Materials of Conferences

THE INFLUENCE OF THERMAL POLLUTION ON HYDROBIOLOGY OF KAMA WATER BASIN

Zinovev E.A., Kitaev A.B., Noskov V.M.

Perm State University, Perm,
e-mail: zoovert@psu.ru, hydrology@psu.ru

The temperature factor for the aquatic ecosystem is one of the most important among the abiotic components that affect the structure of the aquatic fauna as plankton, so benthos and fish fauna. Thus, any deviation from the natural rhythm of seasonal temperature dynamics, especially in the direction of increasing its level, is classified as thermal pollution. Observations made at the place of discharge of warm water, as well as above and below it, have shown that in the warm water discharge area, there is no tendency for decrease or increase in biomass. There have been some discrepancies between the seasons: the highest biomass has been found in the overheating water zone in months of minimum water temperature; then the differences have smoothed out in the warmer months. Therefore, the carried out observation has shown no significant thermal effects on the ground biocenoses in the area suffering from thermal pollution. The increased temperature background can be dangerous in terms of changing the dates of appearance and the number of generations of aquatic animals such as plankton, benthos, and fish. Besides, effects on the genetic structure of the populations are possible. There is controversy regarding when in conditions of high temperature may some positive effect be achieved (due to acceleration of maturity, changes in growing season, increase in the rate of growth). However, in an atypical thermal regime, rhythmic of physiological processes are destabilized, including those associated with reproduction, and the normal course of morphogenesis is also disturbed. The intense rhythm accelerates the mutation processes and leads to the increase in generic variation. Finally, this could lead to a reduction in genetic potential and a decrease in the evolutionary flexibility of the species. Water temperature, which is outside the natural back-ground, can be a powerful destabilizing factor, which may have a decisive impact on populations of fish and other aquatic organisms, transforming their genetic structure. This may have implications not only for the particular species, but also for the ichthyofauna and the entire ecosystem of a reservoir. Thus, thermal pollution, being the consequence of heated water dumping by thermal and nuclear power plants, is the most important anthropogenic factor influencing the thermal regime of reservoir refrigerants and their ecological systems, and creating conditions for the emergence of environmental risks.

The decrease of dissolved oxygen in a thermal influenced zone has been observed during the whole navigation period when the Perm State District Thermoelectric Power Station has been constructed.

According to the sanitary standards of the Russian Federation the content of the dissolved oxygen in a sample should not be lower than 4 mg/dm^3 during the whole year round. The oxygen content in water during the navigation period in the case study area equals to the 2nd class of quality (clean). In winter season the oxygen content changes from 8,9 up to 12,7 mg/dm^3 and waters also belong to the 2nd class of quality (clean). According to biological oxygen consumption (BOC_5) (in winter this index changes from 0,54 up to 0,65 mg/dm^3) waters correspond to the 1st class of quality (pure). Thus, warm water discharge by the Perm State District Thermoelectric Power Station actually has not influenced the class of water quality according to oxygen and biological oxygen consumption.

The conducted field works have revealed the possibility to use quantitative correlation of saprophilic bacteria of mesophilic group (with 20 °C temperature optimum) with thermophile bacteria quantity (with 30 °C temperature optimum).

The quantity of both saprophile bacteria extracted from water varied widely from June till October. It achieved its maximum in summer (13,5/11,0 thousand cells per ml.), and its minimum in autumn (0,01/0,02 thousand cells per ml.). The near-bottom samples were characterised by a larger quantity of bacteria [2].

The quantity of heterotrophic bacteria in a thermal influenced zone is approximately in 2–3 times higher in comparison to reference areas (in the area of an old river-bed). The maximum quantity of heterotrophic bacteria has been observed in the zone of strong heating. The quantity of saprophile bacteria decreased significantly when heated water mixed with non-heated one. This tendency has been observed during the whole period of study.

The amount of thermophile saprophyte bacteria exceeded the mesophile bacteria quantity in the zone with strong thermal pollution. The extraction of mesophile bacteria from the biocenos is the evidence of the strong effect of a thermal factor on the bacteria community formation.

The decrease of water temperature in autumn leads to the decline of the total amount of saprophytic bacteria in the case study area as well as across the water body. The thermophile forms of saprophile bacteria have been distinguished in autumn. Their largest amount (0,30 thousand cells per ml.) has been discovered in the zone affected by thermal pollution. This amount is mostly remarkable in summer water samples collected at the surface of water body. It is approximately in ten times exceeds the bacteria amount at the river-bed reference area.

