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Wastewater Treatment in the Slovak Republic

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Abstract

This paper reviews the present status of sewage, wasterwater treatment and water quality management in Slovakia. The impact of discharged wastewater on the quality of receiving waters is presented. Legislation in Slovakia is compared with European legislation concerning water quality effluent standards. Typical treatment methods used are described and the problems of wastewater monitoring discussed. The serious problems with sludge treatment and disposal are analyzed. Possible perspectives with the relation of size of wastewater treatment plants and the requirements of approved effluent standards are indicated. The suggested steps for improving the present situation in this field are presented.

Keywords: wastewater treatment, sludge treatment and disposal, water quality control, effluent quality standards, legislation and standardization in water sector, environmental policy

Introduction

Since 1990, political, economic and social changes in Slovakia have influenced almost every element of socioeconomic life, including water management. The ongoing economic transition has also affected the generation and quality of wastewater. Increasing water prices have been reduced and might continue to decline the production of wastewater. These changes have improved the quality of particular river parts in Slovakia by one or two water quality classes. However, it is expected that domestic wastewater flows will hardly change despite the liberalization of water price.

It is known in Slovakia that the required costs to clean up the environment are huge (the environmental debt of the Slovak Republic for the past five decades is estimated at about 3.5 billion USD), but financial resources are not available for these investments. This fact has had a great impact on environmental policy and it seems to be characteristic of all post communist countries located in Central and Eastern Europe (CEE).

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The objective of this paper is to review the present status of sewage and wastewater treatment in Slovakia, their impact on the quality of receiving waters, to discuss possible wastewater treatment technologies used with respect to the new legislation for effluent standards, and to attempt to evaluate the priorities in this field.

Background Information

The Slovak Republic is situated in the center of the European continent in the watershed of two seas: the Baltic Sea and the Black Sea. The territory can be characterized as the roof of Central Europe, because the majority of the rivers draining Slovakia and entering those seas (Váh, Hron, Nitra, Ondava, Torysa, Laborec, Bodrog, Hornád, Poprad) originate here. Evidently, the formation of ground and surface water resources depend mainly on atmospheric sources (760 mm annual average).

The area of the Slovak Republic is 49,036 km^2 and its population is ca. 5,300,000. The average population density is 108/km^2; however, the irregularity of population density in particular regions is relatively high.

The environment carries the burden of the environmentally hazardous industrial and, especially agricultural activities. It is assumed that production of industrial BOD_5 represents a pollution load corresponding to ca. 18 mil. population equivalents [1].

The total length of watercourses is 44,666 km, but only ca. 8,200 km are systematically controlled. The majority of the rivers are direct or indirect tributaries of the Danube River, which flows to the Black sea. Only the Poprad River flows to the Baltic sea. As there are only two significant rivers flowing through Slovakia (the Danube and Morava) and as they are only boundary rivers in the south and south-west of the country with a relatively short length, the majority of the pollution leaving this country originates from Slovak sources and contributes to the pollution of neighbouring countries, especially of Hungary and Poland. Because of the dense population and industrialization, the dilution capacity of rivers is often insufficient.

From the facts mentioned above it is evident that the most important factor influencing the quality of watercourses in the Slovak Republic will be the quality of water treatment. Consequently, this problem is and will be of international significance.

Legislation and Standardization Activity

The present water law is based on Water Act No.138/1973. This act was framed very progressively, thus it satisfies even the existing needs of water pollution control in the country, except the articles concerning state ownership of water management. Regarding wastewater treatment, the most important requirement is that all subjects discharging wastewater or special water into surface or ground water must ensure treatment in a manner corresponding with the contemporary state of technical development to ensure the quality of receiver. The Water Act also authorizes the government to specify effluent standards according to the level of knowledge and technical possibilities by means of governmental directives.

The first Gov. Directive concerning water quality came into force in 1975 (No.30/1975). It was based on ambient water quality standards, which defined the quality of receiving water after mixing with the effluent. Effluent quality standards were set up for most parameters describing the quality of surface water. However, everyday practice has shown that the approach and also the numeric values of individual standards were not realistic according to the existing possibilities, especially concerning the lack of investments. The government "solved" this problem with the system of "exceptions" (consent for effluent discharge differing from the Water Act).

