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MATHEMATICAL MODELLING OF BIOFILTER EFFECTIVENESS IN PH REGIMES

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Abstract. The efficiency of a biofilter filled with pine bark charge was modelled under conditions of interchanging pH. Hydrogen ion concentration is significance for the growth of microorganisms, therefore biological metabolism is strongly dependent on pH. Many microorganisms will only grow within a particular pH range. Since pH has a strong influence on kinetic parameters and governs the process into the biofilm, proton concentration (H+) was included as a state variable in the model. Different approaches to model pH variations in biological systems can be found in literature.

The biofilter model was implemented in a home-made simulation environment developed in MATLAB. Model evaluation was performed by comparison of model predictions with experimental data obtained in the pine bark charge of biofilter. The model was able to predict qualitatively and quantitatively the behaviour of the system under dynamic conditions, particularly for pH. Modelling were performed with different pH regimes (4, 5, 6, 7, 8, 9 and 10) in the charge filled with pine bark. Moreover, the dependence of the filter efficiency on its charge height (0.15–0.75 m) with different initial pollutants (xylene, butanol and buyl acetate) concentrations and at different velocity of passing air (0.02–0.1 m/s) were modelled. Similar to experimental tests, the increase in the charge height from 0.15 to 0.75 m results in the increase in cleaning efficiency. For example, when the pH of 7 is maintained in the biocharge and the air is being cleaned of butyal acetate (with its initial concentration of 74 mg/m³) the efficiency of removal of butyl acetate starting with the height of the charge equal to 30 m is 70.1 %, starting with the height of 60 m is 77.6 %. Furthermore, modelled expression were similar to experimental data of the air flow rate results in the decreased efficiency of the biofilter. Respectively, when the pH of 7 is maintained in the charge and the air is beeing cleaned of xylene (with its initial concentration of 63 mg/m³), with the velocity of the passing air increased from 0.04 to 0.08 m/s, air cleaning efficiency significantly reduces from 76.8 to 68.3 mg/m³. Therefore, mathematical expression of environmental processes such us biofiltration lighten theoretical calculations and seek ultimate air cleaning efficiency.

Keywords: biofilter, biofiltration, volatile organic compounds, biocharge pH, mathematical model.

1. Introduction

Air pollutants released in one country may be transported in the atmosphere and harm human health and the environment elsewhere. According to the scientist Li (2008), Vaiškūnaitė and Zigmontienė (2005) VOC are generally toxic gases emitted from wastewater treatment plants and many industries, such as printing and coating facilities, chemical industries, electronics, and paint manufacturing. In Lithuania, the average of VOC quantity released to the atmosphere from 2000 to 2010 was 23.3 thousand tones. Generally, in Lithuania the following hydrocarbons are found in the air at industrial concerns: benzene, toluene, xylene, isomers, etc., which could be removed with a help of biofilters.

Traditionally physical and chemical processes have been applied to treat polluted air emissions. However, the high costs of operation and energy consumption associated to conventional treatments have lead to increase the attention on biological processes. During the last years biofiltration has emerged as an efficient and reliable biological process to treat pollutants from contaminated air emissions according to the scientists Baltrėnas, Vaiškūnaitė, Zigmontienė and Zuokaitė. This technology has been successfully used to remove a wide range of pollutants such as volatile organic compounds (VOCs), ammonia and sulphurous compounds, amongst others (Groenestijn and Kraakman 2005; Delhomenie and Heitz 2005).

Most of the experimental works on biofiltration are focused on removal of VOCs, sulphide and other inorganic compounds (Baquerizo *et. al*. 2007), therefore it is necessary to use modelling programs to express environmental process on equations to facilitate theoretical calculations.

Some of the main purposes of modeling are to organize experimental data, to understand simple relationships between parameters and pollutant removal, to design equipments according to a specific operation, to predict the performance under given conditions and to perform processes optimization (Vaiškūnaitė et. al. 2005). In any case, biofiltration modeling has received less attention in comparison to experimental approaches. Numerous studies dealing with mathematical models of volatile organic compounds removal by biofiltration can be found in literature. Simple and complex models have been employed to emulate VOC biofiltration under both steadystate and dynamic operating conditions. In all modeline works reported in the literature VOC removal in biofilters is based on bacterial degradation activity with environmental condition, special pH (Dorado *et. al.* 2007). Mathematical modelling was carried out on biological air cleaning process, depending on different pH in the charge filled with pine bark and main filters parameters.

The aim of this work – to model the efficiency of biological air cleaning process and to make regression equations by varying biocharge pH regimes (4, 5, 6, 7, 8, 9 and 10), filter parameters (charge height and air flow speed), and initial concentrations (up tp 100 mg/m³) of the following pollutants: butanol, butyl acetate and xylene.

