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ABSTRACTS

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Tomasz STYPKA

Critical review of municipal solid waste management models

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The article reviews the existing models of municipal solid waste management. Three, the most well known models' classifications are presented. The author analyses the categories developed by MacDonald, Björklund and Morrisey and presents its own classification. According to the author, the models can be divided into three categories: mathematical models, computer simulation models and models of sustainable development. The mathematical models category contains all the models which try to describe the solid waste management assuming the full accuracy of the data. The models which use techniques of linear programming , mixed integer programming and dynamic programming are all in this category.
The computer simulation category contains models which accept the fact that made assumptions do not have to be fully accurate. To solve the problem of uncertainty the models implement the theory of fuzzy sets, grey sets, and probability.
The last category of models contains all the models which try to solve the problem of solid waste management implementing the concept of sustainable development as the main objective of analysis. This category contains the models which are based on Life Cycle Analysis, Decision Support System models and models which use multicriteria analysis.
The author presents different models from each category specially focusing on the models belonging to the category of models of sustainable development. The critical analysis of models shows the potential direction of further models' development.

Lucyna PRZYWARA, Bożena MROWIEC, Jan SUSCHKA

Anaerobic treatment of municipal sewage in the psychrophilic conditions

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Psychrophilic anaerobic process is an attractive option for sewage treated at moderate and low temperature. The article discusses possibilities of municipal sewage treatment in the bioreactor - upflow anaerobic filter (UAF), operated in the psychrophilic conditions. Investigations were carried out in laboratory scale and the temperature of the bioreactor varied between 17- 20ºC. The investigations have comprised of two series of tests. The values of hydraulic retention time (HRT) amounted to 30 and 48 h. The digestion feedstock comprised of sewage taken from a treatment plant (WWTP Bielsko-Biala Komorowice), operated in a full scale. The treatment process of sewage with the application of UAF system has shown positive results in the laboratory scale of studies. The process ensured a high effluent quality - COD < 200 mgO_2/dm^3, however, degree of COD removal depended on the value of HRT used.

Yuliya VYSTAVNA, Yuriy VERGELES, Felix STOLBERG

Study of pharmaceuticals in a model urban river as potential molecular markers of wastewater effluents, their sources and socio-economic correlates (the city of Kharkiv, Ukraine)

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In recent decades the amount of pharmaceutical residues have significantly increased in water bodies located near and within urbanized areas, as a result of extensive use of different medical drugs. Pharmaceutical residuals are suspected to enter rivers, streams and surface waters through the effluent of sewage treatment plants. After intake, pharmaceuticals are excreted with urine or faeces to raw sewage in both an unchanged form and as metabolites. The presence and behaviour of these emerging pollutants in the aquatic environment are still poorly known, and continuous research is demanded. The goal of our study was to identify the targeted pharmaceuticals and their potential sources in a model river, Lopan, in the city of Kharkiv, Ukraine. The Polar Organic Chemical Integrative Samplers (POCIS) have been applied for the detection of pharmaceuticals in sites upstream and downstream of wastewater treatment plants from which treated wastewaters are discharged to the river. The sampling has been done during May 2009 and December 2009. Totally, 19 of 21 targeted substances were detected in sites upstream and downstream of the urban areas and treated wastewater discharge. Such compounds as, diclofenac, carbamazepine, caffeine were found in the highest contents in all installed passive sensors. The carbamazepine can be used for tracing pathways of sewage water, even the treated one. In contrast, the caffeine is a labile and easy degradable compound so it can be used for the identification of effluents of untreated wastewaters. It was also found that the presence of some pharmaceuticals exhibits seasonal variations.. In spite of steady increase of pharmaceutical residues in water bodies, the elimination of these substances is not provided on a high level within the conventional sewage treatment.

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Removal of nitrogen from the main stream of municipal wastewater treatment plant with combination of Ion Exchange and CANON process (IE-CANON) – effect of NaCl concentration

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Keywords: wastewater, main stream, ammonium, ion exchange, CANON, IE-CANON.

Completely Autotrophic Nitrogen Removal Over Nitrite (CANON) is a combination of partial nitritation and Anammox process that is currently used for treatment of wastewater streams with high ammonium concentration and low C:N ratio. Removal of nitrogen from the main stream of municipal wastewater which has relatively low ammonium concentration with CANON process is challenging because of low biomass production rates of Anammox bacteria. One of the possible solutions for overcoming this limitation is concentration of ammonium from the mainstream before biological treatment.
The technology that is being studied implies concentration of ammonium from mainstream municipal wastewater with ion exchange on strong acid cation exchange resin with further removal of ammonium by CANON process and is referred to as Ion Exchange assisted CANON (IE-CANON) process.
This paper presents results of evaluation of NaCl concentration on the two parts of the technology performance – ammonium concentration with ion exchange and CANON process. The results showed that higher NaCl concentrations give possibility to reach higher concentration of ammonium in regenerate in ion exchange process. However, these concentrations lead to partial inhibition of bacteria responsible for nitritation process and almost complete inhibition of anammox bacteria in CANON process. Therefore it is concluded that the optimal concentration of NaCl in regenerant is 10 g/L. At this concentration both the concentration of ammonium to the required level is possible and bacteria responsible for the biological removal are not getting inhibited. These results prove that it is possible to remove ammonium from the main stream of wastewater without any need of external carbon.