The new legislative norm for effluent standards was issued in November 1993. Gov.Directive No.242/1993 (analogy to Czech Gov.Directive No. 171/1992) was prepared with the aim of corresponding with European legislation, especially with Directive 91/271/EEC. It represents a step in the transition from ambient water quality standards to (end-of-pipe) effluent standards common in European countries. The Directive represents the combination of end-of-pipe and ambient water quality standards and as such, contains two kinds of standards:

- end-of-pipe standards (maximum acceptable level of pollution in the discharged effluent), which are defined both for municipal (see Table 1) and selected industrial wastewaters,
- ambient water quality standards, which are defined for the receiving water. The receivers are divided into the two groups-watercourses protected for water supply, and watercourses not utilized for this purpose.

Table 1. Effluent Standards in Gov Directive No. 242/93

Pollution source size	Effluent Standard [mg/l]				
	BOD_5	COD	SS	NH_4^+-N	P_{total}
	*/**	*/**	*/**	*/**	*/**
<50	80/60	-	65/50		-
<500	60/50	-	55/40		-
<5 000	50/40	170/140	45/35	-/20	-
<25 000	45/35	150/120	35/30	25/15	-/5
<100 000	35/30	125/100	30/25	15/10	5/3
>100 000	30/20	110/90	25/20	10/5	3/1,5

Note: At treatment plants with more than 25,000 P.E. even partial nitrogen and phosphorus removal is expected; standards are valid till the year 2005(*) and after the year 2005(**); parametr BOD_5 with suppressed nitrification; standards are set up for 8-hour composite sample

Nowadays, Gov.Directive No.242/1993 is the most important legislative norm and it will hopefully influence the perspectives of wastewater treatment in the Slovak Republic for a long time. However, problematical section exist and in the near future it will be necessary to modify this Directive (e.g. missing effluent standard for total inorganic nitrogen as a sum of ammoniacal, nitrite and nitrate nitrogen; system of sampling, etc.) - experience from the Czech Republic with very similar conditions is described in [2].

Except for the discussed Gov. Directive new technical Standards (former ČSN, now STN) corresponding to the contemporary state of knowledge and technical development are being prepared to ensure required water quality (14 technical Standards (STN) in 1995). The most important Standard according to the described purpose will be the STN Municipal wastewater treatment plants, especially for the problems of nitrogen and phosphorus removal processes.

Receiving Water Quality

Quality of receiving waters is evaluated according to the following documents: the Standard STN 75 7221 and Gov.Directive No.242/1993. The Standard classifies the quality of surface waters into 5 classes, the Directive into two classes (above-mentioned water supply purposes and others). Both of them have their own criteria for water pollution control (according to the Directive classification, e.g. water supply watercourses should have BOD_5 less than 8 mg/l - compare with Table 2). In Slovakia ca. 60 watercourses have been declared protected for water supply purposes [1]. The real quality of receiving waters, which determines the selection of priorities in protection of most polluted watersheds, is illustrated in Table 2.

Table 2. Quality of Watercourses in Terms BOD_5 (in 1991) [1]

River catchment area	Length in watershed*)	River length with BOD_5	
		8-15 mg/l	>15 mg/l
	[km]	[km]	[km]
Danube	1158	315	316
Váh	2187	210	860
Hron	2166	27	749
Bodrog/Hornád	2858	87	153
Total	8368	639	2078

*) Length is given only for the permanently controled parts of watercourses.

Sewage and Wastewater Quality

The total population served by sewage is 51 %. The best situation is in Bratislava (the capital) with 96 %, in other regions it varies from 42 to 54 % [1]. These values are comparable with many European countries (see Fig.1).

However, several towns with a population of 10,000 or more still do not have a complete sewer system and only half of their inhabitants are served by sewage. About 1,400 settlements are without any sewage and only 283 settlements (only 10%) have complete sewer systems [3].

Specific wastewater production, including sewered industries, ranges in larger towns from 200 to 500 l/cap.day. In smaller communities it ranges from 150 to 260 l/cap.day [1]. And a permanent decrease of specific production has been observed over the last few years as a result of increasing water costs [4].

The quality of sewage is the next problem. A high portion of groundwater infiltration causes the dilution of wastewater and a decrease of temperature. Consequently, problems in wastewater treatment occur. BOD_5 concentrations in influent to municipal wastewater treatment plants are summarized in Table 3.