2. Materials and methods

Biofilter with a pine bark charge was used for the experimental tests in Vilnius Gediminas technical university, department of Environmental Protection. The biofilter (0.5x0.48x2.0 m) with biologically activated charge contains five separate layers of biomedium, which don ot press each other, are separated mesies and ensure even distribution of airflow. The experimental devize contained five separate 0.15 m high layers instead of containing a single 0.75 m high layer. Treating the polluted air with volatile organic compounds, the flow of polluted air pasies through all five layers of biomass. Valves installed in the air duct regulate the speed of the incoming and outgoing airflow passing through the filter (from 0.02 to 0.1 m/s). To enhance the speed of the polluted air, the entrance aid duct is of a cowl form. The cleaned air is exhausted from the filter through the flexible exit air duct (Baltrėnas and Vaiškūnaitė 2003).

Different pH regimes were used in the pine bark charge: 4, 5, 6, 7, 8, 9 and 10. The necessary pH was achieved by temperature, moisture content and calcium oxide. Higher temperature 45º and lower moisture content 20–30 % influence acidic pH. Moreover, biodegradation of volatile organic compounds decline pH to acidic medium too. To enhance pH value it was chosen calcium oxide (CaO). 4 g CaO is necessary to increase the value of pH 2.8. For instance, if pH=7 it is added 4 g CaO and then the pH value is 9.8. The filter contained a pH measurement opening, to take pH value with pH-meter 538 device.

The biological air treatment process could be started after microorganisms activation, which continues about two weeks (Baltrėnas *et. al.* 2005). In activation process, volatile organic compounds are heated and evaporised (Baltrėnas and Zagorskis 2009). When air cleaning process was in progress, 20 l of water per day was used to maintain humidity of 60 % in the whole volume of the bark (0.18 m³). With the help of five pumps water from a reservoir was pumped to each layer so that 60 % moisture content was maintained. Water was spread above each layer and its excess was collected in the waste collector together with waste generated. Charge humidity was monitored periodically by weighting method, by desiccating bark samples at 100–105 ºC until constant weight was obtained. The necessary temperature 28 ºC in the filter was achieved by heating bio-medium at the side walls of the filter with the help of two heating elements.

For microbial growth there are three essential elements: carbon (C), nitrogen (N), and phosphorus (P). Carbon can be provided by the VOCs in the air stream, but both nitrogen and phosphorus must be provided by the filter material according to the scientists Vanloon and Duffy. Prior to starting the equipment and when operating it, up to 0.43 kg of solution of mineral salts (K_2HPO_4 – 1 g, KCl – 0.5 g, $FeSO_4 \cdot 7H2O$ – 0.1 g, $NaNO_3$ – 0.91 g, $MgSO_4 \cdot 7\ H_2O$ – 0.5 g per week were consumed. These mineral salts are necessary to obtain energy and growth of microorganisms (Baltrėnas and Vaiškūnaitė 2004). Biogenic elements were consumed by microflora in the charge together with sprinkled water.

It was used speed meter „TESTO-452" with thermopair to measure the air flow rate in this experimental researches. When increasing speed of the airflow injected up tp 0.1 m/s, measurement error also increased. Each mesurement was repeated five times.

To assess the aerodynamic resistance of charge differential pressure device „DSM-1" was used. It was performed 5 measurements in every layer of biomedium and the averages of obtained result were derivabled.

In experimental researches were applied different composition of volatile organic compounds (butanol, butyl acetate and xylene), their initial concentrations, airflow speed, and the height of charge layers. To compare volatile organic compounds biodegradation in the activated pine bark charge, six different concentrations up to 100 mg/m³ were take approximately every 15–20 mg/m³.

Concentration of pollutants was determined by photo-ionization sensor MiniRAE 2000, which has 9.8, 10.6, or 11.7 eV UV lamp. MiniRAE 2000 consists of a PID with associated microcomputer and electronic circuit. The unit is housed in a rugged AB S + PC case with a backlit 1 line by 8 character dot matrix LCD and 3 keys to provide easy user interface. Device MiniRAE 2000 is build to measure 102 VOC gases. Temperature range of this photo-ionization sensor is from 0 to 45°C (32 to 113°F), and relative humidity range is from 0 % to 95 %.

After determing concentrations of volatile organic compounds under investigation by MiniRAE 2000 analysis, efficiency of biofilter was estimated. Furthermore, during the experiment the temperature of laboratory was 18–20 ºC, atmospheric pressure 749–751 mm Hg column and humidity 68 % (Baltrėnas and Vaiškūnaitė 2003).

