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INVESTIGATION AND ANALYSIS OF AIR-CLEANING BIOFILTER HYBRID BIOCHARGE QUANTITATIVE AND QUALITATIVE PARAMETERS

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Abstract. Investigation of microorganism quantitative and qualitative parameters in the hybrid load of the biofilter allows improving the parameters of one of the most effective and cheapest air cleaning technologies of volatile organic compounds (VOCs) – biofiltration process. The point of biofiltering is the partitioning of volatile organic compounds during the metabolism of microorganisms. In pursuance to assure the best conditions for their growth, the biofilter is loaded with biocharge mixture made of zeolite, foam and wood shavings. The device is filled with VOCs mixture consisting of: acetone of ketone group; butanol of alcohol group and xylene of aromatic carbohydrate group. The optimal temperature of 30 °C is sustained in the air-cleaning device as well as neutral concentration of hydrogen ions (pH 6.9–7.1), biocharge mixture is irrigated with mineral saline solution. The investigation results show that the biofilter is operating most effectively 8 weeks after the end of its activation. The most propitious conditions for growing in the first biofilter cassette is when mould fungus and bacteria cultures have grown, the distribution percentage of which is respectively 5.3% and 94.7% in regard to all grown colonies. The most acceptable for mould is the faction of zeolite granules and activated synthetic foam cubes for bacteria.

Keywords: air cleaning, microorganisms, metabolism, biofiltration, volatile organic compounds (VOCs), bioload, effectiveness.

1. Introduction

Since the number of means of transport, manufacture and use of solvents are increasing rapidly as well as services of publishing, VOCs use and segregation into the environment increased as well. Hydrocarbons, alcohols, aldehydes, ketones, esters fall under VOCs. One of the mostly used ketones is acetone. It is a very popular organic compound in everyday life, which is mostly used in adulterating paint, glue and nail polish. In industrial activities this chemical material is mostly used in textile, metal processing sectors and solvent manufacturing (Bing 2005). Out of alcohol group butanol should be mentioned. Butanol, which has a strong fungicidal effect, is widely used for protection of cultural values. In Lithuania, in document preservation and restoration centre of M. Mažvydas National Library, since the year 2000 the printouts harmed by microfungus are disinfected in a hermetic chamber using butyl alcohol steam (Minderienė, Krištaponis 2005).

Xylene, which falls under the aromatic hydrocarbon group, can get through into the environment during burning of gasoline or tar; it also forms during the forest fires. This chemical material, same as solvent, is widely used in publishing, leather and rubber processing companies (Kučerova *et al.* 1999; Vaiškūnaitė *et al*. 2009).

It should not be forgotten that despite the advantages of using VOCs compounds, using this material too often or in unlimited quantities not only brings harm to our health but pollutes the environment as well. Environment and atmosphere pollution caused use of a wide variety of cleaning methods and creation of new technologies as well as use in industrial activities and in everyday life (Baltrėnas *et al.* 2004; Baltrėnas and Zagorskis 2010).

Scientific research proved that one of the most effective and cheapest air-cleaning technologies clearing the air from VOCs is biofiltering. The essence of the method is the partition of volatile organic compound with help of micro organisms (Zigmontienė and Baltrėnas 2004). The bacteria, yeast, fungus play the main part in the process of biodegradation of VOC, which had gotten through to the environment due to natural or industrial processes. The biological partition of VOCs with help of microorganisms is possible when these components are used as energy and carbon sources for micro organisms. When parting VOCs new microorganisms are growing (catabolism is in progress), components oxidize to carbon dioxide and water (Baltrėnas *et al.* 2004; Vaiškūnaitė *et al*. 2005).

The growth of microorganisms happens in accordance to such a scheme: inert phase; growth phase; stationary phase; and lethal phase (Fig. 1). The growth of microorganisms in the closed utensil is limited by either feeding medium expenditure or accumulation of toxic metabolism products (Masteikienė 2002).