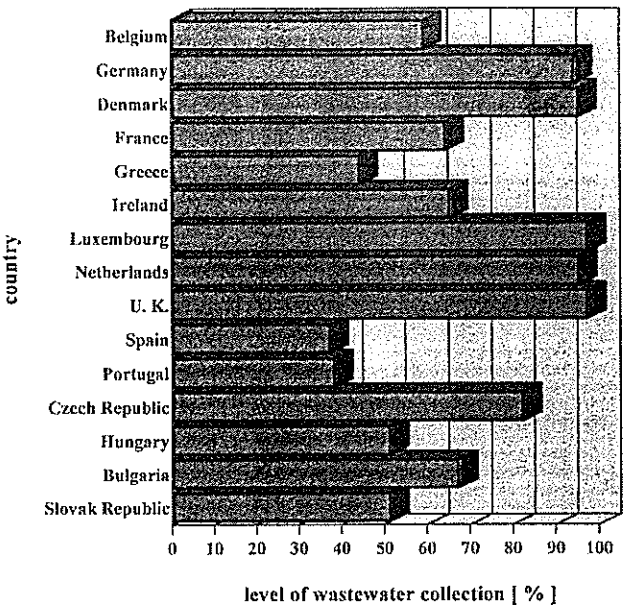


Fig. 1.Wasterwater collection in EU countries [5,6] and selected CEE countries [6].

The majority of industrial wastewater is collected together with municipal wastewater and consequently it is treated at municipal treatment plants. Industrial wastewater influence is characterized by the following values [1]:

- ratio of industrial and municipal flow rates Q_{ind}: Q_{mun} is higher than 1 in 45 % of cities with more than 25,000 inhabitants
- ratio of industrial and municipal BOD_5 (BOD_{ind}: BOD_{mun}) is higher than 1 in 51 % of municipal treatment plants,
- ratio BOD_5: COD in raw wastewater is lower than 0.4 at 12 % of treatment plants.

Recently these ratios have been changed due to the decline of the production of industrial wastewater.

Wastewater Treatment Plants and Sludge Management

About 100-130 municipal treatment plants are regularly monitored in the Slovak Republic, the total number is about 170. Total capacity is ca. 1,400,000 m^3/day. However, only ca. 41% operates in accordance with the required effluent standards [6]. The main reason of inadequate treatment is hydraulic and mass overloading. Inefficient quality of wastewater treatment process is documented also by effluent BOD_5, COD and by BOD_5 removal efficiency (Fig. 2).

Presently, over 300 treatment plants, mainly small plants, have been designed and prepared for construction [1]. About 140 treatment plants remain incomplete due

Table 3. Influent concentration at municipal treatment plants [6].