3. Model development

The model was built considering the most relevant phenomena occurring during the biofiltration process like convection, absorption, diffusion and biodegradation. The theoretical model describing the elimination of VOC in a biofilter bed is based on formulas, which are necessary to express air cleaning process with MATLAB program.

The MATLAB environment along with the Java CoG provide a flexible and robust user interface for grid computing. By exposing the compute, data and notification features as toolkit components it is able to construct high level functions which utilise grid resources for design search tasks and structural optimisation problems. Given commands in a high level interpretive language it is straightforward for the engineer to exploit available grid-enabled resources to tackle computationally and data intensive tasks. MATLAB operation principle are based on equations, which are considered of matrix. Matrix is designed by Rayleigh dissipative function R, which consists of systems friction elements (Vasylius *et al.* 2008). Future work on environmental processes with MATLAB will focus on the creation of high level application components (Eres *et. al*. 2004).

Value pH is one of the most important parameters in a wide number of biological processes according to the scientists Vaiškūnaitė and Zagorskis. This parameter has a notable influence on the activity of different bacteria besides to governing processes such as absorption or stripping (Baquerizo 2007). Moreover, it is important to evaluate initial concentration of pollutants building a model. Furthermore, air flow rate and the height of charge filled with pine bark will be incorporated to the formulas trying to model efficiency of air cleaning process.

4. Results and discussions

During biofiltration processes with different pH regimes (4, 5, 6, 7, 8, 9 and 10) maintained in the biofilter, pollutant oxidation in the activated pine bark charge takes place within the laws of linear adsorption. The ability to oxidise pollutants and their cleaning depend in the pH maintained in the charge, the charge height and the velocity of the air flow. Regression equations were solved using, like it was mentioned before with MATLAB Simulink modelling program.

Biofilter charge height exerts considerable impact on the biological air cleaning process. It largely determines two parameters of the fllter: the aerodynamic resistance and the cleaning efficiency. To that end, the research on how the pollutant cleaning efficiency depends on the filter charge height X under different initial concentrations C_0, and the charge pH regimes (4, 5, 6, 7, 8, 9 and 10) is accordingly illustrated in Fig 1. With the help of regression equations for each curve was obtained. Solution of this eąuation system gives an expression for butanol at the biocharge pH=7.

$$E = 94.63 - 0.3\,C + 0.1\,X \qquad (1)$$

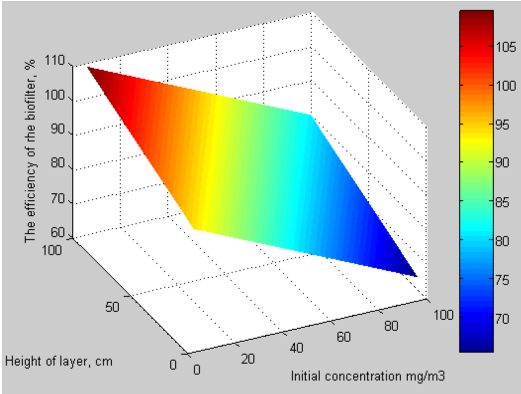

Fig 1. Efficiency of air cleaning from butanol depending on the height of layer, when pH=7

Dependence of the efficiency of butanol removal from the air on the filter biocharge height and initial concentrations is illustrated graphically (Fig 1). First of all it is recorded that the tested material with the initial concentration of (5, 15, 31, 52, 78 and 98 mg/m^3) is injected through the filter. Perpendicular lines in three-dimensional diagram show that removal of butanol from the air on biocharge layers from 15 to 75 cm and the efficiency depends on height of layer. When the height changes from 30 to 60 cm with 78 mg/m^3 initial concentration the efficiency increases from 71 to 79 %. The presented modelling results confirm that the height of biocharge is very important in the process of air cleaning.

The following expression is obtained for butanol at the charge pH=6:

$$E = 88.00 - 0.28C + 0.09X \qquad (2)$$

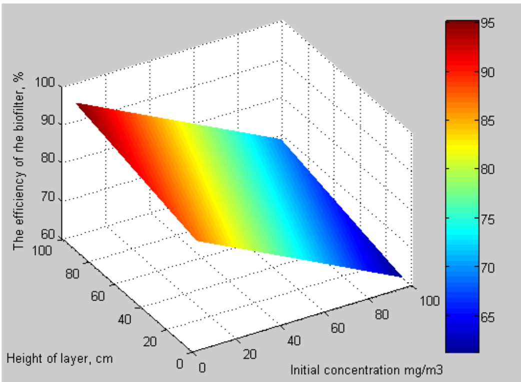

Fig 2. Efficiency of air cleaning from butanol depending on the height of layer and of charge pH 6 and 8

Fig 2 shows, the efficiency of biofilter depends on initial concentration and the height of layer too, like it was in the Fig 1. In comparison between Fig 1 and Fig 2 the efficiency depends on pH, for instance if the range of efficiency in Fig 1 was from 63 to 97 %, in Fig 2 shows that the efficiency was less, i.e. from 60 to 95 %.

