

XV CONFERENCE ON  
PROGRESS IN WATER TREATMENT

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JUERG AEPPLI\*, PETER DYER-SMITH\*, JULIE PLUMRIDGE\*

OZONE IN POTABLE WATER TREATMENT IN THE UK

The use of ozone in potable water treatment has become increasingly common throughout the UK. This is an advanced treatment option which can be optimised to meet specific requirements. The theory behind the application of ozone and some of the different treatment options available are discussed with reference to case studies where possible. There have been significant recent advances in ozone generation technology including improved economics and higher ozone concentrations. These have enabled ozone to become a more viable option for potable water treatment. Today, the major application for ozone within the UK is pesticide removal in order to achieve the standard of  $0.1 \text{ g/m}^3$  required by the EC Drinking Water Directive for organic micropollutants. However, more extensive use of ozone has given a broad base of practical information regarding other benefits such as improvement in taste and odour, colour removal, algae control, minimisation of THMs, etc.

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SŁAWOMIR BIŁOZOR\*, ANIELA DANIELAK\*

EVALUATING THE BIODEGRADABILITY OF ORGANIC MATTER IN WATER

Biological stability of drinking water is an essential criterion of treatment efficiency, especially when the water to be treated contains large amounts of organic matter. While standardized analytical methods are available for the quantitative determination of many different unstable species (ammonia nitrogen,

nitrite, bisulfide ion, hydrogen bisulfide, thiosulfate, Fe(II) and Mn(II)), no such technique has been developed so far for the measurement of biodegradable organic matter. The paper includes a critical account of four analytical techniques which are in use now and enable evaluation of biodegradable organic matter. Thus, there is the van der Kooij method, which allows determination of easily assimilable organic carbon (AOC) by measuring the growth of the *Pseudomonas fluorescens* P17 strain. The method proposed by Werner and Hamsch consists in measuring the turbidity produced by the regrowth of microorganisms which utilize biodegradable organic matter. Servais and co-workers developed an analytical technique providing measurements of bacterial growth either by epifluorescence or by incorporation of  $^3\text{H}$ -thymidine. Joret and co-workers suggested a method in which biodegradable dissolved organic carbon (BDOC) is estimated by daily measurements of dissolved organic carbon (DOC) in incubated water samples. According to the authors of the paper, the Joret method seems to be best suited for routine determinations, especially when supplemented by measuring the rate of heterotrophic bacteria regrowth.

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#### CHARACTERIZING THE POROUS STRUCTURE OF ACTIVATED CARBON BY THE $\alpha_s$ -METHOD ON THE EXAMPLE OF BENZENE ADSORPTION FROM AQUEOUS SOLUTIONS

Experimental isotherms of benzene adsorption from gaseous and liquid phases at 20 °C were determined for four commercial activated carbons. Their micropore capacity and mesopore surface area were established by the  $\alpha_s$ -method. The isotherm of benzene adsorption from aqueous solutions on the SAO macroporous carbon (reference sample) was evaluated from the corresponding benzene isotherm in terms of the similarity coefficient ( $\beta^* = 0.52$ ). It was found that the porous structure parameters evaluated on the basis of gas phase data differed only slightly from those established on the basis of liquid phase data. This finding shows that benzene adsorption from diluted aqueous solutions provides useful data for the characterization of the porous structure of activated carbons.

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HENRYK DERA\*

#### GROUNDWATER DISINFECTION BY UV RADIATION: A CASE STUDY

The investigated object is the Waterworks of Oświęcim and its two water treatment plants, Zasole and Zaborze (south-west Poland). At the Zasole Treatment Plant (infiltration water intake) chlorine dioxide was substituted for gaseous chlorine in 1994. At the Zaborze Treatment Plant (groundwater intake) sodium hypochlorite was replaced by UV radiation in 1995. The treatment train adopted for the needs of the Zaborze Plant includes water disinfection via a UV lamp system (made by Berson UV, Holland). In this paper, a technical description of the UV device has been given, and the efficiency of disinfection

obtained by this method has been discussed. The paper also includes a brief analysis of capital and operating costs. As shown by the results of this case study, disinfection performed with the Berson UV lamp system yields satisfactory bacterial kills, and the water supplied to the municipal pipeline tastes and smells like spring water. The disinfecting device is easy to handle and creates no hazards either to the service staff or to the natural environment.

