2. Introduction

In 1999, when the project started, Hungary had a critical wastewater management problem. Approximately 30% of the wastewater treatment plants (WWTP) were overloaded and the effluent water quality did not meet either the Hungarian or the European Community water quality standards.

As a result of the joined treatment of industrial and domestic wastewaters, toxic materials frequently caused shock loads resulting in inadequate effluent quality. There was no ammonia, organic nitrogen, nitrate and phosphorous removal at the 88% of WTPs. There were 412 WTPs in the country with a total capacity of 1.719 million m^3/day. The total treatment capacity consisted of 85.8% (1,474,902 m^3/day) biological and mechanical treatment from which 179,000 m^3/day treatment capacity involved nitrogen and phosphorous removal as well. The remaining 14.2% of the total treatment capacity consisted of only mechanical treatment. The shortfall of biological treatment capacity (BTC) in the country was approximately 843 thousand m^3/day from which 442 thousand m^3/day was related to the overloaded WTPs. (Recently the total treatment capacity is 1,954,082 m^3/day and the daily quantity of untreated wastewaters is 793,357 m^3)

The wastewater treatment technologies (WWTT) usually increase the loadability of WTPs and improve the effluent water quality by enhancing the efficiency of pollutant removal and/or by increasing the detention time of the wastewater in the treatment facility. The latter approach however, requires a larger aeration basin and higher investment, as well as operation cost. Because the establishment of new WTPs and enlargement of the existing ones were limited by financial constraints in Hungary, the best way to improve the quality of sewage effluent was to increase the efficiency of existing facilities.

The most often used wastewater treatment method in Hungary is the aerobic biological one in which the organic and inorganic pollutants are decomposed and converted to gases and cell tissue by bacteria in the presence of oxygen. The culture of bacteria forms a living, so called activated sludge. The capacity and the loadability of WTPs depend on the activity and settling characteristics of the activated sludge. These sludge parameters however, can be improved with the addition of zeolite particles into the raw wastewater. Since Hungary has abundant zeolite supplies and also has experiences in the application of natural zeolites in wastewater treatment (WWT) to solve or reduce the problem, it was logical to upgrade the biological WTPs using zeolites.

Zeolite particles are excellent carriers of bacteria and substrates. Since oxygen and the adsorbed substrates are accessible in high concentrations for bacteria immobilized on the zeolite particles, the decomposition rate of organic compounds becomes higher. Since the specific gravity of bacteria flocs containing zeolite is higher than that of usual flocs, the settling rate of the waste sludge will be higher.

The application of natural zeolite, in spite of the advantageous effects, has a significant drawback. The zeolite additive becomes effective only after 5 - 7 days. This can be explained by the slow or inhibited biopolymer production of bacteria, since bacteria attach to the zeolite particles through their biopolymer chains. In this project, a novel zeolite modification method and a wastewater treatment technology have been developed in order to accelerate and improve the zeolite - bacteria interaction, as well as increase the loadability of WTPs, improve the quality of treated water and decrease the investment and operation costs of WTPs.

The WWTT based on the application of modified zeolite (trade name: ZeoRap®) was tested and introduced at twelve WTPs in Hungary between 2001 and 2004. The laboratory- and industrial-scale applications showed that the ZeoRap® WWTT

- instantly improved the biological treatment processes of wastewaters and sludge settling
- increased the decomposition rate of organic compounds (expressed in COD) by 20 - 50%,

- increased the nitrification and denitrification rates by 40 - 60%,
- increased the rate of phosphorous removal by 15 - 25%,
- decreased the value of sludge volume index (SVI) by 20 – 40%
- reduced the polyelectrolyte demand of sludge dewatering by 20 – 30%
- decreased the effect of low water temperature on nitrification and denitrification activity

As a result of the above effects the ZeoRap® WWTT increased the capacity of biological WTPs and improved the quality of treated wastewaters. These beneficial effects could be attained by negligibly low investment costs and reduced operation expenses resulting in lower expenses of WWT.

Assuming that at least 20% of the overload can be eliminated by using the ZeoRap® WWTT, 88,000 m^3/day virtual WWT capacity increase can be realized at the currently overloaded WTPs. If the technology is adopted nation-wide to all WTPs, virtually a BTC of 295 thousand m^3/day can be obtained. Considering that the unit investment cost for 1 m^3/day BTC is 450 EUR, the value of the increased capacity is 39.6 million EUR at the currently overloaded plants and 132.9 million EUR at all WTPs.

The zeolite modification method and the WWTT using modified zeolite have been patented in Hungary and are pending at the PCT Office in Germany for international patenting since 2001. Scientific and technical results of the project have been (1) presented at three international and five national conferences. Three papers introducing the new zeolite modification process, the properties of modified zeolite and its effects on biological WWT, as well as the results of industrial-scale applications of the ZeoRap® WWTT were submitted to the editorial board of three scientific journals (Measurement, Hydrological News, Water Environmental Science) in 2004. Four WTPs in Hungary regularly employed the ZeoRap® WWTT (WWTP of Szob, Dunakeszi, Dombóvár, Kiser) that was authorized in Hungary by the National Water Authority in 2003. Two companies (Unichem Ltd. and Bioteam Corp.) regularly manufacture and dispense modified zeolites for WTPs. The Institute of General and Analytical Chemistry of the Technical University of Budapest and the Civil Engineering Department of the University Florida consistently teach the analytical aspects of zeolite modification, as well as the ZeoRap® WWTT. The project has a PhD student (Ms. Kucsák) at the Szent István University and had an MSc student (Mr. Kucsora) at the Ybl Miklós Technical High School. (Mr. Kucsora defended his thesis, and graduated in 2002.) The Chematech Ltd. and the Uwatech International Consultant, Ltd. included the ZeoRap® WWTT in a Romanian (WWTP of Beszterce) and a Hungarian (WWTP of Debrecen) projects in 2004. Scientific instruments and software procured and developed in the frame of the project had an important role in the laboratory and field measurements, data evaluation, as well as in demonstrating the environmental and economic effects of ZeoRap® WWTT.

In order to make the project visible and relevant to the public, the project itself, its results, and those effects on the Hungarian zeolite industry and wastewater management were presented in various television (6 times) and radio (5 times) programmes, as well as published in daily papers and magazines (21) times) between 2000 and 2004.