All the four phases presented in the Fig. 1 are important for the biological degradation process. To reach a good product output, it is necessary to shorten the inert phase (phase I) as much as possible and increase the speed of

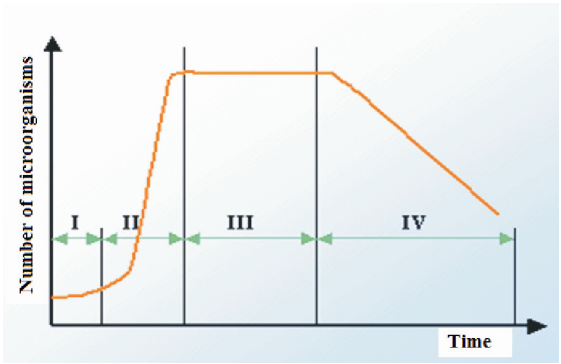

Fig. 1. Growth phases of microorganisms in closed system: I – lag phase, II – exponential phase, III – stationary phase, IV – lethal phase (Prescott *et al.* 1994)

microorganism growth in the growth phase as well as prolong the duration of that phase. This is done to receive the highest possible density of microorganisms at the end of the process (Pukalskas 2007).

The highest impact on the microorganism reproduction and biochemical reaction speed is caused by temperature. The best reproduction of microorganisms happens at an optimal for them temperature (Baltrėnas and Zagorskis 2008; Tymczyna *et al.* 2004).

The dependence of microorganism growth speed on temperature may be expressed by Arenius equation:

$$\log_{10} V = \frac{-\Delta H}{2.303RT} + C\,, \qquad (1)$$

where V – reaction speed; ΔH – reaction energy; R – gas constant; T – temperature K.

However, this equation is only valid at certain temperature limits in which the microorganisms survive. It is usually considered that life can exist at a temperature limit from –5 °C to +95 °C (Prescolt *et al.* 1993; Pukalskas 2007).

The main element of biological air cleaning is biocharge which is necessary as microorganism substratum. Various biocharges such as natural compost, turf, wood shavings or wood bark (Baltrėnas and Vaiškūnaitė 2003; Baltrėnas and Zagorskis 2009) as well as man-made ceramic beads, foam or plastic are used in practice (Yun and Ohta 1998; Lugauskas *et al.* 1997). To prolong the period of biocharge operation, it is necessary to combine natural and artificial charges in one biofilter cassette, since some of them have biological effectiveness and others – good sorption qualities (Fig. 2).

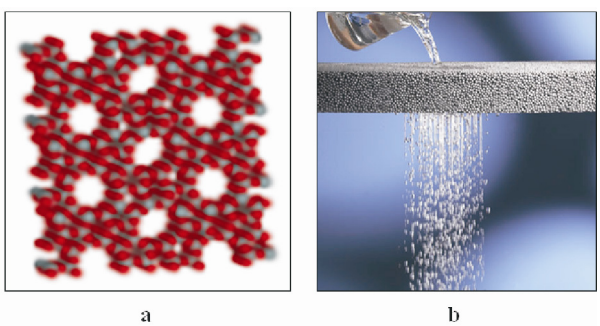

Fig. 2. Material used in the process of biofiltration: a – zeolite structure, b – foam

For example, when mixing wood shavings with zeolite or foam, such a mixture has better moisture sorption qualities, low density and large active surface area. Besides, VOC, after it has absorbed into the porous material, remains longer in the cleaning device, in such way making the appropriation of them for microorganisms easier, thanks to which the VOCs are fissioned more effectively (Baltrėnas *et al.* 2004; Baltrėnas and Paliulis 2002).

Goal of research: to determine and evaluate quantitative and qualitative microbiological parameters in separate biocharge mixture factions when activating the biofilter with the VOCs mixture and maintaining constant temperature of biofilter charge.