Grażyna BEŚCIAK

Biofilm as a basic life form of bacteria

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Most of bacteria present in the environment grow in the form of biofilms. This structure provides better cells protection harmful influence of external factors, allows fast and effective intercellular communication and genetic information exchange. Biofilm-forming bacteria may be metabolic differentiated- cells on the surface of this structure have different properties and carry out other processes than cells in deeper layers. Such cells co-operation saves energy and increases the chance of survival.

Biofilms are common in the environment, both natural and anthropogenic. They often develop in the water and sewer pipes, on surface of various devicees in the contact with water and significantly contribute to their destruction. The prevention against biofilm development is very difficult, so researchers still seek new methods of restricting their growth. This goal requires a good knowledge of properties, metabolism and growth rate of this structure. Scientists search for this purpose by conducting various experiments.

In presented studies research were performed on Escherichia coli SM1699 biofilm development, under laboratory conditions. This strain has a gfp (Green Fluorescent Protein) gene, located in the chromosome. GFP is a protein emiting green light. Application of GFP-labeled strain allows the observation of biofilms using a CLSM microscope (Confocal Laser Skanning Microscope). In this experiment various studies on biofilm, such as number of bacterial cells and the number of cells emitting GFP light were performed. Also the overall number of bacterial cells and the number of cells emitting GFP light were evaluated. The study was conducted in the laboratories of The Silesian University of Technology, as a part of a research grant for gene replacement in the biofilm.

Mariusz KUGLARZ[1], Bożena MROWIEC[1], Jolanta BOHDZIEWICZ [2]

Influence of kitchen biowaste addition on the effectiveness of animal manure digestion in continuous condition

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The aim of the research was to establish the influence of kitchen biowaste as a co-substrate on the effectiveness and stability of animal manure anaerobic digestion for biogas production, conducted in mesophilic conditions. Digestion process was conducted for the animal munure as well as mixtures containing 10% (ww.) of kitchen biowaste and 90% (ww.) of animal by-products. The proportion of substrates in the co-digestion mixture was established as optimal, on the basis of tests conducted in static conditions. The digesters were maintained at a mesophilic temperature of 36˚C and the process was carried out at the hydraulic retention times (HRT) ranging from 20 to 50 days. Anaerobic digestion of manure for the HRT value of 30÷35 days ensured the most appropriate amounts of biogas produced (0,77-0,85 $dm^3/dm^3 \times d$) and organic matter reduction indices (42-54%). Whilst co-digestion of kitchen biowaste and munure allowed to achieve between 10 and 60% higher biogas production rates. The highest biogas production rate (1,25 $m^3/m^3 \times d$) as well as the most appropriate organic matter reduction indices (66%) were achieved for the HRT value of 35 days. The digestion process conducted for the shortest value of HRT (30 days) turned out to unstable and exhibited a relatively low effectiveness.

Bożena MROWIEC, Mariusz KUGLARZ, Jan SUSCHKA

Removal of selected organic pollutants in anaerobic wastewater treatment process

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Aromatic compounds belong to one of most widely distributed classes of organic substances used in industry, services and households and, therefore they are relatively often measured in municipal wastewater. Their efficient biological degradation is essential to reduce the subsequent disposal of such substances into the waters of the receiver, or release into the atmosphere. The mineralization of organic compounds by facultative or obligate anaerobic bacteria can have importance for next state of treatment, because most of organic contaminants are toxic for microorganisms of conventional activate sludge process. The aim of the study presented was assessment of the removal of specific organic contaminations BTX (benzene, toluene and xylenes) found in wastewater in municipal WWTP during anaerobic treatment process. The experiments have been performed in the laboratory anaerobic reactor of the 5 L volume. The concentrations of BTX in wastewater were in the range of 1.0 and 5.0 mg/L as the sum of the compounds. After the anaerobic treatment process the concentrations of BTX decreased in average: 45 % for benzene, 59 % for toluene, 65 % for o-xylene and 76 % for p-xylene.

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Influence of aeration strategy on behavior of different microorganisms in deammonification process

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In one stage moving bed biofilm reactor (MBBR) with deammonification process, two groups of microorganisms, which are ammonium oxidizers (AOB) and anammox bacteria, play the key roles to remove nitrogen. An investigation has been carried out to evaluate the activity of different groups of microorganisms and N2O emission in MBBR operated under various aeration strategies.

The pilot scale reactor of volume 200 L, filled 40% with Kaldnes biofilm carriers (K1) and continuously fed with reject water, was run for 500 days at 25°C under different aeration strategies, characterized by the ratio between non - aerated and aerated phase duration (R) and dissolved oxygen concentration (DO). After the initial adaptation period I, four different aeration strategies were introduced in the system with DO 3 mg/l and R=0 (Period II), DO 3.5 mg/l and R = 1/3 (Period III), DO 3 mg/l and R = 1/3 (Period IV), and DO 3.5 mg/l and R=1 (Period V); air supply was decreased gradually. In each period, Kaldnes carriers with biofilm were taken out for microbial activity tests: specific anammox activity (SAA) tests based on the measurement of nitrogen gas production, oxygen uptake rate (OUR) and nitrate utilization rate (NUR) tests.

