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# Environmental problems induced by the thermal discharges from the power plant (Chinese progress in thermal effects studies)

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## Introduction

Before the middle of the 1970's, some developed nations began to pay much attenttion to the effect of the thermal discharges from power palnts on the eenvironment. And some international symposiums were held in these nations. However, Chinese experts did not pay much attention to this problem until 1978. Chinese experts began to publish some results of thermal effect on the environment in the aerly 1980's. These results provided a ascinetific basis of the regional water temperature and contributed to eavaluate a crliterion for an assessment of environmental problems in water bodies. This reprot introduces the main achievements of these studies in China.

## Methods

Thermal effect of the discharge from power plant on water abodies is complicated. The researches of the thjermal effects in China are divided linto the following aspects:

a. Effect of the thermal dioscharges on the physical and chemical properties of water bodies.
b. Effect of the thermal discharges on plankton community.
c. Studies on the resistibility of freshwater fishes to the high temperature.
d. Studies of a whole effect of a cooling system of power plants on environment.

We referred some reports of foreign experts to analyses above aspects. And we also employed the methods of simulation tests in the laboratory beside the field studies.

## Results

### Influence of thermal discharges on water quality

Thermal discharge influlences some physical and chemical characters of water bodies. From 1980 to 1985, we studied the relationchip between temperature and dissolved oxygen (T-DO) in three different water abodies where were influenced by a thermal discharge. Thelir locations, their environmental condition and their history of temperature raise were differnt. However there was a similarity of a regular change of T-DO relationbship in these water bodies (Figure 1). The correlation of T-DO in each water body was relatively high (Table 1). There was a negative correlation of T-DO in the range from 0° C to 40° C. When the water temperature rise from 5 to 10° C, the DO concentration reduced from 0.5 to 3.0 mg/l. The water temperature was 35° C, the DO concentration was still more than 5.0 mg/l. But tlhe attention was drawn to the DO chnage in the deep layer of the reservoir, when the water body was stratified in the warm period (Figure 2).

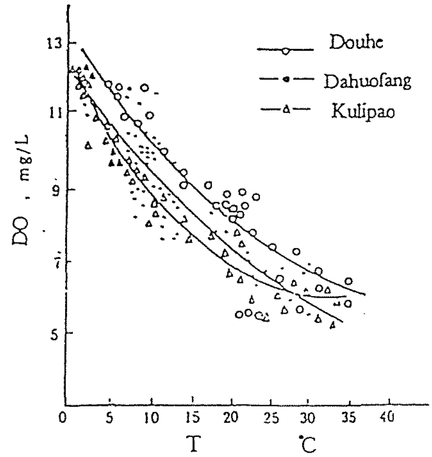



Fig. 1 Relation between tempe-rature and dissolved oxygen in three water bodies with increasing temperature

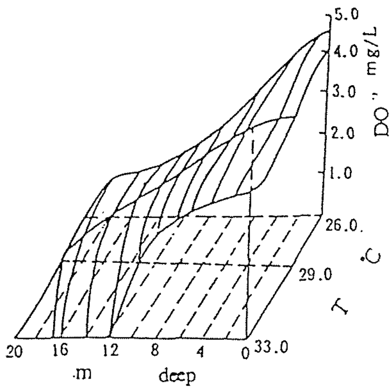
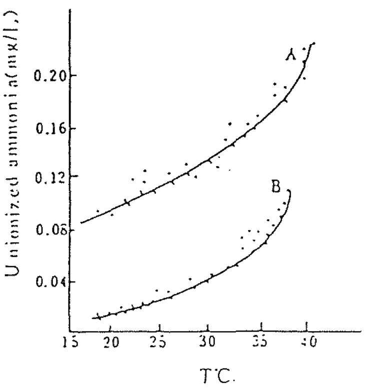



Fig.2 Vertical distribution of DO under extreme climate condition of summer in Dahuofang reservoir

table1. The Correlative equation of T-DO with water temperature

| water bodies | correlation equation | r value |
|---|---|---|
| Dahuofang reservoir | $DO=1.09\times 10^3/(T+56.6)-6.64$ | 0.87 |
| kulipao Lake | $DO=2.76\times 10^2/(T+26.7)+1.5$ | 0.95 |
| Douhe reservoir | $DO=5.2\times 10^2/(T+34.4)-1.25$ | 0.98 |

The un-ionized ammonia is a harmful matter for aquatic animals. The study proved the content of un-ionaized ammonia increased together with temperature raise and pH value raise (Figure 3).




curve $A$: $C=4.2\times 10^{-2}e^{0.417T}$ $r=0.98$
curve $B$: $C=4.6\times 10^{-4}e^{0.142T}$ $r=0.95$
$C$ = un-ionized ammonia content (mg / L)
$T$ = water temperature (℃)
The un-ionized ammonia content of the water

Fig. 3 Relation of un-ionized ammonia and temperature in summer

Long-term monitor data during 15 years of Douhe reservoir where receivced the thermal discharges were compared with the data of nearaby water abody. Statistical analysis indicated that the thermal discharge might cause the change in contents; of some ions iln the waters. The contents of these ions increased obviously after the operation of the power plant (Table 2).