2. Investigation methods

Experimental research of quantitative and qualitative microbiological parameters is performed in an air-cleaning device–biofilter (Fig. 3). 1–5 cartridges of this device were charged with the same biocharge mixture of wood shavings, 10×10×30 mm size foam cubes and zeolite granule (size of granules 8–12 mm) factions. Overall volume of the cassette is 0.135 m^3. The biocharge mixture is received by mixing these factions at a ratio of 1:1:1. Each cassette is separated by metal nets for maintaining equivalent air flow in the entire device (Baltrėnas and Zagorskis 2007a).

The biofilter charged in such a manner is activated for 2 weeks. During this time the biocharge mixture is irrigated in automatic mode (7–8 s/h) by nozzles set up above each cartridge. During the day, to maintain the humidity of the entire biocharge, about 10 litres of water is sprayed from a water reservoir. To maintain the vital and reproduction functions of microorganisms, the water used for the charge irrigation is saturated with the solution of mineral salts, the composition of which in 1 *l* of water is: 1g – K_2HPO_4; 0.5g – KCl; 0.5g – $MgSO_4 \cdot 7H_2O$; 0.1g – $FeSO_4 \cdot 7H_2O$ and 0.9g – $NaNO_3$.

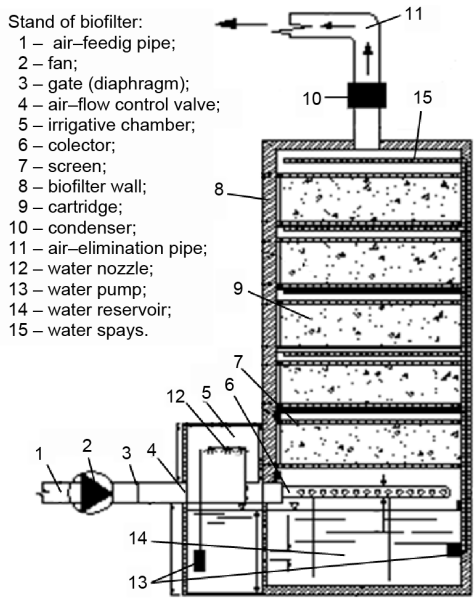

Fig. 3. Air-cleaning biofilter. Dimensions of the device: 0.75×0.9×2.2 m. Dimensions of the cassette: 0.75×0.9×0.2 m (Baltrėnas and Zagorskis 2008)

Neutral ion concentration (pH – 6.9–7.1) and an optimal temperature of +30 °C are necessary for the self-sustained existence of the microorganisms in the mixture of charges (Baltrėnas and Zagorskis 2007b). To maintain neutral pH during the investigation, buffer solutions of sodium and hydrophosphates were used.

VOCs (acetone, toluene and butanol) were evaporated into the biofilter 2 times a day with the help of an electric stove to maintain a steady VOCs concentration which is necessary to sustain the life of microorganisms. Since the evaporation time of these compounds is not equal, the fixed 10 ml quantity of each compound was evaporated separately.

The concentration of each of these compounds is measured by a gaseous chromatograph in the biofilter. When the chromatograph is switched on, the speed of nitrogen gas is determined – 30 ml/min. speed of hydrogen gas – 30 ml/min. and speed of air – 200 ml/min. The temperature of the column is 100 ± 2 °C. The temperature of the vaporizer is 200 ± 5 °C. When the chromatograph is ready, the gaseous pipette is slightly warmed up until 45 ± 2 °C and is sustained for 1 hour. Out of it through the silicone hose 1 cm^3 of analysed specimen is infused into a clean medical syringe and later it is injected into the gas chromatograph vaporizer. Not less than 3 chromatograms are written down, according to which the analysed specimen concentrations are calculated (Baltrėnas and Zagorskis 2007a; Baltrėnas and Vaiškūnaitė 2003; Baltrėnas *et al.* 2004).

The measured VOC concentrations are: acetone – 100 mg/m^3; butanol – 50 mg/m^3 and xylene – 35 mg/m^3.