Moreover, pH value of 6 and 8 influence the efficiency of air cleaning process in similar way, therefore formula was used the same to model the efficiency of biofilter at pH 6 and 8.

Other expression is obtained for butanol at the biocharge pH of 5 in formula 3:

$$E = 47.30 - 0.15C + 0.05X \qquad (3)$$

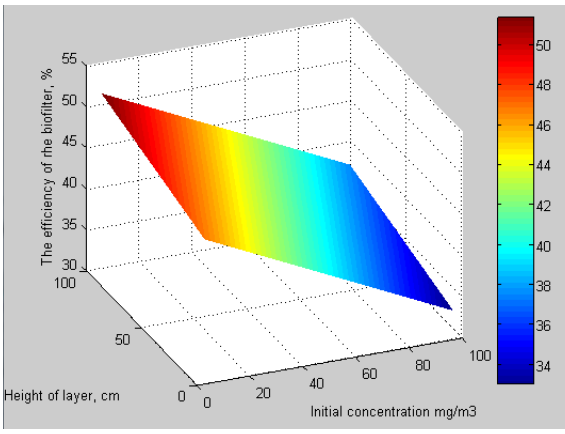

Fig 3. Efficiency of air cleaning from butanol depending on the height of layer and of charge pH 5 and 9

Fig 3 shows, that the efficiency of biofilter decreases significantly, when we reduces pH till 5 or increased pH to 9. Maximum value of biological air treatment is just 52 %.

Moreover, there is an equation which is suitable to model the efficiency of biofilter, pH of 10 maintained in the charge. The following equation is:

$$E = 8{,}33 - 0{,}03C + 0{,}01X \qquad (4)$$

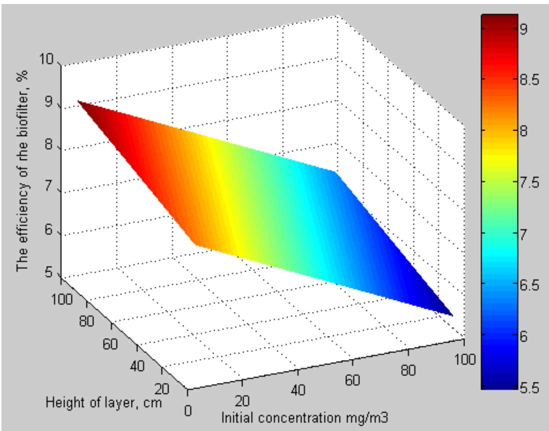

Fig 4. Efficiency of air cleaning from butanol depending on the height of layer and of charge pH=10

From the Fig 4 it can be seen, that the efficiency of biofilter is very low, the heighest point is 9.1 %.

The following expression is obtained for butanol at the charge pH=4:

$$E = 6.62 \;- 0.02C + 0.01X \qquad (5)$$

The approximation reliability coefficient of this equation is relatively high: R^2=0.99.

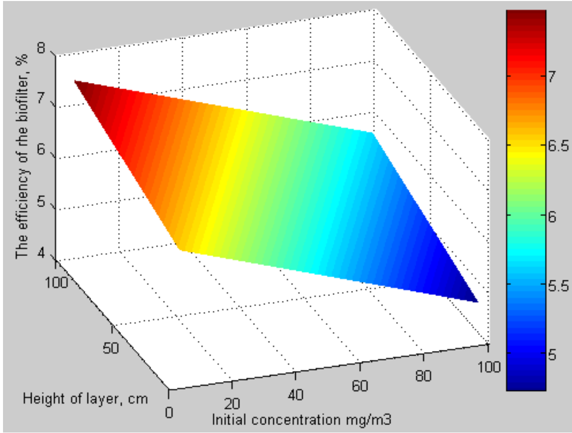

Fig 5. Efficiency of air cleaning from butanol depending on the height of layer and of charge pH=4

MATLAB graphics of the efficiency of biofilter treating butanol at different range pH (4, 5, 6, 7, 8, 9 and 10) depends on initial concentration and height of layer. The greater the number of layers, the more efficient removal of butanol from the air. Additionally, the bigger concentration of butanol influences less efficiency of air treatment.