From period II to V, air supply decreased from value of 1.5 m^3/h to 0.8 m^3/h. Activity of anammox bacteria increased when continuous aeration switched to intermittent aeration because more anaerobic phases were introduced. AOB however decreased activity from 3.82 to 3.02 mgO_2/m^2•h due to less oxygen supplied. In the period V, low oxygen supply led to a low production of NO_2--N by AOB and this was the rate-limiting step for anammox process.

The study showed that a choice of proper aeration strategy could decrease air supply and energy requirement without any loss of process efficiency. A proper duration of non-aerated phase could improve anaerobic conditions in the biofilm and decrease possible inhibition effects of oxygen on anammox bacteria. N_2O production was mainly due to ammonium oxidizers in aerated phase and heterotrophic denitrifying bacteria in non aerated phase.

Jerzy MIKOSZ

Simulating the effects of the introduction of membrane filtration at a municipal BNR plant

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Sedimentation is still the most common method of biomass separation at majority of medium and large biological nutrient removal municipal wastewater treatment plants (BNR WWTP). In recent years some plants have been replacing this process with membrane separation and transforming their typical biological reactors into membrane units (MBR). This is often linked to the required increase in plant's capacity and/or improvement in effluent quality. However, such modifications significantly affect plant functioning especially in regard to operation of biological processes, energy management and solids treatment. The article presents the results of computer simulation research on effects of the introduction of membrane filtration at a municipal BNR plant. The simulations allow to compare the most important operational parameters and effluent quality for the traditional layout with secondary clarifiers and the layout with membrane biological rectors. Wastewater treatment plants' operators and decision-makers may use is it as an indication of what changes in plant operation can be expected after installing membrane filtration.

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Determination of relationship among influent ammonia nitrogen concentration in activated sludge system and aerators worktime

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Keywords: aeration, aerators work time, energy consumption, nitrogen

One of the most energy consuming processes during biological wastewater treatment is aeration. Oxygen uptake rate depends on many factors thus it is difficult to estimate influence of an individual parameter on the process. This paper presents the method of calculation of ammonia nitrogen influence on energy consumption described as aerators work time.

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The research of activated sludge dewatering processes.

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Key words: activated sludge, filtration, capillary materials, dewatering.

The efficiency of different activated sludge dewatering processes was investigated. The activated sludge for researches was taken from biological processes of public wastewater treatment. Was found that neither pH adjustment no addition of different flocculants can significantly reduce the volume of sludge. The settling failed to provide the required efficiency too. The optimal results were obtained by using filtration for activated sludge dewatering processes. At the same time there was no significant efficiency of dewatering processes that could be compared with the cost of reagents and chemicals. New method of water separation from activated sludge was used. This method involved the use of materials with capillary properties. The laboratory plant with continuous action for activated sludge dewatering processes was developed during researches. Also the efficiency of activated sludge dewatering, the influence of various factors on the parameters of dewatering processes and the working features of the laboratory plant were studied.

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Sulphates and water hardness ions removal from the water in the demineralization process

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The results of treatment of solutions with high sulphates concentration and the high rate of water hardness are given.The task of reducing water salinity was solved by isolation of sulphate in the form of poorly soluble calcium hydroxsulphoaluminate and also due to its softening with lime or lime and carbon dioxide processing.
Calcium hydroxsulphoaluminate has been received during water treatment using lime and highly basic aluminium coagulants.It is shown that the usage of aluminuim hydroxchloride can reduce sulphate concentrations from 1200-4500 to 40-500 mg/l and reduce water hardness from 10-18 mmol/l to 0,25-1,5 mmol/l. In this case the chloride content in water depends on the basicity and hydroxchloride aluminum flow.
Significant reduction of secondary pollution by chlorides achieved through an integrated use of aluminium hydroxchloride and sodium aluminate coagulants.
It was found that that the efficiency of water purification of sulphates and water softening can be increased with the carbon dioxide processing. This helps to remove the calcium ions as calcium carbonate and to increase the yield of calcium hydroxsulphoaluminate.
It is shown that the residual level of salinity and alkalinity depends on its ionic composition, in particular on the content of sodium sulphate, as well as the type and rate of aluminium coagulant. The developed method helps to solve the problems of natural water conditioning, treatment of wastewater with different concentrations.
Perspective is the process of concentrates processing produced by nanofiltration water treatment.
A slight increase in chloride concentration does not significantly influence the efficiency of water treatment in general while treated concentrates are reused in the technological process.

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Electrochemical processing of regeneration solution ion-exchange treatment of water to produce acids and alkalis

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Keywords: electrodialisys; processing of regeneration solutions; current efficiency

The processes of purification of acid, neutral and alkaline solutions containing sulfate or sodium chloride was studied.
The compositions of used solutions was close to solutions that was formed during the regeneration of cation exchangers in the sodium form by sulfuric or hydrochloric acid, as well as the regeneration of anion exchangers in the salt form by alkali.
The conditions for the production of sulfuric acid and alkali in the processing of sulfate-containing solutions in three-chamber electrolysis cells with using cationic and anionic membranes was determined. The influence of pH and concentration of initial solution, the alkali concentration in the cathode area and the acid concentration in the anode area to the current efficiency of sulfuric acid and sodium hydroxide, as well as to the efficiency of water purification from sodium sulfate.
The concentrations of chemicals produced in high efficiency of the electrodialysis was determined.
It is shown that by using a four chamber electrolyser in the electrolysis of solutions containing sodium chloride, along with an alkali solution, the solution of hydrochloric acid can be obtained.
It is established that the usage of electrodialysis of cationic and anionic membranes effectiveness of the process largely depends on the initial concentration of sodium chloride. In the concentration of sodium chloride exceeding 40 g/dm^3 the efficiency of electrolysis is greatly reduced due to the diffusion transport of chloride anions to the cathode area.
Current efficiency of acids and alkali decreases with increasing concentrations respectively in the cathode and the anode area.
When the concentration of alkali and acid above 3000 mg-eq/dm^3 goes a significant reduction of the current efficiency of electrolysis products with a significant increase the time of process for all used voltages and current densities.