During activation and experimental investigation, which lasted 8 weeks, the same conditions were sustained in the biofilter. Each week 3 g of each biocharge mixture faction were taken out of each biofilter cassette in principle of "rhombus". In total 15 controlling specimens per week, 120 during the entire study period, were, collected. Controlling specimen microbiological study is performed applying the determination of the overall number of microorganism method common in the microbiology practice.

The initial suspension of controlling specimen (peptone saline: ferment casein hydrolysate – 1.0 g; NaCl – 8.5 g, distilled water – 1000 ml) is prepared in such a manner to receive equal distribution of microorganisms in the specimen and ten folded solutions are made to decrease the quantity of microorganisms in 1 g as much as possible to be able to observe their colonies after the incubation and count them in dishes (from 10 to 300 in one dish). To that end the specimen of wood shavings and zeolite are weighed at an accuracy of 0.01 g. Foam, before weighing it, is thoroughly shredded. About (1±0.01) g of specimens is weighed in sterile crusher bags. Each specimen is placed into a separate bag. Each bag is with weighed specimen is filled up with 9 ml of thinner. The bag with its content is placed into the crusher. The shredding process in the crusher takes about 2–3 min. The bags with shredded specimens are placed into the stand and remain there for 15 min. in order to allow larger particles to subside. In such a way the initial suspension (10^{-1}) of the specimen is prepared. To prepare the further ten folded solution (1±0.01) ml of initial suspension (10^{-1}) is measured with a sterile pipette of volume of 1 ml. It is then poured into the test-tube with 9 ml of thinner. The surface of the solution in the test-tube is not to be touched. The content of the test-tube is stirred in a stirrer of Vortex type for 5–10 seconds. When stirring, the liquid in the test-tube should not ascend higher than 2–3 cm. In such a way the initial suspension's first tenfold solution 10^{-2} is prepared. For preparation of a further tenfold solution 10^{-3} the procedure is repeated. The number of prepared solutions depends on the implied with microorganisms of the specimen with microorganisms. Such solutions were prepared out of the wood chip, zeolite and foam specimens: 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} and 10^{-7}. Quantity of (1±0.01) ml of solutions is seeded into the Petri dishes: 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} and 10^{-7}.

After seeding the analysed suspensions into the Petri dishes, about 15 ml of 44 °C – 47 °C temperature breeding-ground is poured into each dish right away (but not later than in 15 minutes). Feeding medium, necessary for determination of the overall number of microorganisms, consists of: ferment casein hydrolysate – 5.0 g; yeast extract – 2.5 g; waterless glucose ($C_6H_{12}O_6$) – 1.0 g; water caltrop – from 9 g to 18 g (considering the water caltrop gel rigidity); distiller water – 1000 ml. The period from the end of preparation of initial suspension until the breeding-ground pouring into the dishes should not be longer than 45 minutes. The crop and the breeding-ground are quickly well mixed. They are kept on the horizontal surface of the table until the feeding medium freezes. The stagnation duration may be not longer than 10 minutes. When the medium on the dishes freezes the dishes are flipped over with bottoms up and incubated in the thermostat for 72±3 hours at a temperature of 30±1 °C. After the incubation period has ended the dishes are taken out of the thermostat. First of all the growth in the Petri dishes is checked. The results of control dishes are registered in the journal. A dark background is placed into the colony counting device tray, the device is plugged into the power outlet and the colonies in each dish, where less than 300 colonies have grown, are counted. Very small colonies are also counted.

The number of the analysed specimen is determined as weighted average and calculated from 2 sequential solutions by using the formula:

$$N = \frac{\sum C}{V \cdot 1{,}1 \cdot d}, \qquad (2)$$

where $\sum C$ – amount of colonies counted in 2 analysed dishes with 2 sequential solutions when at least 1 dish has at least 10 colonies; V – volume of seeded solution in the dish in millilitres; d – solution that corresponds with the first analysed solution.