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BOGDAN KOCZKO\*, ANNA MOSSAKOWSKA\*, BEATA PACHOLEC\*

### ON THE MODERNIZATION OF THE PRAGA WATERWORKS IN WARSAW

The benefits from removing organic and mineral pollutants (especially ammonia nitrogen) by riverine filter beds are discussed. A two-stage method of laying drains in the river bottom is proposed, which makes it possible to upgrade not only the yield of the intake, but also the quality of the taken-in water. The experience gained from the operation of such an intake has substantiated the utility of the adopted system. The operation of the intake has been failure-free so far, and it has been possible to maintain a stable yield in the winter season as well. The quality of the water supplied by the Praga Waterworks and the potentiality for its upgrading were analyzed. Making use of the results of model investigations, it was suggested that the treatment train should be added two more unit processes – ozonation and sorption on GAC beds. This modernization option allows application of chlorine dioxide to water disinfection at doses equal to, or lower than,  $0.4 \text{ g/m}^3$ , thus providing potable water of desired quality. The potentiality of using hydrogen peroxide for the purpose of ozonation was also investigated.

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TADEUSZ KOWALSKI\*

### EFFECT OF FERRIC CHLORIDE POLYMERIZATION ON THE EFFICIENCY OF WATER COAGULATION

Water samples collected from the Odra river were treated by ferric chloride coagulation at varying polymerization of the coagulant ( $\text{OH}^-/\text{Fe}=0$ ;  $\text{OH}^-/\text{Fe}=1.5$ ;  $\text{OH}^-/\text{Fe}=2.0$ ). The dosage of polymerized ferric chloride was found to have no effect on the efficiency of organic matter removal. Non-polymerized ferric chloride yielded better removal efficiencies, especially for COD, which were by 5 to 10% higher than when polymerized ferric chloride was applied. The same holds for the removal of other organic substances and coloured matter. The application of polymerized ferric chloride did not affect the chemism of the coagulation process, which manifested in the occurrence of a minimum in the COD reduction versus Ca/Mg curve. Polymerization of ferric chloride had a noticeable effect on the concentration of iron in the effluent from the coagulation-filtration process.

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### PROTECTED ZONES FOR WATER INTAKES: A CASE STUDY

There were investigated two water intakes (both being part of the water supply system for the city of Białystok) situated in the Supraśl river valley, which has a specific geological structure and favourable hydrological conditions. One of the intakes (Wasilków) draws surface and infiltration water, whereas the other one (Jurowce) draws groundwater. Both the intakes need a strict determination of a sanitary protection zone in order to preserve, or upgrade, the quality of the taken-in water. The extension of the protected zone should be considered very carefully, as the region in question has not only urban and rural areas, but also natural landscape parks and spas. The authors of the paper suggest a number of solutions to the problem. They also indicate how to reach a compromise between the variety of interests expressed by land users.

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URSZULA OSIŃSKA\*, KAROL KUŚ\*

### OZONATION BY-PRODUCTS IN BROMIDE-CONTAINING WATER

The presence of bromide ions in the water to be treated for municipal supply creates serious problems, especially when the treatment plant uses ozone for technological purposes. Some of the by-products which build up in the course of ozonation show mutagenic activity (e.g., dibromochloromethane, bromoform, dibromoacetonitrile or bromochloroacetonitrile); others are even more dangerous due to their cancerogenic nature (e.g., bromate or bromodichloromethane). The investigations reported in this paper concentrated on the following major items: (1) mechanisms governing the formation of bromate and trihalomethanes; (2) influence of the ozone dose ( $O_3$  to TOC) on the quantity of THM and bromate produced in the course of the ozonation process, and (3) the relationship between bromide concentration, contact time, residual ozone concentration and ozonation by-products. The experiments were run with untreated and treated water samples.

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JANUSZ ŁOMOTOWSKI\*, JAROSŁAW HALINIAK\*

### AMMONIA NITROGEN REMOVAL FROM GROUNDWATER VIA BIOFILTERS

Nitrification process that occurs in a water supply system was investigated in a laboratory. The process was found to occur in two stages: with oxidation of ammonia nitrogen to nitrites at the first stage and oxidation of nitrites to nitrates at the second stage. When nitrification occurred in the water supply system, there was a concomitant increase in the number of nitrifying bacteria as well as in the concentrations of nitrites and nitrates in the tap water. Investigations into the biological mechanism of

'dry' filtration showed that the growth of nitrifying bacteria in the 'dry' sand filter differed from the one in the 'dry' activated carbon bed. The results of laboratory tests substantiated the high efficiency of the fluidized-bed reactor (packed with granular activated carbon) which provided favourable conditions for an effective biochemical oxidation of ammonia nitrogen.