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Start-up performance of constructed wetland microcosms for electroplating wastewater polishing

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Keywords: constructed wetlands; cyanides; electroplating wastewater; metals; vertical flow

Two experimental systems which mimic full scale vertical flow constructed wetland were established to study their feasibility to polish electroplating plant effluent. Each system consists of vertical flow PVC columns (80 cm height, 20 cm diameter) filled up to 63,5 cm (20 L) with either mineral or organic media. The systems are fed with either real or synthetic electroplating wastewater containing Zn, Cu, Ni, Pb, Fe, Al, and cyanides. Six different configurations (each in duplicate) were selected for the experiment based on flow mode, type of bed media (and presence or absence of vegetation (Phragmites australis). The main objective of the system design was to promote metals removal by precipitation as metal sulphides mediated by sulphate reducing bacteria (SRB), which, in general, are obligate anaerobes. Thus, most of the columns are strictly anaerobic. However, also aerobic processes were reported to be efficient for removal of metals and cyanides. Therefore, selected columns of the experimental system are operated as intermittently anaerobic and aerobic. The remarks on the four-month start-up period of the system operation and the scope of the system application are presented.

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Modelling treatment performance of temperate climate constructed wetlands receiving municipal wastewater effluent

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The basic Stritter-Phelps equation was applied to model decomposition of pollutants in constructed wetlands receiving domestic wastewater effluent in temperate climates. More than 360 laboratory measurements were done for BOD_5 and COD, 350 - for suspended solids content, 230 - for ammonia nitrogen and ortophosphate content in the wastewater at different treatment stages in experimental constructed wetland system (capacity of 40 m^3/d) and different seasons in 1998-2001 in Kharkiv region, Ukraine. Hydraulic residence time was calculated following the Dupuit's equation. Decomposition coefficients for each of the substances have been derived. Differences between decomposition coefficients derived at different scenarios were analysed with use of Fisher's **F**-criterion and Student's **t**-criterion. The Principal Component Analysis of decomposition coefficients carried out for series obtained at vertical, horizontal flow and free-surface systems separately have shown that more than 95% of explained variance is attributed to joint influence of season and temperature. Differences in input concentration did not significantly influence decomposition coefficients. It should be noted that mean values of pollutant content at different units and the coefficients derived both data reorganized according to the calculated hydraulic residence time, i.e. true time series, and data taken without such sorting, i.e. 'pseudo'-time series, were not significantly different (t- and F-tests). Model has been validated with the use of data on treatment performance of similarly designed constructed wetlands in the Great Britain, Sweden, Denmark, and Estonia from published sources.

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Biosurfactants – biodegradability, toxicity, efficiency in comparison with synthetic surfactants

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Biosurfactants are natural surfactants of microbial origin. They are produced by variety of bacteria, yeast and fungi and waste materials can be used as a source of carbon in their production (glycerol, molasses, oil refinery wastes, waste frying oils). At first biosurfactants focused the attention of scientists due to the ability to solubilise hydrocarbons. But the more and more popular trend to use renewable resources in industry (especially food and farmaceutical industries) has led to increasing interest in obtaining and application of natural surfactants, mainly biosurfactants.

In this paper a review of biosurfactants physicochemical properties, toxicity, biodegradability in comparison with synthetic surfactants is presented. The studies have shown that biosurfactants indeed are less toxic (*Dehghan-Noudeh et al. 2005*) and more easily biodegradable than chemically synthesized surfactants (*Lima et al. 2011*). They also display promising physicochemical properties (*Pastewski et al. 2008*) and comparable or higher than synthetic surfactants efficiency in different applications (*Makkar R.S. and Rockne K.J. 2003*).

In the experimental part there are researches on degumming of crude vegetable oil (phospholipids removal) with using of biosurfactant solutions, whereas deep industrial degumming process is carried out with using of sulphuric acid. Biosurfactant used is biocomplex of rhamnolipid and alginate produced by Pseudomonas sp. PS-17. It was obtained with omitting purification stage of rhamnolipid thus the cost of synthesis has been lower and the process was less time-consuming in comparison with purified biosurfactants obtainmement. Vegetable oil chosen for research was the most popular in Middle Europe rapeseed oil. Degumming process was run at different parameters (biosurfactant's solutions concentrations, amounts and pH). Biosurfactant turned out to be very effective in phospholipids removal (up to 98%). Moreover, simultaneous oil deacidification was possible when strongly alkaline biosurfactant solution has been used.

Summarizing, one can state that biosurfactants application is environmentally friendly technology due to waste minimization (which can be used for biosurfactant producing bacteria cultivation), lower chemicals usage (for oil refining) and higher recovery of phospholipids.