BOD_5 [mg/l]	Number of treatment plants
<100	11
100-150	31
150-200	51
>250	26

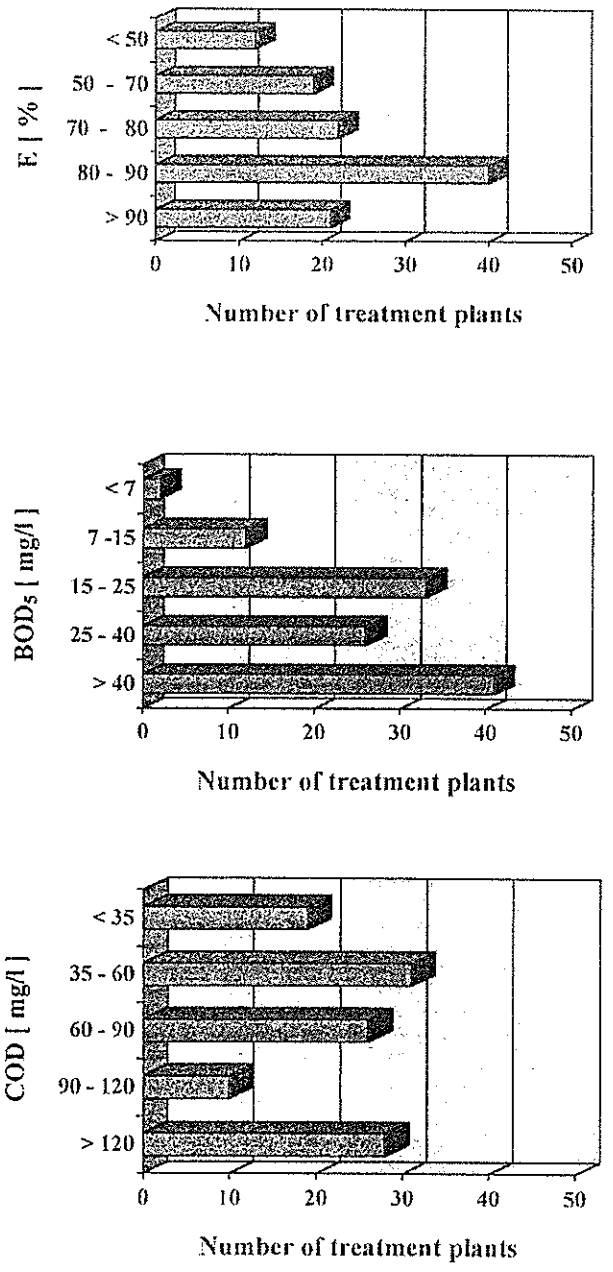


Fig. 2.Municipal treatment plants effluent quality in terms in BOD_5, COD and BOD_5 removal efficiency ver. number of municipal treatment plants in Slovakia [6].

to lack of investment. This problem is serious because more of these plants belong to the large treatment plants according to their population equivalent capacity.

The distribution of treatment plants in Slovakia is in Figure 3. It is evident that smaller plants prevail. Due to the demographic situation of Slovak population and due to the more realistic local investment possibilities it is expected that the small plants will be those most frequently designed and constructed in the near future.

Typical municipal treatment plants contain mechanical-biological processes. Application of physical-chemical methods is exceptional. The range of technologies is relatively low and this fact will be a serious problem according to the new legislative demands on nitrogen and phosphorus removal. The distribution of treatment processes is as follows [1,6]:

- mechanical treatment, Imhoff tanks (ca. 23%)
- mechanical treatment in primary clarifiers or Imhoff tanks followed by biofilters (ca. 4%)
- mechanical treatment in primary clarifiers followed by high or medium loaded activated sludge process (ca. 45%)
- low loaded activated sludge process with extended aeration (aerobic stabilization) (ca. 24%).
- other technologies (4%).

Low loaded activated sludge systems are characteristic of small treatment plants. Because of the high loading of the biological step in the majority of the larger treatment plants nutrient removal processes are ineffective. Only some of the recently constructed treatment plants are applying nitrification-denitrification or biological phosphorus removal. However, these plants are only of a small range and the described processes are applied mainly with the aim of reducing aeration and to decrease the operation costs of activation. The two largest treatment plants (capacity more than 100,000 population equivalents) with controlled biological nitrogen and phosphorus removal are under construction in Poprad and Rimavská Sobota. Because of the lack of investments, probably future upgrading of treatment processes will be oriented on modification of existing technologies (upgrading of biofilters and activated sludge reactors, application of new aeration systems, combination of fixed-film and suspended biomass processes, improvement of final clarifiers, etc.). In any case, according to the Standards introduced in Gov.Directive No.242/1993 in many cases "hi-tech" nutrient removal systems will have to become a standard technology in Slovakia (in contrary to "low-tech and low-cost" systems very often recommended for Central and Eastern European countries).

An interesting fact is connected with the application of non-standard technologies. In spite of a significant production of high-loaded wastewaters, e.g. high ratio of wastewaters from agriculture, chemical industry etc., application of anaerobic treatment technologies is minimum (less than 10 plants in Slovak Rep. in 1995).

The next serious problem concerns the monitoring of wastewater treatment plants and the regulation/optimization of the treatment process. At present, only fundamental wasterwater characteristics are measured (BOD_5, COD, suspended solids, volatile solids, pH). Measurement of nitrogen and phosphorus forms in raw waste or treated water is still rare and the basic information about these important compounds is still missing. Optimization of treatment, especially of activated sludge processes is realized by measurement of dissolved oxygen which has been applied recently at many plants. ORP is the next parameter, which will be applied in the near future very often. However, there is a lack of operational experience with these methods.