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#### ON THE UTILITY OF THE CAD/CFD PROGRAM IN ANALYZING AND MODELLING SLOW-MIX TANKS: A CASE STUDY

The Podolszyce-Płock Water Treatment Plant (Masovia, Poland) is the object investigated. The high-efficiency CAD technique was used for the simulation of hydrodynamic phenomena in full-scale through-flow systems (slow-mix tanks). In this way the existence of dead zones in fluid mixing was detected. To overcome this drawback it was suggested that the number and shape of the baffles should be changed.

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WŁODZIMIERZ MOŻARYN\*

#### CORRELATION BETWEEN WATER QUALITY AND CHLORINE DIOXIDE DEMAND FOR FINAL DISINFECTION

The paper presents the results of a 12-month pilot-plant study which aimed at establishing the chlorine dioxide demand for final water disinfection. Statistical methods revealed that there was a correlation between chlorine dioxide doses and typical water quality parameters. The study led to an unexpected finding – chlorine dioxide demand was only about one-third the required chlorine disinfection dose. The possibility of predicting the disinfection dose demand was analyzed.

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URSZULA OLSIŃSKA\*, KAROL KUŚ\*

#### TOTAL HARDNESS REMOVAL BY CRYSTALLIZATION

The proposed technique of total hardness removal (a heterogeneous crystallization process) is a modification of the well-known method made use of in boiler-water preparation. With filter sand acting as crystal nucleus, the crystallization process runs in the reactor. The sand forms a kind of fluidized bed supported by the water stream flowing through the reactor. In their paper, the authors concentrate on two major items: on the choice of the reagent (NaOH) dose and on the problem of how this affects the

efficiency of the process. Process efficiency is related to the operating parameters of the fluidized-bed reactor (flow velocity, pellet diameter, fixed-bed depth), which determine the other hydraulic parameters of the reactor (Reynolds number, head loss, porosity, specific surface area, velocity gradient). The course of the reaction is influenced by the shape of the reactor as well as by the method and point of raw water and reagent injection. And this means that an appropriate choice of both hydraulic and technological parameters provides an effective course of the process, thus contributing to the achievement of the hardness removal efficiency desired.

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JAN PAWELEK\*

### REDUCTION OF WATER TURBIDITY BY STORAGE: A CASE STUDY

The object under study is the water intake of Szaflary (south of Poland), which draws river water (Biały Dunajec) for municipal supply. The water entering the treatment plant is characterized by an increasing turbidity. The study reported in this paper aimed at assessing the potentiality for turbidity reduction by near-bank storage. There were analyzed the turbidity levels and water consumption measured within the area of the 'Nowy Targ' Municipal Supply Network (which makes use of the investigated Biały Dunajec intake) in the hydrological years of 1987/88 to 1995/96. According to the adopted values of critical turbidity (above which the operation of the intake should be discontinued and the municipal supply system should be fed with the stored water), several variants were established. The investigations showed that during episodes of very high water turbidity the use of the water from near-bank storage was beneficial. For the critical turbidity of 15 g/m<sup>3</sup>, 50 g/m<sup>3</sup> and 100 g/m<sup>3</sup>, the total turbidity load decreased to the level of 33.24%, 53.61% and 60.25%, respectively.

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### TWO-PART TARIFF AS AN INSTRUMENT OF TARIFF POLICY IN WATER SUPPLY SERVICES

The problem of tariff policy has always attracted the attention of both local authorities and users. Their interest increases with the increasing charges for water supply services, the more so as they almost comprise the total costs of water intake, treatment and distribution. The paper presents some general principles of tariff policy in water supply. Consideration is given to such major aspects as self-financing of water supply services, fairness of charges, encouragement to reasonable water use, promotion of high-quality and high-efficiency services, etc. There are analyzed the reasons for implementing a two-part tariff which includes a fixed lump-sum charge compulsory for everyone (irrespective of the quantity of water used) and a variable charge, increasing or decreasing according to the amount of water used. The authors proposed a mathematical formula for the calculation of the said charges. However, the latest

regulations (issued at the end of 1996) do not permit implementation of the two-part tariff proposed, as they require that one-part tariffs (directly proportional to the volume of water used) shall be collected.