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Effect of water characteristics, method of cation exchange resins modification with ferrous compounds on the efficiency of dissolved oxygen removal

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Key words: oxygen, cation exchange, oxidation-reduction cationit, sorption, iron, capacity

In Ukraine the biggest volumes of water in industry are used for the refrigerating systems. The transition to a closed water circulation systems can minimize wastewater discharge into natural water bodies. This can be achieved with new methods of stabilizing water treatment that prevent scale formation and corrosion.
A corrosion and destruction of heat exchangers elements and pipelines result in considerable expenditure of energy and materials and water contamination. In neutral aqueous medium in power plants corrosive processes are usually caused by the presence of dissolved oxygen.
The removal of dissolved oxygen (DO) from water was studied experimentally in cation-exchange resins modified by ferrous compounds.
The influence of ion-exchange resin form on the reducing capacity and secondary contamination of water with iron ions was studied. The results shows that reducing capacity increases with a decrease in reaction medium at low water hardness and sorption of ferrous ions occurs efficiently on strong-acid cation resin in the acid form. The exchange capacity of sodium-form ion exchangers grows with the acidification of ferrous sulfate solutions to the sulfuric acid concentration of 1.5%. The best results with multiple processing of ion-exchange resins with ferrous solutions were obtained using macroporous sorbents.

Renata TOMCZAK-WANDZEL, Joanna GÓRNIACZYK

Anaerobic treatment of distillery wastewater

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The estimated global ethanol production in 2009 was 73,92 mln m3. It is commonly used in food, pharmaceutical and chemical industry. In the recent decade it has been applied by a rapidly developing energy branch as a fuel alternative to fossils. While only about 7% of ethanol is obtained through chemical synthesis, alcoholic fermentation remains the predominant production process.
The most common raw materials for ethanol production are mainly: corn, wheat, rice, potatoes, sugar beets, sugar cane, molasses. After fermentation remain waste from bottom of distillation columns, termed stillage. This highly aqueous, organic solubles containing residue is considered a troublesome and potentially polluting waste due to its extremely high BOD and COD values and intense brown coloration. Moreover, for each liter of produced ethanol 8-15 liters of stillage are generated on average.
Ethanol production is expected to continuously increase due to its growing importance in biofuel industry. Proportionally to ethanol manufacture, an amount of its co-products will be generated. For this reason there are carried out intensive research into the use of alternative methods for utilization of distillery stillage in order to ensure both economic and environmentally friendly solutions. Research is focused on biological methods for treatment distillery stillage, mainly on the anaerobic methods.
An idea of utilizing distillery stillage as a feedstock for methane fermentation came out as an alternative to thermal processing. In recent years anaerobic treatment has been successfully applied on both pilot and full scale. Not only it allows passing over the drying stage, but also offers an opportunity for energy recovery. Estimated biogas yield from 1 tone of stillage is 55 m3 with at least 55% methane content. Its combustion is capable of covering significant part of thermal energy demand in ethanol production and purification stages. Depending on the choice of technology, methane combustion can cover even 75-100% of the process energy demand.

Wiesława STYKA, Piotr BEŃKO

Experience in nitrogen removal - the case study of the Kujawy WWTP, Krakow

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The research works on biological removal of nitrogen has been initiated at the KUJAWY WWTP in Kraków in 2003, as a consequence of more restricted nitrogen effluent standards; the new nitrogen effluent concentration has been set at 10 g N/m3. The results of the initial research investigations helped to identify some causes of limited removal of nitrogen compounds at the plant. They included in order of importance: characteristic of wastewater entering the bioreactor, especially a very low level of easily biodegradable organic compounds (the BZT5/Nog rate holds back denitrification), adverse impact of supernatant and lower activity of activated sludge at low anoxic bioreactor volume (25 % of the total bioreactor volume). Since there was more than one cause that hindered the increase of nitrogen removal, the following strategy was accepted, that allowed for a gradual elimination of particular causes. At the same time, both a continuous supervision of the plant operation and adjustment of preliminary assumptions were employed. Once the technological modifications were introduced, the nitrogen removal reached over 80 % , mostly due to better deniitrification efficiency. However, such performance did not guarantee a stable performance and therefore a further analysis of technological solutions and operation conditions was continued to intensify deniitrification. It comprised: (a) utilization of biodegradable organic materials present in raw sewage, including additional processes enhancing their hydrolysis in wastewater and sludge; (b) proper management of supernatant generated at the sludge treatment line; (c) need for dosing of an additional substrate.

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Fate of LAS surfactant in WWTPs based on measured concentrations in wastewater and sludge

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Surfactants are widely used in household and industrial products. After use, surfactants as well as their products are mainly discharged into sewage treatment plants and then dispersed into the environment through effluent discharge into surface waters and sludge disposal on lands. Surfactants have different behavior and fate in the environment. Nonionic and cationic surfactants had much higher sorption on soil and sediment than anionic surfactants such as LAS. Most surfactants can be degraded by microbes in the environment although some surfactants such as LAS and alkylphenols may be persistent under anaerobic conditions. These pass into the sewage treatment plants where they are partially aerobically degraded and partially adsorbed to sewage sludge that can be applied to land. The biodegradation of LAS surfactant in wastewater treatment plants has been considered.