Similarly, the following expression is obtained for butyal acetate cleaning polluted air and evaluating E – efficiency of biofilter depending on filter height X under different initial concentrations C and the charge pH of 7:

$$E = 93.75 - 0.34C + 0.16X \qquad (6)$$

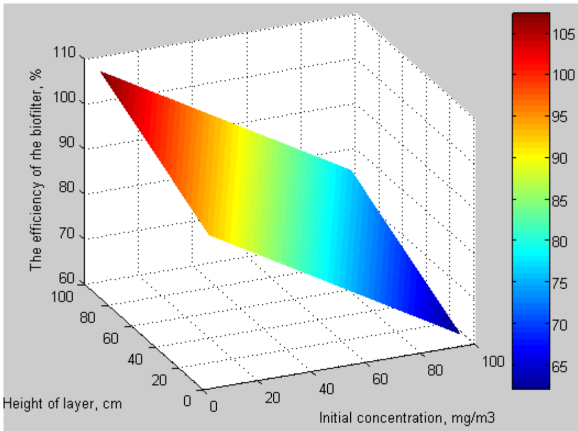

Fig 6. Efficiency of air cleaning from butyl acetate depending on the height of layer, when pH=7

Another expression was obtained for butyl acetate at the biocharge pH of 6 and 8:

$$E = 87.19 - 0.32C + 0.15X \qquad (7)$$

The following expression was obtained for butyl acetate at the biocharge pH of 5 and 9:

$$E = 48.88 - 0.17C + 0.08X \qquad (8)$$

When pH=10, equation (9) is applied:

$$E = 8.25 - 0.03C + 0.01X \quad (9)$$

When pH=4, equation (10) is applied:

$$E = 6.56 - 0.02C + 0.01X \quad (10)$$

The approximation reliability coefficient of this equation is R^2=0.93.

The latter expression shows the way the efficiency of the butyl acetate cleaning depends on the filter charge height X and the initial concentration C_0, and the pH maintained in the charge (4, 5, 6, 7, 8, 9 and 10). This again proves that removal of butyl acetate from the air is efficient at pH=7. The same as in the case of butanol, the approximation reliability coefficient of this equation (10) is rather high: R^2 =0.99.

The dependence of the efficiency (E) of the xylene removal from the air on the filter charge height *(X)* under different initial concentrations (C_0) and charge pH=7:

$$E = 64.54 - 0.45C + 0.47X \quad (11)$$

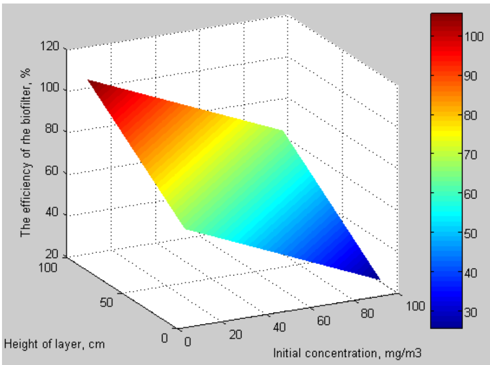

Fig 7. Efficiency of air cleaning from xylene depending on the height of layer, when pH=7

Other expression was obtained for xylene, when pH=6:

$$E = 60.02 - 0.42C + 0.44X \quad (12)$$

Value pH of 6 and 8 influence the efficiency of air cleaning process in similar way, therefore formula was used the same to model the efficiency of biofilter at pH 6 and 8.

The following expression was obtained for xylene at the charge, in which pH is 5 and 9:

$$E = 32.27 - 0.23C + 0.24X \quad (13)$$

Moreover, there is an equation which is suitable to model the efficiency of biofilter treating xylene, when pH of 10 maintained in the charge. The following equation is:

$$E = 5.68 - 0.04C + 0.04X \quad (14)$$

The following expression was obtained for xylene at the biocharge pH=4:

$$E = 4.52 - 0.03C + 0.03X \quad (15)$$

The approximation reliability coefficient of this equation is relatively high: R^2=0.97.

Generalisation of results obtained during mathematical modelling allows stating that removal of xylene from the air at pH=7 in the charge is efficient (between 60 and 80 %), when its initial concentrations do not exceed 19 mg/m^3. Accordingly, reduction in the number of charge layers results in the drop in efficiency of biofiltration. For instance, when the initial concentration of xylene is 19 mg/m^3, after one layer of the charge the efficiency of pollutant removal is only 60 %. It could be stated that with the height of layer going up from 0.15 to 0.75 m, the process of air cleaning increases from 60 to 80 %. This is clearly reflected in the graphical obtained in the mathematical modelling (Fig 7).

Biological air cleaning process is also influenced by the velocity of the air passing through the filter, and the efficiency of air cleaning and aerodynamic resistance of the charge depend on that velocity. The modelling results show the way the efficiency of the pollutants removal depends on the air flow rate *V,* the initial concentration C_0, and the pH regimes (4, 5, 6, 7, 8, 9 and 10).

