

9. Conclusions

The statically modeling approaches (MONERIS) together with the harmonized data base allow the reconstruction of nitrogen and phosphorus loads in water bodies of Berlin since the pre-industrial time.

Specific nutrient emission per inhabitant of Berlin depends on the living standards, particularly on the application of P-containing detergents and automatic wash machines. The specific nitrogen emission per inhabitant has not been deviated during the last 150 years, while the specific phosphorus emission per inhabitant has dramatically changed at temporal and spatial scale (West and East Berlin), especially after the Second World War.

The atmospheric nutrient depositions in Berlin are strongly affected not only from the local source, but also the regional and global sources and closely related to the fossil fuel combustions.

The riverine lakes of the lowland river system in Berlin have a high nutrient retention capacity. However, after a long time of overloading, their nutrient retention capacities have been degraded, especially for phosphorus.

The transitional points in the course of nutrient development are due to changes in water supply and drainage system, the sewage farms, the establishment of waste water treatment plants and their technological improvements and the legal and management system. Technological improvement for waste water treatment plants, closure of sewage farms and the nutrient-related legal requirements are the major driving forces for the decreasing trend of nutrient loads recently. The diffuse sources play more and more an important role in nutrient emissions to surface water bodies.

Nitrogen loads to surface water bodies of Berlin have been reduced since 1987. Total phosphorous loads have been reduced from the peak in 1979. Total nitrogen introduction into Berlin's surface water system by waste water treatment plants is considerably higher than its total input by inflowing waters. Nitrogen and phosphorus have also different priority in the technological improvement for waste water treatment plants. Most technological improvement in the 1980ies focused on the phosphorus elimination. Nitrogen elimination has just been applied since 1990. Due intensive anthropogenic impacts, some surface water bodies in Berlin (for example, the Teltowkanal) have quite different seasonal variations compared to the natural water bodies.

The present level for nitrogen load is about 4-4.5 times higher than the level in the mid 19th Century. Phosphorus load is 3 times higher. In order to get the "good status" required by the The Water Framework Directive (WFD), phosphorus emissions from urban area of Berlin

must be continuously reduced. This goal can be reached by application of new technologies in waste water treatment plants as well as new efforts in nutrient mitigation.

The spatial differentiation of Berlin water bodies is predominantly determined by the inside factors (effluent of waste water treatment plants, overflow water, heat emission from power plants) and inflow waters. Overflow from the combined sewer system is an important diffuse pollution source in the inner city area and inflow water also contributes to the differentiation in the quality of Berlin waters. At present, the runoff from urban area increases the discharge in Berlin's rivers by one third. But the nitrogen load of these waters doubles the nitrogen load of the sources in the upstream catchments.

The experience on the mitigation of nutrient emission of Berlin during the last 150 years can be a good lesson for other cities, especially in the developing countries. This research method will support other reconstruction efforts, for example by diatom analysis from sediment cores.