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WITOLD SUMISLAWSKI\*

#### MEDIUM-RANGE INVESTMENT PROGRAM (1997-2003) OF THE WATERWORKS OF WROCLAW

The investments included in the program aim at modernizing the water supply and sewerage systems of Wrocław, a municipality of about 700,000 inhabitants. There is an urgent need to improve the quality of drinking water supplied to the households as well as to provide an efficient and reliable sewerage system. Thus, the investment program concentrates on the following major items: modernization or retrofit of the existing objects, construction of new facilities, and reduction of operating costs.

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#### ON THE UTILITY OF MICROBIOLOGICAL ANALYSIS IN MEASURING THE BIOLOGICAL ACTIVITY OF CARBON FILTERS USED IN WATER TREATMENT

Some of the methods made use of in evaluating microorganism growth in carbon filters which are part of a water treatment train were analyzed in terms of their efficiency. Comparative tests were run to establish how the method of carbon sample preparation or microorganism number determination might affect the results obtained. Dominant organisms (in terms of quantity) were identified. There were evaluated the results of microbiological and physicochemical analyses before and after treatment on filter beds made of Chemviron F-400, Norit 0.8 Supra or Picabiol activated carbons. Homogenization and a phosphate buffer as the rinsing solution were found to be best suited for the removal of microorganisms from the carbon grains. The highest number of microorganisms was the one obtained with the method of phospholipids determination in the carbon bed film. The results of physicochemical analysis (which had been performed after passage through the filter beds) substantiated a higher efficiency of Chemviron and Norit 0.8 Supra carbons as compared to Picabiol. *Pseudomonas* bacteria were found to be dominant. Bacterial growth was more intensive in the upper than in the lower layers of the carbon beds. The proposed microbiological method of bacteria growth control for granular activated carbon beds is of utility in evaluating the efficiency of the water treatment process.

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WOJCIECH BALCERZAK\*, IZABELA ZIMOCH\*\*

## MATHEMATICAL MODELLING OF WATER QUALITY VARIATIONS

The theoretical background to a eutrophication model and the computing program EUTRO 4 (based on that model) were characterized. With the eutrophication model and the EUTRO 4 scheme, concentration variations were simulated for some of the water quality parameters which characterize the eutrophication process. The agreement between theoretical and measured results was promising. This indicates that the program will provide reliable predictions of water quality.

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MARIAN BŁĄZEJEWSKI\*

REMOVAL OF LEAD, CADMIUM AND NICKEL BY INFILTRATION  
THROUGH A LOW-FLOODED AREA WITH MEADOW PLANTS

The presence of heavy metals is particularly troublesome when water treatment involves infiltration. For small objects, specifically when the water to be treated contains heavy metals, infiltration through a low-flooded area with hydrophilic meadow plants is a promising alternative. Two physical models were used to assess the efficiency of Pb, Cd and Ni removal. Infiltration was carried out with tap water treated with peptone, dextrin, humus extract, clay suspension and relevant heavy-metal salts. The models were flooded with a 10-cm water layer five to seven times a week. Model investigations were carried out for three years in the vegetation seasons. Both models provided removal efficiencies of 80–90%, 91% and 98% for lead, cadmium and nickel, respectively, which means a decrease to the levels admissible for drinking water. The grassy model was found to adsorb higher quantities of heavy metals than the non-grassy model. This indicates that infiltration of water containing Pb, Cd and Ni through a low-flooded thin soil layer grown with meadow plants provides effective heavy metal removal for a markedly longer period than does a soil layer with no vegetation. Another advantage of meadow-plant growth is a higher infiltration factor.