The fate of the LAS surfactant in two different types of wastewater treatment plants has been reviewed: the small “Swarzewo” WWTP (45 000 PE), and large WWTP “Wschód” (760 000 PE). The wastewater treatment process in “Swarzewo” is based on the Sequencing Batch Reactor system (SBR) and sewage treatment is based on composting. On the contrary the biological treatment unit in “Wschód” consists of 6 multiphase MUCT (modified UCT system) reactors and as far as sewage sludge is concerned stabilization of thickened sludge is currently achieved through anaerobic digestion.

The elimination of LAS from the water stream in Swarzewo (98,7%), is superior to that found in Gdańsk (97,6%). In the sludge treatment course, the reduction of LAS in Gdańsk is smaller than that in Swarzewo due to the greater biodegradation of LAS surfactant in composting treatment that take place in Swarzewo WWTP.

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A method for sustainability evaluation of small wastewater treatment systems

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The article presents the application of multi-criteria analysis for selection of the best treatment technology and the best technical solution of a small wastewater treatment plant. The calculations performed for two plant capacities and for various effluent standards are based on compromise programming method. The effluent standards considered for the smaller plant (133 PE) are only BOD5, COD and TSS while for the larger plant (670 PE) also nitrogen and phosphorus. For each plant's capacity the three different treatment technologies are analyzed. The analyzed technologies included biofilters, continuous and cyclic activated sludge, rotating biological contactors and natural treatment methods. The selection of the best technology is done with a define set of sustainability criteria that can be easily modified and adjusted to specific local conditions. The proposed method can be used for selection of the best treatment technology and the technical solution at the stage of wastewater system planning and designing as well as for evaluation of already operated plants from sustainability standpoint.

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Impact of wastewater sludge composition on methane – rich biogas generation process

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Results of laboratory and full-scale tests on impact of an enhanced sludge composition on a biogas production has been presented in the paper. Intensification of biological treatment processes was found potentially responsible for decrease of a biogas production from the sludge and both quantitative and qualitative assessment of a biogas production dynamics were presented in paper. Better energy recovery is of crucial importance in the overall sludge disposal, however it deeply depends on methane rich gas generation. Increased net biogas production and thus better energetic characteristics of the plant are recognized as the most important reasons to apply disintegration to the wasted activated sludge (WAS). Until now an assessment of efficiency of this process was done by steady state measurements of COD solubilisation, change of sludge flocs' size or change in a protein concentration. Results from these methods cannot be simply incorporated into design procedures of wastewater treatment plants. Full-scale investigations supported by laboratory tests enlightened some specific problems which may occur in wastewater treatment plants with an intensive biological phospohorus removal, where a relatively high consumption of biodegradable carbon is usually one of adverse and unfavourable effects. In the system where mesophilic fermentation of sludge was used as a stabilization method a significant decrease of a biogas production was proved. Operational procedure basing on a methanogenic activity respirometric tests was proposed and tested in full-scale design procedure.

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Evaluation of the Activated Carbon produced from Different Precursors

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Key words: Impregnation ratio, Sawdust, Adsorption capacity, Iodine number

Activated carbon (AC) is used for waste water treatment for many years. In this case, preparation of activated carbon from different type of precursors (tomato seed, grape fruit peel and sawdust) can be considered as a sustainable way regarding environmental issues.
In this regard, the paper is aimed to evaluate different activation characteristics of the produced activated carbon by iodine number, gas adsorption capacity. Different process parameters such as carbonization time, activation temperature, impregnation ratio have been studied for different precursors. Adsorption capacity for the produced activated carbon was investigated by using ammonia, benzene and gasoline gases.
The study showed that, all the parameters of interest, such as impregnation ratio, carbonization time and activation temperature, influence iodine number or gas adsorption capacity. Regarding iodine number, tomato seed has given better iodine adsorption rather than grape fruit peel in certain impregnation ratio and certain carbonization time. It was found that certain combination of parameters might yield good adsorption properties for a certain gas, for example ammonia, while the same combination might have different adsorption properties for gasoline.

Olga KHANDOGINA, Valeriy BARANNIK

Studying walnut shell properties as natural adsorbent for treatment of oil-contaminated water

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Recently different organic and organic-mineral adsorbents presumed to be the most prospective materials for removal oily contaminants from water. Walnut shell is one of the promising adsorbents for wastewater treatment. Widespread occurrence of the species within Ukraine as well as physical and chemical properties of walnut shell indicate potential possibility of its using as adsorbent for removing oil products from sewerage water. Capacity of crushed thermally untreated shell to adsorb oily contaminants both from water surface and from water-oil mixture has been studied experimentally. Walnut shell is found to adsorb oil pollutants from water, and the adsorption capacity increases with decreasing walnut particle size. Studies have shown the selective adsorption capability of walnut in dependence on molecule structure of hydrocarbons. The obtained results show the potential possibility of using adsorbents based on crude shells to remove oil from sewerage water.