Table2. The change of ions contents in Douhe reservoir

| Ions and Unit | A | B |
|---|---|---|
| $Mg_{2+}$ (mmol/L) | 1.30 ± 0.24 | 0.75 ± 0.18 |
| $K_+$ + $Na_+$ (mg/L) | 24.2 ± 18.1* | 11.6 ± 8.0 |
| tatalions(mg/L) | 353.2 ± 91.3* | 274.9 ± 46.1 |
| tatal hardness(mmol/L) | 1.99 ± 0.42 | 1.58 ± 0.27 |
| $Cl^-$ (mg/L) | 17.90 ± 10.2 | 8.42 ± 1.64 |
| $SO_4^{2-}$ (mg/L) | 49.1 ± 51.1* | 10.9 ± 13.1 |
| $CO_3^{2-}$ (mg/L) | 6.78 ± 6.77* | 0.72 ± 1.88 |
| $Ca^{2+}$ (mmol/L) | 0.98 ± 0.25 | 0.84 ± 0.23 |

A: the contents of ions after the operation of power plant
B:the contents of ions before the operation of power plant
*: T－inspection have signalized different.

## Effects of thermal discharges on the plankton community

The classic studies of the influence of temperature change on phytoplankton community had achieved by Cairng (1956). In China, Yuntian Xie (1988) also studied on this aspect. Jin Lan (1992) and Lianxi Sheng (1994) reported the succession of the phytoplnkton community in the process of thermal eutrophication. The author (Lianxi Sheng) contributed mainly to the effect of temperature raise on the zooplankton community. According to the laboratory study of the temperature range from 20° C to 50° C, the numper of the zooplankton species was the largest and its diversity index was the highest in the water of 30° C (Table 3). But the quantity of Rottifera (Rotatoria) was the largest in the water of 40° C (Figure 4),and quantity of Copepoda was the largest in the water of 30° C (Figure 5).

The relationships between the dynamic changes of water temperature and zooplankton community were analyzed by the PFU method. According to the MacArther-Wilson's fromula of St=Seq(1-e-GT), t90%, Seq and G were gotten by using the minimum square error method. The result indicated that the colonization changed with water temperature (Figure 6, 7 and 8).

Table 3 The kinds and diversity index in different water temperature

| temperature ℃ | 20 | 25 | 30 | 35 | 38 | 40 | 42 | 45 | 50 |
|---|---|---|---|---|---|---|---|---|---|
| number of respcie | 25 | 29 | 32 | 22 | 16 | 14 | 12 | 7 | 2 |
| quantity | 1068 | 862 | 827 | 517 | 393 | 438 | 363 | 177 | 135 |
| S－1/LogeN | 3.44 | 4.14 | 4.61 | 3.36 | 2.51 | 2.14 | 1.87 | 1.16 | 0.2 |
| $S/\sqrt{N}$ | 0.77 | 0.99 | 1.11 | 0.97 | 0.80 | 0.67 | 0.63 | 0.53 | 0.17 |

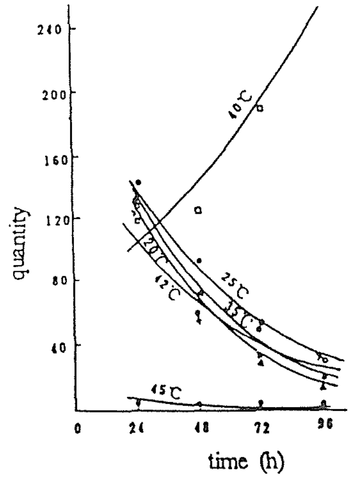



Fig. 4 The relation of the quantity and time of the Rotifera in the different water temperature

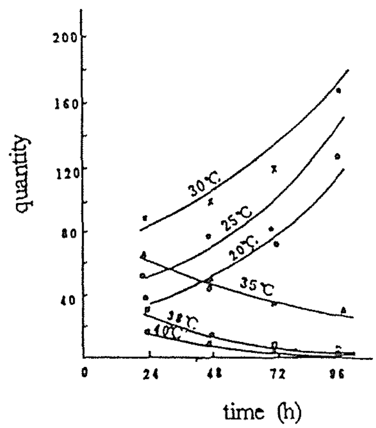



Fig. 5 The relation of the quantity and time of the Copepoda in the different water temperature