Final result is expressed by the number of microorganisms between 1.0 and 9.9 which is multiplied by 10^x (x is a number meaning how many numbers there are after the first number or the whole number out of two significant digits). The result is expressed as the number of microorganisms for N gramme.

3. Investigation results and discussion

In accordance with the received and statistically processed study results of separate weeks, which are presented in Fig. 4, it was decided to finish the microbiological investigation in the biofilter after duration of 8 weeks since, according to the curve of microorganism growth in a closed system (Fig. 1), they are supposed to have reached the stationary growth phase. The body of microbiological cultures is the most massive in this phase. Since the speed of VOCs partition directly depends on the number of microorganisms, a conclusion can be drawn that in 8 weeks from the beginning of investigation the air-cleaning device will work most efficiently.

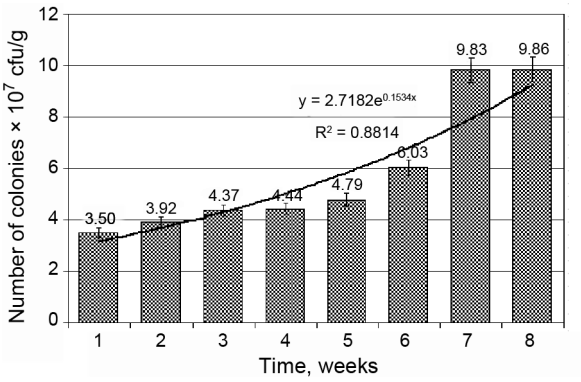

Fig. 4. Dependence of the number of grown microorganism colonies on time in the mixed charge of the biofilter

In accordance with the data provided in Fig. 4 the microorganisms were tendentiously growing in the cassettes of the biofilter through the entire investigation and the highest increase was determined after 7 and 8 weeks. During this period on average respectively $9.83 \cdot 10^7$ and $9.86 \cdot 10^7$ cfu/g of microorganism colonies have grown in each biofilter cassette. After comparing the results of 1st and 8th weeks an increase of microorganisms has been noticed, and this creates hope that the device will be operating efficiently.

The curves provided in Fig. 5 illustrate best the dependence of the microorganism growth on biocharge faction nature. These curves were formed after calculating the study results of separate weeks in each biofilter cassette.

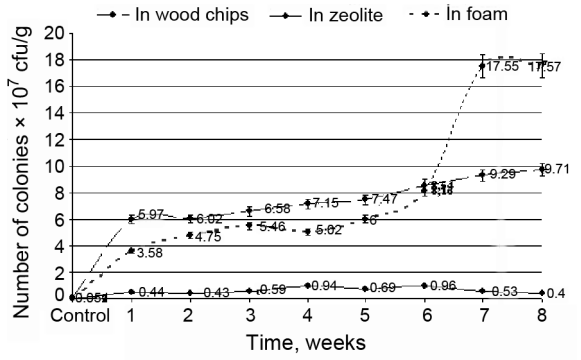

Fig. 5. Dependence of microorganism cultures in the biofilter on time in separate biocharge mixture factions

These results show that the most favourable medium for the microorganisms to grow are the foam cubes of a size of 10×10×30 mm. In this faction the growth of microorganisms was determined to be the fastest and the highest, comparing the results of the first and last weeks. During the first week in this faction on average $3.58 \cdot 10^7$ cfu/g of microorganism growth was registered and during the 8th week even $17.57 \cdot 10^7$ cfu/g – almost 5 times more. Although there were no microorganism cultures found when analysing the control specimen of this synthetic biocharge faction, the larger quantity of microorganisms was determined by better absorption features of the foam (Fig. 2). When the charge porosity is higher, a thicker layer of biomembrane forms on the charge surface and it determines the higher microbiological activity of the charge in the foam (Baltrėnas and Zagorskis 2007a). However, the absorption features are not sufficient for the biocharge. Although the zeolite granules of 10–12 mm thanks to their original nature are able to better absorb than the foam cubes, the microorganism activity in this biocharge faction was noticed to be low in both control and study specimens. During the entire investigation the number of microorganisms in gathered zeolite specimens was determined to be rather low, the highest value of it in the 6th week of study was $0.96 \cdot 10^7$ cfu/g. The growth dependency of microorganisms on time in the zeolite faction could not be determined since the received data were increasing as they were decreasing regardless of the weekly study interval.