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ZYGUMUNT DĘBOWSKI\*, JOANNA LACH\*, EWA OCIEPA\*

ON THE CONTRIBUTION OF ACTIVATED-CARBON PROPERTIES  
TO THE REMOVAL OF CHROMIUM COMPOUNDS FROM WATER

Hexavalent chromium and trivalent chromium were removed from water, using three activated carbons produced by the vapour-gas method. The experiments were run under static conditions with



single-component solutions (containing either  $\text{CrO}_4^{2-}$  or  $\text{Cr}^{3+}$ ) and two-component solutions (containing both the species). Each of the investigated activated carbons provided sufficient sorption of these pollutants. The adsorption isotherms for the single-component solutions in the investigated concentration range (up to  $0.8 \text{ g/m}^3$ ) were straight lines. The sorption effect for the two-component solution was not as good as that of the sum of relevant Cr(VI) or Cr(III) concentration in the single-component solutions.

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ANDRZEJ JODŁOWSKI\*

### ON THE CONTRIBUTION OF TECHNOLOGICAL PARAMETERS TO THE REMOVAL OF ALGAL SUSPENSIONS BY DISSOLVED-AIR FLOTATION (DAF)

The efficiency of algae removal by the DAF technique was related to the parameters of agglomeration and separation. The experiments were run with laboratory-grown green algae cultures. The parameters of agglomeration included oxidant ( $\text{ClO}_2$ ) and coagulant (alum) doses, pH as well as duration and rate of mixing in the course of flocculation. The parameters of separation comprised recycle ratio and saturation pressure. Destabilization of particles was necessary to provide favourable conditions for micro-agglomerate attachment to the collectors (bubbles). Coagulation was a pretreatment step in the DAF process, which aimed at destabilizing algal particles. Alum doses were lower than those used in the conventional process, as there was no need to produce large-size flocs. Preoxidation with  $\text{ClO}_2$  made algal particle destabilization easier and had a beneficial influence on the kinetics of the agglomeration process. Flocculation time was short in order to avoid large floc formation: flocculation periods shorter than 5 minutes provided a good performance of the DAF process. High volume fractions of air bubbles created favourable conditions for particle-bubble collision. The contribution of the air-bubble volume fraction to the efficiency of the DAF process was investigated by varying the saturator pressure and maintaining a constant recycle ratio. It was found that saturation pressure should exceed 0.4 MPa so as not to deteriorate the efficiency of the process.

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APOLINARY L. KOWAL\*

### CORROSION CONTROL OF MUNICIPAL WATER DISTRIBUTION SYSTEMS

The mechanism and development of corrosion in water networks are related to tap water quality parameters and treatment methods. The problem of corrosion control of distribution systems and plumbing is illustrated on the example of some waterworks from different countries, where use is made of a variety of inhibitors. Consideration is also given to pipe encrustation, which can be prevented by corrosion control or hard water softening via decarbonation. Corrosion of water nets produces 'red water', whereas corrosion of plumbing increases heavy metal concentrations in tap water. Soft water, of a hardness  $<125 \text{ g CaCO}_3/\text{m}^3$ , is very aggressive. Increasing the hardness over that limit, keeping pH at saturation limit and dosing inhibitors decrease the corrosion effects, which is important for economical and public health reasons.

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GRZEGORZ KOŹMIŃSKI\*, KAROL KUŚ\*

### THICKENING AND DEWATERING OF COAGULATION SLUDGES AT THE WATER TREATMENT PLANT OF GOCZALKOWICE

Laboratory tests were run to investigate the proneness of coagulation sludges to thickening and dewatering. On the basis of experimental results, the type and dose of the flocculating agent were established, and the method of sludge processing was selected. The results of laboratory tests were verified by full-scale experiments which revealed that coagulation sludge was quite effectively thickened by gravitation (for 1.5 h) and thereafter by seasoning in sludge-drying beds or, alternatively, by centrifugation, once the capacity of the drying beds had been exhausted.

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### WATER PRETREATMENT BY DISSOLVED-AIR FLOTATION (DAF): A PILOT-SCALE STUDY FOR THE NEEDS OF THE NORTHERN WATER TREATMENT PLANT IN WARSAW

The pilot plant is part of the water supply system in the north of Warsaw. The objective of the study was to investigate the utility of coagulation and DAF in the pretreatment of potable water. At the first stage of the experiments, optimum pH and optimum coagulant (ferric sulphate – PIX or alum) doses were established. The second stage involved experiments with two-stage coagulation and DAF, using all possible configurations of the coagulating agents at their optimal doses. There was investigated the problem of how the DAF process affects the removal of phytoplankton and organic substances (expressed in terms of COD and UV absorbance). The results obtained seem to support the utility of DAF as a pretreating process for the needs of the Northern Water Treatment Plant. Removal efficiencies varied from 60 to 75%, from 60 to 71%, and from 92 to 98% for COD, UV absorbance and phytoplankton, respectively.