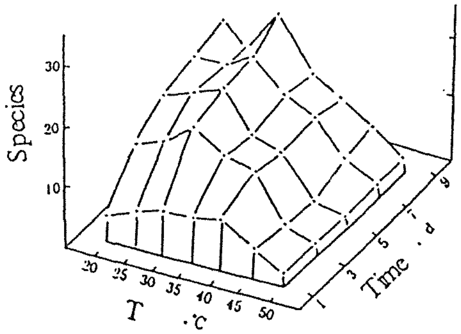



Fig. 6 Protozoan colonization curves in laboratory test

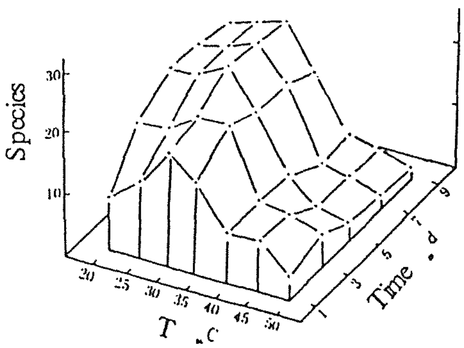



Fig. 7 Colonization curves of periphytic protozoa in laboratory test

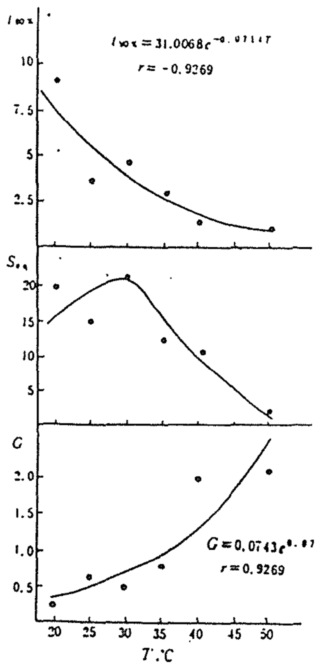



Fig. 8 Temperature dependence of protozoan functional parameters in colonization process

## Studies of fish ecology on the temperature raise

A lot of studies on the influence of temperature raise to fish were done in China. Jin Lan (1989) analyzed the influence of thermal discharges from a power plant on the embryonic development of a carp fish. Lu Wei (1989) reported the influence of different water temperature on the growth of four young fishes. Lianxi Sheng (1989, 1992) repoarted a fish polulatio dynamics in the water bodies with the temperature raise. Zhentang Wang (1989) analyzed a population dynamics of carp using the Lestie matrix method. All of the results indicatted athat the influence of thermal discharges on fish was very complex. The influence on fish related with a trophic niche and a space niche in the whole ecosystem. It was very difficult to assess that benefit or harm. However, it was certain that temperature raise advanced a spawning period of fish (Table 4). But the early spring (Table 5). According to the observation of changes of water temperature, a cold shock was a main factor which led to these results.

table4 spawned roes time of carp fish in Douhe reservoir

| Location | time of spawn roes | | | W.T. ℃ |
|---|---|---|---|---|
| | 1973 | 1984 | 1985 | |
| ΔT>3℃ | end of APR | 14.APR | 17.APR. | 19.0−20.4 |
| ΔT<3℃ | or early of | 18.APR | 15.APR. | 16.0−18.0 |
| Nature water region | MAY | 23.APR | 18.APR | 14−15.8 |
| Neaby water body | ditto | | 17.MAY | 17−19 |

table5 Embryo ecolsion rate of carp fish in Douhe resrvoir

| Item | time | location | | | | N.W.T |
|---|---|---|---|---|---|---|
| | | ΔT>3℃ | ΔT>3℃ | ΔT<3℃ | ΔT<3℃ | |
| W.T.(℃) | APR. | 18.9 | 21.4 | 20.5 | 16.6 | 16.2 |
| | MAY | 22.1 | 24.5 | 20.0 | 19.6 | 16.4 |
| N.R(G) | APR. | 100 | 100 | 100 | 100 | 100 |
| | MAY. | 100 | 100 | 100 | 100 | 100 |
| R.E.E(%) | APR. | 28.0 | 46.0 | 7.6 | 19 | 14 |
| | MAY | 66.0 | 48 | 56 | 41 | 55 |

N. W. T = Natuer Water temperature N. R.= number of roes

R. E. E.= rate of embryonic ecolsion G = grain

This reprot is an outline on the studies of thermal discharges in Chaina. Much of work had been done by the staffs of the Department of Environmental Scinces, Northeast Normal University. The history of study on environmental problems induced the thermal dixchasrges by a power plant in China is very short. Some problems still need further study. After the beglinning of 1990's, experts began to pay more attention to study the problems of a whole effect.