Just as it was expected, the most sable and proportionate growth of microorganisms was in the biocharge faction of a natural origin – in wood chips. During the 1st week of study the largest number of microorganisms was determined ($5.97 \cdot 10^7$ cfu/g) compared to all the biocharge factions, and it increased twice during the entire duration of the investigation – to $9.71 \cdot 10^7$ cfu/g.

As seen in Fig. 6, the most favourable conditions for the microorganism development were in the first biofilter cassette. This was mostly caused by the air feed tube installed in the bottom of the biofilter through which, as described in the invesigation methodology, VOCc mixture was let in twice per day. It is believed that the highest pollution concentration was a cause for such a tendency of the microorganism growth.

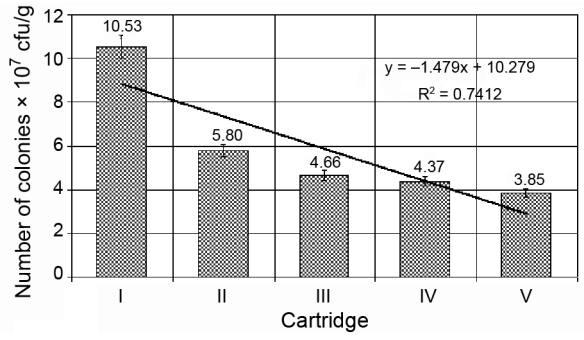

Fig. 6. Dependence of grown microorganism cultures on the position of biofilter cassettes

The quantity determined in the 1st cassette was $10.53 \cdot 10^7$ cfu 1 g of biocharge mixture, and the lowest was in the 5th cassette and reached $3.85 \cdot 10^7$ cfu 1 g of biocharge mixture. The gradually decreasing number of microorganisms in the 1st–5th biofilter cassettes causes a more efficient operation of the device.

The data provided in Fig. 7 allow to see in greater detail the distribution of microorganisms in the biofilter. Most of the microorganisms on all the biocharge factions have grown in the 1st biofilter cassette: $21.19 \cdot 10^7$ cfu/g in foam, $9.34 \cdot 10^7$ cfu/g in wood shavings and $1.05 \cdot 10^7$ cfu/g in zeolite, compared to adequate factions in the other biofilter cassettes.

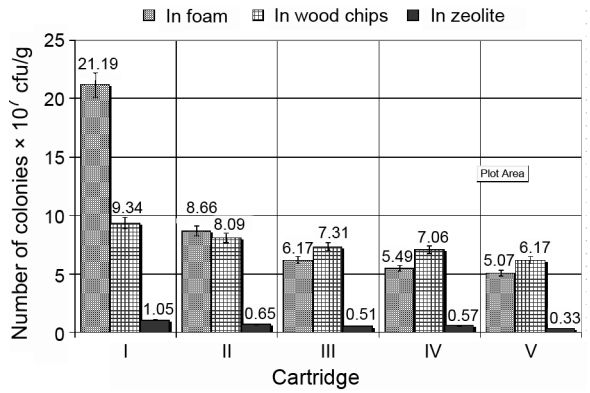

Fig. 7. Dependence of grown microorganism cultures on the nature of biocharge mixture factions in separate biofilter cartridges

In the 2nd cassette the microorganism decrease in the foam faction is obvious compared to the 1st cassette, besides the kvs number in 1 g of material is very similar to the wood shavings – respectively $8.66 \cdot 10^7$ cfu/g and $8.09 \cdot 10^7$ cfu/g.