Respectively, Fig 8 illustrates the results of butanol removal from the air. The following expression is:

$$E = 69.77 - 0.34C + 1.0V \quad (16)$$

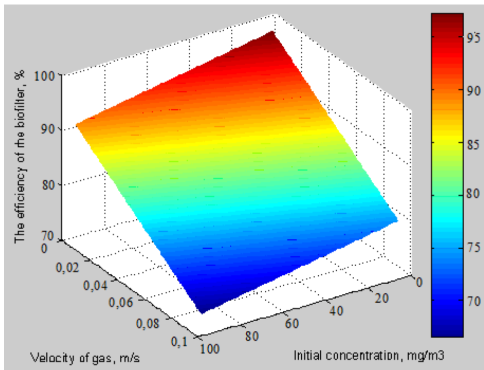

Fig 8. Efficiency of air cleaning from butanol depending on air flow rate, when pH =7

Dependence of the efficiency of butanol removal from the air on on air flow rate and initial concentrations, when the charge pH=7 is illustrated in the Fig 8. Butanol removal efficiency is very high, even with the initial concentration of 98 mg/m³ on velocity of 0.1 m/s the efficiency is 78 %.

The following expression is maintained for butanol at the charge when pH=6.

$$E = 64.89 - 0.32C - 0.93V \quad (17)$$

From the Fig 9 it can be seen, that the efficiency of biofilter depends on initial concentration and the air flow rate. In comparison between Figs. 8 and 9 the efficiency depends on pH, for instance if the range of efficiency in Fig 8 was from 61 to 95 %, in Fig 9 shows that the efficiency was less, i.e. from 78 to 99 %.

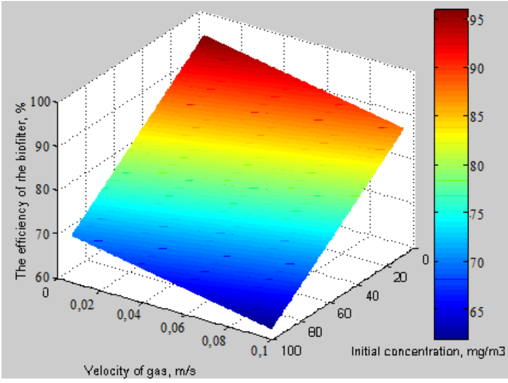

Fig 9. Efficiency of air cleaning from butanol depending on air flow rate, when pH=6

Additionally, pH value of 6 and 8 influence the efficiency of air cleaning process in similar way, therefore formula was used the same to model the efficiency of biofilter at pH 6 and 8.

The following expression is maintained for butanol at the charge when pH=5.

$$E = 34.89 - 0.17C - 0.5V \qquad (18)$$

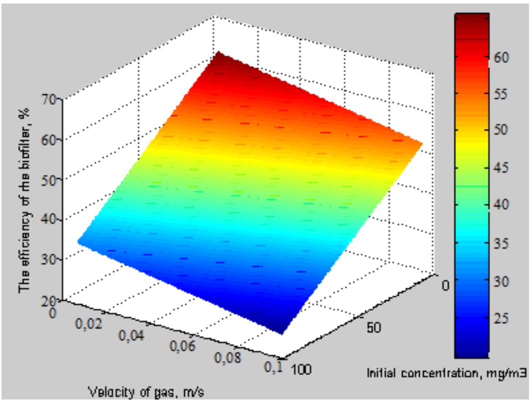

Fig 10. Efficiency of air cleaning from butanol depending on air flow rate, when pH=5

Fig 10 shows, that the efficiency of biofilter decreases significantly, when we reduces pH till 5 or increased pH to 9. Maximum value of biological air treatment is just 62 %.

Respectively, pH value of 5 and 9 has impact on the efficiency of biological air treatment in analogous way, hence expression was used the same to model the efficiency of biofilter at pH 5 and 9.

When pH=10 it is used the following expression:

$$E = 6.14 - 0.03C - 0.09V \qquad (19)$$

Fig 11 shows, that the efficiency of biofilter is very low, when pH=10. The efficiency of air cleaning process reach just 11 %.