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ZBIGNIEW ŁEPKOWSKI\*

### THE ROLE OF OZONE IN WATER TREATMENT PROCESSES

The application of oxidizing agents for the purpose of disinfection is an important part of the water treatment train. It was conventional to use disinfectants (chlorine compounds) as a final step of water treatment. But once the implications of chlorine to human health had been detected, disinfection became part of an earlier stage of the treatment process (prechlorination) and there appeared a tendency to replace chlorine by ozone. Many water treatment plants, especially in France, began to apply pre-ozonation. However, pre-ozonation was also found to have an adverse effect on human health when the water to be

treated carried high pollution loads. The objective of the study reported in this paper was to determine the stage of the treatment process at which the application of ozone might be most appropriate. There were investigated a number of large water treatment plants in Poland, and the results of introducing ozone into their treatment trains were analyzed. The application of ozone has two major advantages – ozone enhances the technological process and extends the duration of the filter cycle. The decrease of organic matter content is becoming a problem of prime importance, the more so as the admissible levels of organics in potable water have been lowered by the most recent environmental regulations in Poland.

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#### QUALITY OF DRINKING WATER IN 1992–1996 UNDER OPERATION OF SAUR NEPTUN GDAŃSK

In the period of drinking water deficit in the city of Gdańsk, the quality of the water drawn from the overused groundwater intakes deteriorated drastically. The start-up of the surface-water intake Straszyn in 1986 eliminated water shortage, but did not improve water quality (organoleptic properties) or abate the presence of micropollutants in finished water. In 1992, hardly any of the 20 municipal intakes complied with the requirements of the EC Drinking Water Directive and only 10 met domestic sanitary regulations. The problems considered in the paper can be itemized as follows: quality of water in the main sources of municipal supply (with emphasis on the deterioration of groundwater intakes and the Straszyn intake); favourable improvements in water quality in 1992–1996 due to the modernization of the surface-water intake in Straszyn and due to some desirable changes in the management of water production from the main groundwater intakes; water quality forecasts and options for the time span of 1995 to 2010 (on the basis of pilot-plant investigations and modelling of biological treatment of groundwater). The paper also provides the results of 6-month monitoring of water quality in the water supply system for the city of Gdańsk.

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#### MODERNIZATION OF THE ZWIĘCZYCA-RZESZÓW WATER TREATMENT PLANT

Making use of the results obtained from 12-month pilot-plant investigations, the authors proposed a modernization and redevelopment concept for the Zwiężczyca-Rzeszów Water Treatment Plant (south of Poland). The treatment train established for the modernization plant will provide high-quality water.

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BRONISLAW NOWOK\*

INDUSTRIAL REGENERATION OF ACTIVATED CARBON  
SPENT IN THE COURSE OF WATER TREATMENT

In the mid 1990's, a modern industrial system for the regeneration of spent activated carbon was constructed at the Waterworks of Katowice (Upper Silesia). The paper provides the technological diagram of the system as well as a detailed description of its parts and of the high-temperature process during which spent activated carbons are regenerated. There were investigated three types of activated carbon made use of in the treatment-in-water process and thereafter regenerated. It was found that, following regeneration, each carbon displayed adsorbing properties similar to, or even better than, those of a fresh item. The performance of the regenerating system (2,000 t/a) was found to be sufficiently high not only to cover the needs of the Katowice Waterworks, but also to make regenerating services available to other water treatment plants.

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## DEMANDS CREATING WATER SUPPLY SERVICES IN A MARKET ECONOMY

On the example of the city of Gdańsk, the condition and performance of the water supply systems which are in service in Poland were re-assessed so as to meet the demands of a market economy. It was found that the predicted quantity of water consumption had always been overestimated in the past. As a result of that overestimation, the attention of decision-makers was focused on a continual development of water intakes and water mains. The equipment of the water-pipe network as a whole, relevant control systems and their automation were neglected and remained undercapitalized. In the light of the study, the following generalization can be made: The quantity and quality of potable water should be improved without unnecessary development of the pipelines. The actual condition of the water supply systems in Poland calls for radical changes in decision-making and management on the level of local administration.