To determine the thermal pollution extent during the day sampling from three horizons has been done at the station located at the edge of thermal pollution zone. The soil has been taken twice during the day. The significant changes in the bacteria amount in water samples every four hours have not been observed. The quantity of mesophilic bacteria fluctuated slightly from 0,48 up to 1,06 thousand cells per ml., and the amount of thermophilic bacteria fluctuated from 0,76 up to 1,15 thousand cells per ml. The percentages of both groups are very high (from 50–97%). There is a decrease in the amount of both groups nearly a half in the vertical saprophyte distribution. The quantity of bacteria at 0,5H depth horizon and at the bottom is practically equal. The same situation has been observed in the bottom sediments.

The analysis of long-term data has revealed the decrease amount of mesophilic forms of saprophytic bacteria after the construction of Perm thermoelectric power station (1983 – 15,6; 1984 – 3,5; 1985 – 3,6; 1990 – 1,3 thousand cells per ml. respectively). They are substituted by the thermophilic group with prevailing of mesophilic forms. It indicates the sustainability of the thermal pollution effect.

The recent studies have revealed the prevailing of mesophilic bacteria in the development of bacteria community in water during microbiocenos at the active zone of the Perm State District Thermoelectric Power Station. The low amount of thermophilic bacteria has been observed even in the zone influenced by heated waters. The maximum difference in the quantity of these groups of bacteria has been observed in summer water samples. The low amount of thermophilic bacteria in water may be considered as the adaption of bottom-dwelling bacteria to thermal pollution during vegetation period. The water temperature in water heated zone turned out to be favourable for the mesophilic bacteria growth and their prevailing over thermophilic bacteria quantity in the bacteria community.

The effect of heated water discharge from the Thermoelectric Power Station on the zoobenthos has been accurately studied before and after the station design. Bottom-dwelling species of the case study area affected by the thermal pollution is presented by 20 species of chironomids, 7 species of oligocheates, 6 species of molluscs, 1 species of leeches and 1 species of crustasea [1].

To evaluate the species differences at the reference and case study areas the method of cluster analysis has been applied. Although the species differences are not significant it is possible to distinguish two plots with the most similar bottom-dwelling species. They are three stations at shallow water and two stations at the river channel. Natural differences in the depth gradient but not the anthropogenic effect are the key factor differentiating the fauna at the case study area. The order of species dominance at the study area is typical for the mesomix bacteria complex and is determined by two species of low amount. The set of dominants is practically the same for all five stations. The trophic diversity index demonstrating the uniformity of food groups representativeness dramatically increases in the zone of thermal pollution. This fact testifies the unfavourable trophic situation.

The evaluation of the community structure according to the species diversity and hydrobiont uniformity, their quantitative representativeness have demonstrated that the diversity and uniformity are slightly lower at the high temperature pole gradient than at the opposite one. The stability of such communities is low. They are saved due to resilience that is an ability to return to their previous state after changes under the external influence. The change of benthos biomass during time has demonstrated that this parameter is not influenced by heated waters.

It has been revealed that communities located at one depth are similar and temperature does not affect the zoobenthos macrostructure. It only influences separate types of species and trophic structure of bottom cenosis.

Conclusions

1. The construction of Perm thermoelectric power station has led to the decrease of oxygen during the whole navigation period. The warm water discharge has not practically influenced the water quality class according to the amount of dissolved oxygen and its biological consumption.

2. The case study area of the water body has been characterised by the bottom-dwelling bacteria adoption to the thermal pollution condition. The water temperature has been optimal for the mesophilic bacteria development.

3. Thermal pollution has not been the determining factor during zoobenthos macrostructure formation at the pre-dam part of the Kama reservoir.

References

1. Esunina E.I. Dynamics of bottom invertebrates of the Kama reservoir in the area of warm water of the Perm SDTPS // Biol. Resource of Kama reservoirs. – Perm, 1992. – P. 199–206.

2. Kartunova T.A. Changes in the zooplankton of the Kama reservoir during vegetation season (the region of Dobryanka town) // Biology of the western Urals water bodies. – Perm 1985. – P. 14–22.

The work is submitted to the International Scientific Conference «Nature management and environmental protection», Netherlands (Amsterdam), October 20–26, 2016, came to the editorial office on 01.08.2016.