Jaroslav GUMNITSKY, Vira SABADASH, Oksana MATSUSKA, Galina TYZRBIR

Complex water treatment of agroindustrial complexes before wastewaters discharge into the basins of rivers

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Water resources play the vital role in the structure of natural resources of any region. Man-made pollution of Western Bug River is global and irreversible and causes pollution of basin of the Baltic Sea. Investigation is dedicated to the issue of water treatment. The aim of this work was to study the process of phosphate adsorption on natural and synthetic adsorbents such as aluminosilicates. Phosphate sorption properties of natural zeolite (clinoptiolite of Sokyrnytsia mineral deposits) in static and dynamic conditions were investigated. It was found that phosphates are absorbed better in an acidic environment. Adsorption capacity of clinoptiolite unsubstituted phosphates is higher and decreases with substitution of orthophosphoric acid by alkali metal ions. Clear influence of pH on the sorption properties of clinoptilolite P_2O_5 was shown. Research data and the known theoretical relations gave possibility to calculate kinetic coefficients of adsorption process. The mathematical modeling of active component adsorption process by granule-type sorbents was done and behavior was explained with unstationary diffusive-kinetic processes in the multicomponent distributed systems. Zeolites on the basis of fly ashes of Dobrotvir heat power plant were synthesized and modified. Properties of zeolite on the basis of termogravimetric analysis were investigated. Natural zeolite sorption properties for ammonium and and phosphate which are present in wastewaters of meat-packing plants were investigated. The equilibrium values of adsorption capacity are assumed and the proper isotherms are built at a temperature 20^oC. It was found that phosphates are taken in better than ammonia nitrogen. Adsorption ability of clinoptiolite in single-phase systems is higher and diminishes if two components are removed from solution simultaneously. Taking into account the exhaustive supplies of natural zeolites the synthesis of synthetic zeolites is conducted.

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Integrated adsorption and ultrasonic technology for water treatment processes

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Current status of water sources and central water supply systems of Ukraine did not ensure the required quality of drinking water. Research focused on the problem of drinking water preparation. The aim of this work is to study the process of water treatment from mechanical and chemical pollution and pathogenic microflora by adsorption and ultrasonic methods. Proposed technology reduces bacterial contamination and purifies water from organic pollutants, increasing water quality.
Disinfection of water under the influence of ultrasound is carried out by cavitation process during insonation, i.e. formation, growth and destruction of gas bubbles in the liquid. Uniform dispersion of gas in water is provided at simultaneous action of ultrasound and gas on polluted water, which is a factor in the intensification of the decontamination processes. To achieve the desired low microbial number and high water quality additional treatment method is required. In this study the most common natural sorbents (zeolites, glauconites, palygorskite, bentonite) were used for further increasing water quality. Use of natural sorbents in the purification technology does not require its regeneration, so water treatment using sorbents is promising and relatively inexpensive method.
Chemical oxygen demand (COD) and microbial number were used as criteria of water treatment and were analyzed for incoming water, after ultrasonic treatment and after application of natural sorbents.
It was found that interaction of ultrasound and adsorption allows achieving a high quality of drinking water.

Myroslav MALOVANYY, Serhiy HUHLYCH

Theoretical and practical aspects of landfill leachate treatment

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One of the main problems for today's world is municipal solid waste management (MSWM). There are about 2000 landfills and dumps that have been organized mostly with no projects and without engineering and geological surveys in Ukraine. These mistakes led to many environmental problems because one of the main ways of contamination from landfills and an active component that affects the pollution is spreading of leachate and surface water which flows from landfills during precipitation. Moreover leachate pollutes underground water by infiltration of contaminated water into underground aquifers and migration of polluting components along with the leachate flow. The most vulnerable are groundwater, surface water, and soils, however air pollution occur also. Preventing the risk of environmental pollution from solid waste landfills depends on knowledge about laws of migration of chemical elements and organic compounds. This work analyzes the international research experience of the processes that take place in landfills in various stages of existence. Based on this analysis, the assessment of practical approaches to Lviv landfill leachate treatment is done.

Bengt HULTMAN

Wastewater paradigm shift – From pollutant removal to resources recovery

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Keywords: Anaerobic; anammox; biofuel cells; chlinoptilolite; magnesium; magnetite; manganese; paradigm shift; resources recovery; wastewater

Wastewater handling has a long history in many Western countries. In Sweden main focus hundred years ago was to get rid of the increasing amounts of generated wastewater from cities to avoid water borne diseases and odor problems. Later on around 1930´s focus was given to mechanical treatment to remove visible pollutants, followed by focus on biological treatment around 1950´s, focus on chemical precipitation for phosphorus removal around 1970´s, and focus on nitrogen removal around 1990´s. Requirements for effluent discharges have successively sharpened and present most stringent requirements in Sweden are as quarterly average values for Tot-P 0.2 mg P/l and for Tot-N 10 mg/l. However, it is possible that the requirements will be more stringent in the future as a result of fulfilling requirements according to the Baltic Sea Action Plan (BSAP). Many examples exist (as in parts of USA) that it is possible to operate full-scale treatment plants to very low effluent values as for total phosphorus below 0.05 mg/l and for total nitrogen below 2 mg N/l.
As a result of more stringent requirements more sludge is produced and resources of energy and chemicals have increased, raising treatment plant costs and causing secondary environmental effects as emission of green house gases. However, these negative consequences have been met by better use of influent components in the wastewater for energy and product recovery. Today, it seems possible to both meet stringent requirements of discharges of pollutants to water, air, and from sludge and at the same time meet self-sufficiency regarding electricity (as the treatment plant Strass) and finding cost recovery for extraction of phosphorus from sludge (as OSTARA process in Canada/USA) or ashes. Changes in process technology may facilitate goals of high cost-efficiency and it is suggested to better use three-stage technology for pollutant removal, change type of chemicals as iron or aluminum salts to the use of magnesium and manganese compounds, magnetite, and adsorption materials as chlinoptilolite. Increased oxidation of constituents in wastewater by anaerobic methods should be used (as anaerobic treatment of organic materials, anammox process and potentially the use of biochemical fuel cells).