The most favourable medium for the microorganism growth in the 3–5 cassettes is that of wood shavings. The difference of the grown microorganisms in these two cassettes on the wood shavings and foam remained similar. The least impact caused on the microorganism growth, in regard to the cassettes, was in the zeolite faction. In this material of natural origin the microorganisms were growing reluctantly, however, the tendency remained the same as in regard to the wood shavings and foam factions – when going up the biofilter the number of grown microorganisms was decreasing.

The cultures of mould fungus and bacteria, found in the biofilter during the experimental investigation, made respectively 5.3% and 94.7% in regard to all the discovered cultures. Such a low number of the mould fungus may have resulted from the use of butanol as VOCs. As mentioned above, butanol has a strong fungicidal effect and is widely used for protection of cultural values from the mould fungus destruction. Furthermore, some mould fungus secretes materials which prevent the bacteria from multiplying. It is beneficial for the fungus since the feeding competitor is removed in such a way (Lugauskas *et al*. 1997; Pukalskas 2007). The percentage of distribution is rather similar in separate factions of the biocharge mixture.

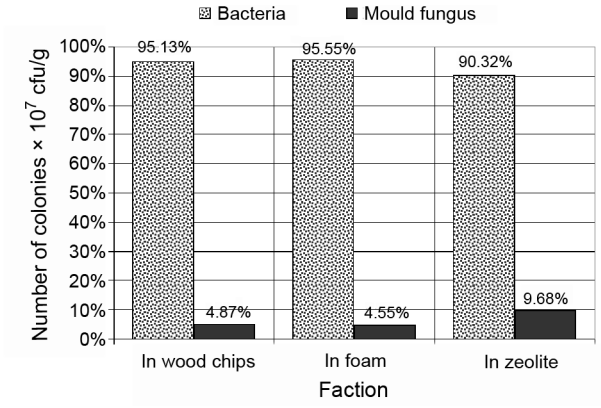

Fig. 8. Distribution percentage of bacteria and mould fungus in separate factions of the biocharge mixture

The data in Fig. 8 show that distribution of bacteria and mould fungus in foam and wood shavings is very similar, approximately 95% and 5%. A little lower domination of bacteria is noticed in the zeolite faction, respectively 90% of bacteria and 10% of mould fungus.

Although using butanol prevented the growth of mould fungus, domination of bacteria cultures was extremely obvious. The performed investigation proves that namely bacteria have the biggest effect when splitting VOCs. Their growth and domination in the biofilter charge definitely increase the effect of the cleaning device.

The data of Fig. 9 show that the growth of bacteria cultures was increasing in proportion to time during the entire duration of the investigation – from $5.61 \cdot 10^7$ cfu/g to $9.42 \cdot 10^7$ cfu/g.

This proves that wood shavings as a natural material is suitable for bacteria growth. This cannot be said about the cultures of mould fungus. The growth of the latter was rather "wavy" in the wood faction in regard to time, and the largest number of them was discovered during the 6th week of study – $0.64 \cdot 10^7$ cfu/g.

It is not surprising that the least of the mould fungus has grown on the wood shavings during the last week of study – $0.29 \cdot 10^7$ cfu/g. A conclusion can be drawn that this was mostly caused by the evaporation of butanol in the biofilter. Since the mould fungus can destroy and