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CONVERSION OF NITROGEN COMPOUNDS  
IN THE INFILTRATION WATER INTAKE OF POZNAŃ

To assess the variations of nitrogen compound levels in infiltration water we made use of the data sets obtained from physicochemical analyses of water samples, collected in the time span of 1970 to 1992 and investigated for the presence of ammonia nitrogen, nitrite, nitrate and organic nitrogen. The data sets

were grouped into three categories: with no disinfection according to water temperature, for water temperature below 10 °C, and for water temperature equal to, or higher than, 10 °C. For the purpose of the study two processes were considered – infiltration and rapid filtration. On comparing the <10 °C data sets for water samples collected directly from the river Warta and after infiltration, we found that the retention time for the investigated period approached 80 days. Statistical analysis revealed a significant difference in ammonia nitrogen concentration between riverine water samples and water samples after infiltration for temperatures <10 °C. Nitrite concentration was lower, and nitrate concentration was higher after infiltration for all the temperatures considered. No significant differences in ammonia nitrogen concentration between the two types of water samples were found to occur at temperatures >10 °C. This might be attributed to plankton blooming and ammonification in the pond bottom. Rapid filtration enhanced the nitrification process, which was concomitant with a decrease of ammonia nitrogen concentration and an increase of nitrate nitrogen concentration, irrespective of water temperature. Concentration of nitrite nitrogen also decreased significantly irrespective of temperature. Total nitrogen concentration after passage through the filters was lower than that before passage. The lacking portion of nitrogen must have been assimilated by the bacterial cells which form a biofilm in the soil, but we cannot exclude the occurrence of denitrification in the filter layers, either.

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#### NITRATE REMOVAL FROM WATER

Consideration was given to three methods made use of in water supply in order to remove nitrates. The course of the water treatment process for each of the three methods was shown in diagrams. For the adopted performance of 50 m<sup>3</sup>/h and an anticipated concentration of nitrates, there were calculated capital costs, energy demand, energy cost and operating costs. Total cost of removing nitrates from one cubic meter of water was calculated for each of the treatment methods applied. The results of the study support the potentiality for nitrate removal from water by physical, chemical and biological methods with the use of domestic devices and facilities.

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#### ASSESSING THE EFFICIENCY OF SURFACE WATER DISINFECTION

A method of determining an effective disinfectant dose for polluted surface water is presented. Water pollution was simulated by inoculation with marker bacteria and by addition of soil extracts containing humic substances. At high pollution loads, disinfection with chlorine or chlorine dioxide was found to be of little effect. The application of high disinfectant doses had the disadvantage of producing new chlororganic compounds of a carcinogenic nature. For this reason, it seemed advisable to determine such a disinfectant dosage (specifically for chlorine dioxide) that would provide sufficient disinfection without

contributing to the formation of carcinogenic species. The efficiency of disinfection was found to be satisfactory only after the highest possible organic matter removal as a prior step.

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### GAC FILTER PERFORMANCE DURING THREE-YEAR FULL-SCALE OPERATION: A CASE STUDY

The object under study was the Upper-Silesian Waterworks of Dzieńkowice with its GAC filters, which were set in operation in the autumn of 1993 and were regenerated following exhaustion in 1996. The performance of the investigated carbon filters was related to water temperature, treatment plant capacity, pretreatment method, filtrate quality and structural parameters of the filter beds. The efficiencies of the filters were analyzed according to the type of the activated carbon used (granular hard-coal-based, granular peat-based, or pulverized hard-coal-based). All the activated carbons under study were found to provide very high removal of organic pollutants, especially THM precursors. There was assessed the relationship between biological activity of the carbon bed and efficiency of organic matter removal as well as the problem of how some factors affected the activity of the microorganisms involved. It was found that a high biological activity of the carbon filters was concomitant with a high oxygen uptake from the water. And this means that reducing the capacity of the carbon bed to very low values or discontinuing the operation of the filter bed might undesirably affect the quality of both filtrate and carbon. The rate of adsorbing capacity exhaustion was estimated by measuring the iodine number of the activated carbons after each cycle. According to these data, deactivation took place after two years of operation. The extension of the carbon life for another year should be attributed to the microbiological processes that occurred in the beds. Heavy metal content varied throughout the three-year operation of the activated carbon beds, but no cumulating effect was observed. Other metals (e.g. sodium or potassium) were partly washed out in the course of operation.

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