Sludge Treatment and Disposal

Municipal treatment plants currently produce about 1.9 million tons of dry sewage sludge solids per year [1]. Future production and disposal of sludge will be affected by two dominant factors: the changes of effluent standards and new tighter sludge disposal regulations. In any case, a gradual increase in sewage sludge production is expected. Sludge treatment methods depend on the wastewater treatment method. For larger plants anaerobic sludge stabilization is preferred. Aerobic sludge stabilization is typical for small treatment plants in Slovakia. The recommended capacity for aerobic stabilization is less than 25,000 population equivalents. The distribution of stabilization methods is in Table 4.

Table 4. Sewage sludge stabilization methods [1]

Method of stabilization	[%]
mezophilic anaerobic stabilization	38
psychrofilic (cold) anaerobic stabilization	30
aerobic stabilization	29
without stabilization	3

Table 5. Sludge dewatering methods [1]

Method	[%]
sludge beds	82
lagoons or without dewatering	6
mechanical dewatering	12

Application of sludge dewatering methods is described in Table 5. The ratio of conventional methods (sludge beds and lagoons) is still relatively high as climate conditions in many regions of the Slovak Republic favor these processes. However, mechanical dewatering is expected to increase. Almost all new treatment plants are constructed with mechanical processes. Most of the plants utilize belt filters (belt filters are produced in the Slovak Republic). Filter presses and centrifuges are used less frequently.

Sludge disposal is the main contemporary problem of sludge management. The actual quality of the sludge and sewage sludge disposal regulations have resulted in a significant reduction of agriculture utilization. Allowable concentrations of heavy metals in composted sludge are summarized in Table 6.

Table 6. Allowable heavy metal content in composted sludge [9]

Heavy metal	Concentration [mg/kg]	Heavy metal	Concentration [mg/kg]
As	50	Hg	10
Cd	13	Mo	25
Cr	1 000	Ni	200
Cu	1 200	Pb	500
Zn	3 000		

According to the results in 1993, 17 treatment plants from 60 plants with capacity more than 15,000 population equivalents produced sewage sludge with higher heavy metals concentration. The annual amount of this sludge was about 34,400 t. Cd exceeded allowable concentration in 9 cases, other problematical heavy metals were Cu (3 cases), Ni (5 cases), Cr (5 cases), Cu (4 cases) and Zn (4 cases) [8]. However, in many cases it is the diffidence, which prevents the reuse of sludge in composting or in direct application on agricultural soil (unfortunately, present legislation has changed sludge from a fertilizer to a waste product even in cases where it is not necessary). In many parts of the Slovak Republic, especially in the northern regions, there are possibilities of sludge disposal in forestry. Application of alternative disposal methods such as incineration, regulated co-landfilling with separated municipal solids waste, source of building material, etc., is minimal.

Perspectives of Wastewater Treatment

Effluent quality required by legislation affects the selection of adequate technologies. As the required effluent quality depends on the size of a pollution source, each particular category will demand specific technologies.

For smaller plants (<5,000 population equivalents) fixed-biomass reactors (trickling filters, rotating bio-

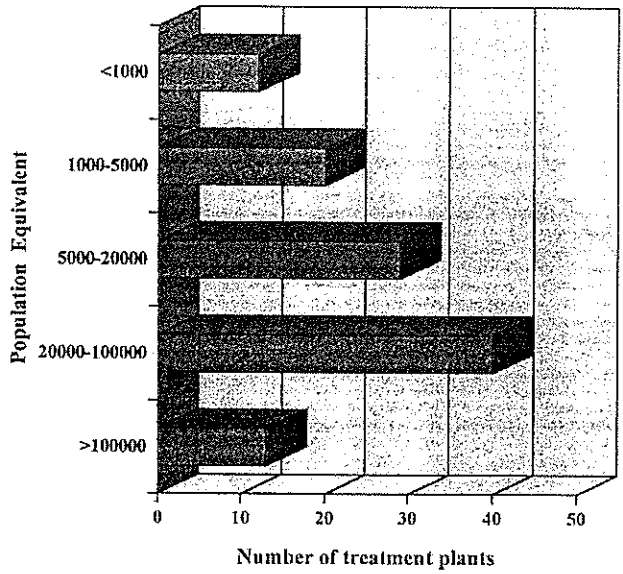


Fig. 3. Capacity distribution of wastewater treatment plants [6].

