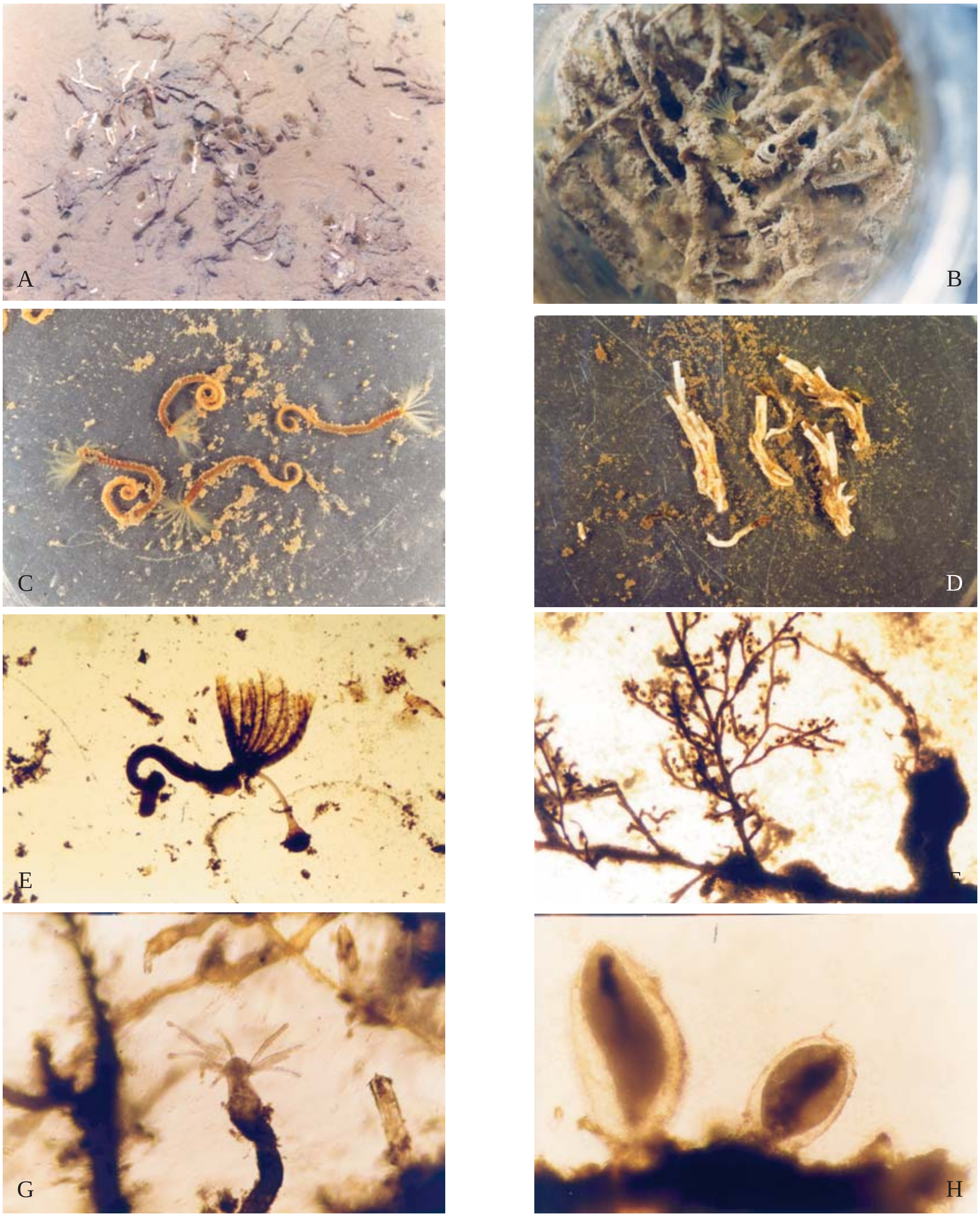

Figure 3 Some fouling organisms : A-C. Muddy tube fan worm (*Sabella penicillus*). A. Showing high density of tube fan worm together with some calcareous tube worm of *Mercerella*. B. The front part of worm emerging from the tube. C. The whole body of tube fan worms. D-E. Calcareous tube fan worm (*Mercerella enigmatica*). D. Calcareous tube fan worms aggregated in colony. E. A single worm separated from its tube. F-H. Colonial hydroid (*Bougainvillia pyramidata*). F. A portion of the colony. G. Hydranth. H. Gonophore.

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