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Extended solids retention process with sludge recirculation for increasing biogas production at anaerobic digestion

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Key words: anaerobic digestion, biogas, BMP biochemical methane potential, methane, mesophilic, OLR organic load rate, specific gas production, total solid and volatile solid. sewage sludge,

In 2008 IVL Swedish Environmental Research Institute and KTH Royal Institute of Technology jointly took over the responsibility for the R&D facility for wastewater purification Hammarby Sjöstadsverk. The facility consists of different pilot-scale lines for wastewater and sludge treatment/handling.
One of the projects that have been initiated at Sjöstadsverket aims at increasing the biogas production by optimized the digestion process. The overall goal is to increase the degree of digestion to over 60% and reducing the hydraulic retention time from 20 days to 10 days. To achieve this an extended solids retention process with an anaerobic mesophilic digestion combined with a sludge recirculation was used. The effluent from the digester was dewatered with a centrifuge and recirculated to maintain a relatively high solid content within the digester.
The results obtained are very promising. The hydraulic retention time was reduced to 10.6 days while the sludge retention time increased to 218 with 78,7 % reduction of VS, organic content in the sludge. However, OLR, organic load rate to the digester, of 0.69 kg VS/(m^3·day) was relatively low compared to sludge digestion at Henriksdal wastewater treatment plant with 1.5 kg VS/(m^3·day). In order to increase the load external sludge had to be taken from Henriksdal wastewater treatment plant. At increasing the OLR from 2.05 to 3.15 kg VS/(m^3·day) measurement of biogas production indicated that biogas yield was enhanced by 73%, with a maximum production of 14.5 m^3/day and methane content was merely promoted by 10.5%, to the highest value of 63%. Specific gas production (SGP), was observed to be 0.65 $Nm^3/kg\ VS_{in}$.
BMP, Biochemical Methane Potential tests of gas potential was made to determine the effect of sludge reprocessing on the activity of the methane bacteria. BMP tests are normally used to measure in batch digestion the anaerobic degradability of a given substrate, which are mixed with an inoculum, source for methane bacteria. In this study digested sludge from Sjöstadsverket (S1) and Henriksdal (H2) was used as inoculum. At BMP tests with an inoculum to substrate ratio of 2:1 based on VS content, S1 and H2 production of CH_4 (in NL, Normal Liters) during the 20 days test period was 0.29 NL/gVS and 0.33 NL/gVS respectively. In a second BMP tests with the same amount of substrate and inoculum for each sample, S1 had a higher methane potential than H2, 0.31 NL/gVS and 0.29 NL/gVS respectively. All BMP tests with Sjöstadsverket inoculum produced a larger volume of total accumulated gas. This imply that methane bacteria grown in the digester at Sjöstadsverket can endure a higher OLR and that the digested sludge has high potential to produce biogas.

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Anammox process: what we know and where we are?

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Keywords: Anammox, mathematical modelling, nitrogen removal, PCR, star-up,

The least resources consuming pathways for transfer of ammonium to nitrogen gas is deammonification based on both partial nitritation and Anammox process. The main advantage of this process compared to the conventional nitrification/denitrification are: low sludge production, decrease of the aeration costs by almost 60% (only half of the ammonia is oxidized to nitrite in nitritation process without further oxidation to nitrate), and absence of external organic carbon source addition (Anammox process). Also, Anammox bacteria oxidize ammonium under anoxic conditions with nitrite as the electron acceptor, and converse energy for CO_2 fixation. Bacteria carrying out the anaerobic ammonium oxidation had not been known earlier and were identified as lithotrophs of the order of Planctomycete. Generally, anammox bacteria are difficult in laboratory cultivation, thus molecular biology techniques are useful in their analysis. In this article we present PCR-DGGE as an excellent tool for Anammox bacteria monitoring in membrane bioreactor systems. Even though the Anammox organisms have now been studied since mid-1990's, knowledge on the model parameters of Anammox is still very limited. This article will deal with the newest knowledge in the field of Anammox process and it will present the state of the art information in this area.

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Identification of Cryptosporidium sp. oocysts in water by modified immunomagnetic separation and RFLP-PCR

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Current methodologies for detection of *Cryptosporidium* sp. in water, despite some efforts for standardization (e.g. EPA Methods 1622/1623), has several drawback that limit the applicability or interpretation of the results of *Cryptosporidium* monitoring. Presence of some chemical dissolved in water, ageing of oocysts, reduced affinity of antibodies used in immunomagnetic separation (IMS) and immunofluorescent assay (IFA) results in reduced sensitivity and specificity. Against this background of molecular biology techniques used for detection of *Cryptosporidium*, are characterized by good sensitivity, reproducibility and acceptable cost analysis.

In this paper, the authors showed the possibility of modifying the protocol of immunomagnetic isolation of oocysts and adjust its scale to the needs of a PCR reaction combined with an analysis of restriction fragments length polymorphism (RFLP-PCR). The method allows relatively rapid implementation of qualitative analysis in the direction of

Cryptosporidium, combined with the identification of species. It is also connected to the determination of several pathogens (including *Giardia* and *Toxoplasma*) through a combination of antibodies used in the IMS and multiplex-PCR.