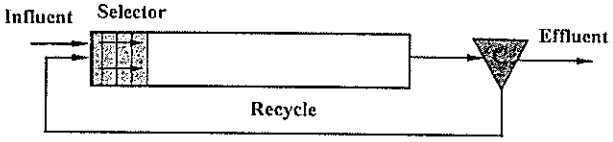
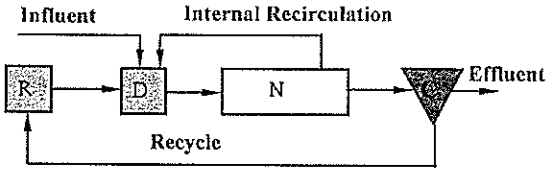


Fig.4. Selector activated sludge system [10], (S-selector, C-clarifier).



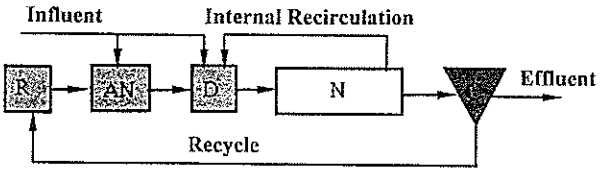


Fig. 5. R-D-N and AN-R-D-N activated sludge system [12, 13], (R-regeneration reactor, D-denitrification reactor, N-nitrification reactor, AN-anaerobic reactor, C-clarifier).

contactors, etc.), low-loaded activated sludge reactors with aerobic stabilization (oxidation ditches or Carousel plants, SBR system, activation with separate stabilization, etc.) are recommended.

For medium size plants (25,000 - 100,000 population equivalents) except of organic pollution removal systems also nutrient removal processes are topical. For this purpose simultaneous (Carousel, oxidation ditch) and pre-denitrification processes are preferred. Application of alternative denitrification or SBR denitrification is exceptional. Sludge is stabilized in separate aeration tanks or by means of psychrofilic or mezophilic methanization.

For treatment plants with more than 100,000 population equivalents systems with enhanced biological phosphorus removal should be considered (with preceded anaerobic zone, often compartmentalized to control the growth of filamentous microorganisms) Sludge is stabilized mostly by mezophilic methanization and mechanically dewatered.

Application of chemical precipitation of phosphorus in many cases is acceptable because of lower investments, however its application should be (if possible) temporary.

Reasonable efficiency, low construction and operation costs of treatment processes will be required. Many plants should be expanded or upgraded in several steps resulting in more complicated treatment lines. Some equipment (blowers, pumps, etc.) have to be imported; however the majority of the necessary equipment for treatment plants is also produced in the Slovak Republic. As for technologies, a significant number of biological treatment systems are designed and constructed by Slovak enterprises. Many technologies with positive references are of Slovak or Czechoslovak origin, e.g. selector activated sludge systems (compartmentalized activation reactors, kinetic and metabolic selection) [10, 11], R-D-N and AN-R-D-N process (nutrient removal systems with compartmentalized anaerobic and anoxic reactor and with regeneration of recycled sludge) [12,13], activated sludge system with internal clarifier ODKAL (high recirculation ratio of activated sludge by means of pressure air, without recirculation pumps) [14], etc.

Conclusions

The presented analysis of the state of water management in the Slovak Republic demonstrates that there is a great need for wastewater treatment in almost all regions. Several receivers are highly polluted. The current number of treatment plants is not sufficient, many of them are overloaded or simply badly operated and do not work with the required efficiency.The range of applied technologies is relatively low and especially nutrient removal technologies should be constructed.

Due to limited financial sources the upgrading of existing plants will be topical. The investment costs required to improve the present state in water treatment, sludge treatment or sewage would cause enormous difficulties even for a stable economy. Therefore, it is necessary to develop a strategy which is in harmony with the needs of the economic changes and existing social problems.

Improving the present situation requires the solution of the following problems:

- determination of correct regional, national and international priorities, short-term and long-term goals
- rational environmental financial policy
- adoption and acceptance of environmental legislation
- reduction of the impact of poorly designed, constructed or operated sewage, wastewater and sludge treatment plants
- integrated approach to the wastewater treatment problem (collection of wastewater, monitoring of wastewater quality and quantity, treatment processes and optimization, sludge management, impact on receiver quality and dilution capacity, etc.)
- enhancing the training of treatment plant designers and operators.

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