Moreover, it is possible to model the efficiency of air cleaning process, when pH=4 and it is obtained the further expression:

$$E = 4.88 - 0.02C - 0.07V \qquad (20)$$

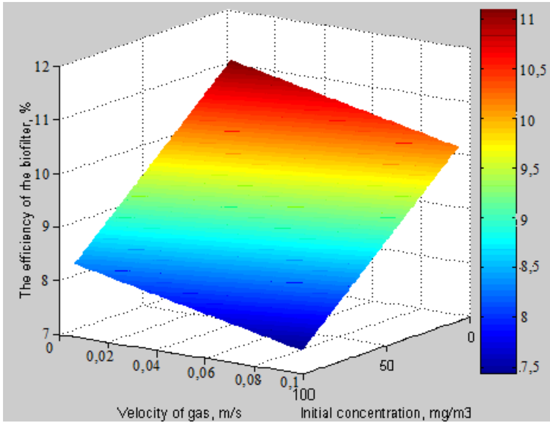

Fig 11. Efficiency of air cleaning from butanol depending on air flow rate, when pH=10

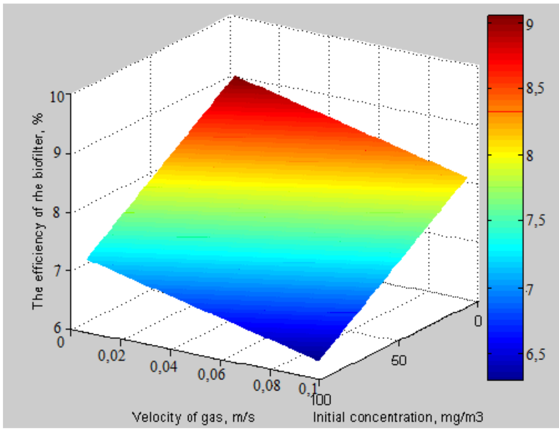

Fig 12. Efficiency of air cleaning from butanol depending on air flow rate, when pH=4

Similarly like in Fig 11, from the Fig 12 it can be seen, that pH is an important factor, which influence the reduce of the efficiency of air treatment process. The efficiency of biofilter is very low, when pH=4. The efficiency of air cleaning process reach just 9 %, less efficiency comparing with pH=10.

The approximation reliability coefficient of this equation is R^2=0.99.

Consequently, the latter modelling results give a clear view of and confirm the experimental test results that the process of the air cleaning of volatile organic compounds is highly influenced not only by the initial pollutant concentration by also by the velocity of the passing air. Conclusion could be made that, when the biocharge maintained pH=7 and the air flow rate of 0.02–0.1 m/s the air being cleaned of butanol with the concentration not more than 78 mg/m³, the efficiency is very high, i.e. more than 80 %.

Similar expression is applied for the efficiency of air cleaning process treating butyl acetate (Eq. 21):

$$E = 94.86 - 0.36C - 0.99V \qquad (21)$$

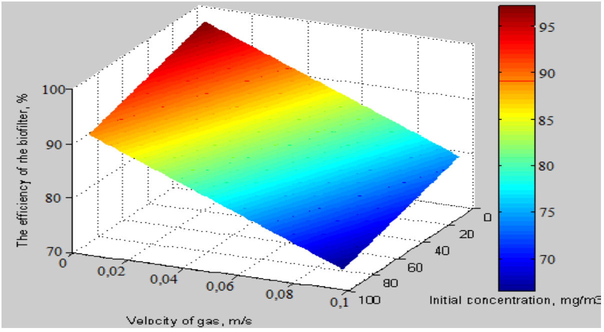

Fig 13. Efficiency of air cleaning from butyl acetate depending on air flow rate, when pH =7

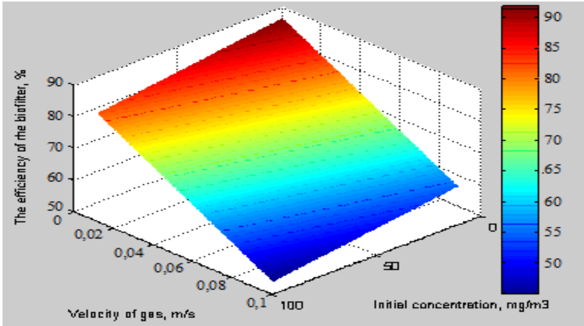

Fig 14. Efficiency of air cleaning from xylene depending on air flow rate, when pH =7

The dependence of the efficiency *(E)* of the butyl acetate removal from the air on the velocity of the injected air *(V)* under different initial concentrations (C_0) and charge pH regimes (4, 5, 6, 7, 8, 9 and 10) is illustrated in Fig 13.

Perpendicular lines in three-dimensional diagram show that removal of butyl acetate from the air, when air flow rate is from 0.02 to 0.1 m/s. When the velocity of passing air changes from 0.04 to 0.1 cm with 47 mg/m³ initial concentration the efficiency increases from 93 to 82 %. The presented modelling results confirm that the velocity of passing air is very important in the process of air cleaning.

The following expression is obtained for butyl acetate at the charge pH=6. In this case, the equation (22) is suitable for the expression, when pH=8:

$$E = 88.22 - 0.33C - 0.92V \qquad (22)$$

When pH is 5 and 9, equation (23) is applied:

$$E = 47.43 - 0.18C - 0.50V \qquad (23)$$

The following expression is obtained for butyl acetate at the charge pH=10:

$$E = 8.35 - 0.03C - 0.09V \qquad (24)$$

The following expression is obtained for butylacetate at the charge pH=4:

$$E = 6.64 - 0.03C - 0.07V \qquad (25)$$

The approximation reliability coefficient of this equation is R^2=0.94.

The efficiency of biofilter was modelled treating the air pollutes with xylene also. The following expression is the following, when pH=7:

$$E = 63.66 - 0.46C - 1.7V \qquad (26)$$

It is denoted, that xylene removal process is relatively efficient. When the initial concentrations do not exceed 63 mg/m^3 and the velocity of the air flow is not faster than 0.06 m/s, the air cleaning efficiency reaches 70 % and more. The above mentioned results show that low concentrations of pollutants are cleaned efficiently.

Respectively, air cleaning reducing tendency was also recorded with higher initial pollutant concentrations (from 7 to 95 mg/m^3) and higher speed of the injected air (from 0.02 to 0.1 m/s). This is proved by the graphical material of mathematical modelling. Hence, air cleaning efficiency results much depended on the initial concentrations of the pollutant. When the latter are increased to 95 mg/m³ and the air is injected at the speed of 0.1 m/s, the biofiltration efficiency reaches only 53%.

The following expression is obtained for xylene at the charge pH=6. In this case, the equation (27) is suitable for the expression, when pH=8 also:

$$E = 59.2 - 0.43C - 1.58V \qquad (27)$$

The following expression is maintained for xylene at the charge when pH=5.

$$E = 31.83 - 0.23C - 0.85V \qquad (28)$$

Additionally, pH value of 5 and 9 influence the efficiency of biological air treatment in analogous way, therefore expression was used the same to model the efficiency of biofilter at pH 5 and 9.

The following expression is obtained for butylacetate at the charge pH=10:

$$E = 5.6 - 0.04C - 0.15V \qquad (29)$$

The following expression is obtained for butylacetate at the charge pH=4:

$$E = 4.46 - 0.03C - 0.12V \qquad (30)$$

The approximation reliability coefficient of this equation is R^2=0.98.

Hence, modelling results give a very clear view of the results of the experimental tests. Compared with the above given and analysed examples, the air cleaning process was linear dependence from the initial concentration of pollutants, the height of layer and the velocity of passing air. Expressions for modelling were obtained in the pH regimes from 4 to 10. Naturally, the best view of butanol, butyl acetate and xylene removal results were reflected on the graphical at the pH=7 in the charge filled with pine bark.

All regression equations show, that the obtained approximation reliability coefficients are higher than 0.9.

Thus, air cleaning efficiency expressed as the latter equation suits for all pollutants that passed the biofilter (butanol, butyl acetate and xylene).

5. Conclusions

1. Mathematical modelling of biological air treatment was carried out with the help of the date of experimental tests and regression formulas used with MATLAB depending on pH regimes (4, 5, 6, 7, 8, 9 and 10), different filter parameters: height of layer (0.15 to 0.75 m), velocity of passing air (0.02 to 0.1 m/s) and pollutants (butanol, butyl acetate and xylene) with its initial concentrations were obtained.
2. The influence of charge height (0.15–0.75 m) with different initial pollutants concentrations at different pH regimes (4, 5, 6, 7, 8, 9 and 10) on the efficiency of air cleaning process was modelled. Similar experimental results, the grow in the height of layer from 0.15 to 0.75 m influence the increse of the efficiency of biofilter. For instance, when pH=7 and the air is being cleaned of butanol (with its initial concentration of 78 mg/m³), the efficiency of removal of xylene starting with the height of the charge equal to 0.3 m is 71 %, starting with the height of 0.6 m the efficiency is 79 %.
3. The dependences of the filter efficiency on the velocity of the passing air (0.02 to 0.1 m/s), initial pollutants concentrations (up to 100 mg/m³) at different pH values from 4 to 10 were modelled. These results confirms experimental tests, therefore the increase of air flow rate (up to 0.1 m/s) influence the reduce in efficiency of biofilter. Respectively, when pH=7 of the charge filled with pine bark and the air is being cleaned of butanol (with its initial concentration of 96 mg/m³), with the air flow rate of 0.02 to 0.08 m/s, air cleaning efficiency reduces from 81 to 92 %.
4. Obtained expression of the efficiency of biofilter, which depends on initial pollutants concentrations, the velocity of passing year and the height of layer, let to model air cleaning process with MATLAB modelling program, which in future lighten theoretical calculations, choice of suitable equipment characteristics and receive effective biological air treatment.

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