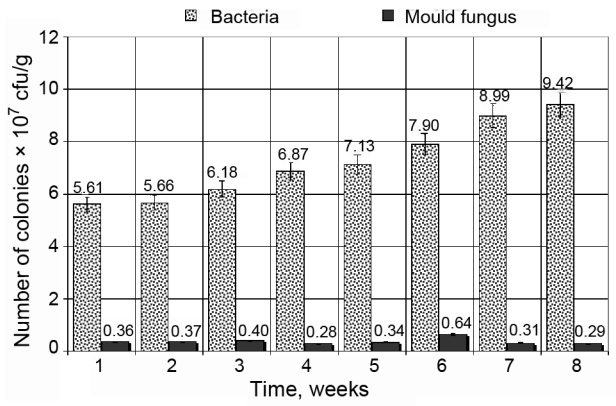

Fig. 9. Dependence of bacteria and mould fungus cultures on time in wood shavings faction

assimilate various organic material (wood, paper, leather, plastic) thanks to the perfect ferment system, such a decrease of them at the end of investigation will allow keeping the wood shavings faction unharmed as this material is very important for the growth of bacteria cultures.

The data provided in Fig. 10 show that the zeolite faction is the least stable component of the biocharge mixture on which the microbiological cultures were growing.

This faction shows no bacteria or mould fungus growth tendencies in regard to time. Furthermore, the highest number of grown bacteria was $0.95 \cdot 10^7$ cfu and the highest number of mould fungus was $0.17 \cdot 10^7$ cfu per 1 g of material. The numbers are relatively low compared to 1 g of wood shavings or 1 g of foam. This information once again confirms the fact that zeolite, due to its tough crystal gridiron and absorption qualities, can be used for VOCs desorption and charge decrease and even for total elimination of this process, as a support of the overall structure of the biocharge mixture, but not as a medium suitable for growing microorganisms.

The highest jump of growth of bacteria cultures during the entire investigation period was noticed in foam faction. After the first week of study after the biofilter activation it was determined to be $3.68 \cdot 10^7$ cfu/g, at the end of investigation it was even $19.01 \cdot 10^7$ cfu/g.

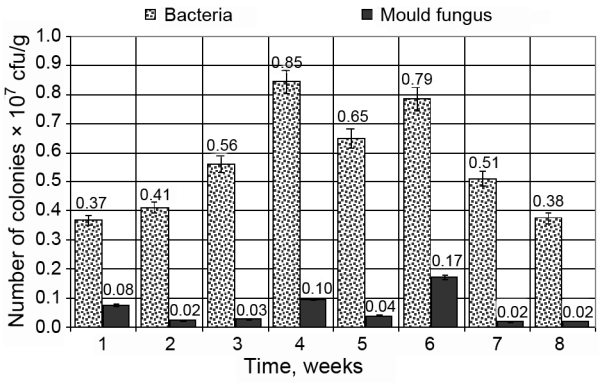

Fig. 10. Growth dependence of bacteria and mould fungus on time in zeolite faction

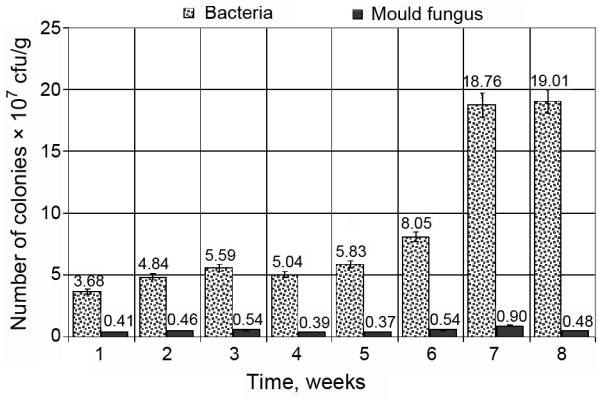

Fig. 11. Growth dependence of bacteria and mould fungus on time in foam faction

With reference to the previously described investigation results, where it is mentioned that no mould fungus or bacteria were discovered in the control specimen of foam before the activation of the biofilter, a conclusion can be drawn that the longer this synthetic faction is activated, the more it will be favourable for microorganisms to grow.

As the data in Fig. 11 show, foam is a favourable faction for mould fungus to grow. Although after the 4th and 8th weeks a decrease of micro organisms of that type was noticed, a tendency still remains that when exploiting the biofilter longer the number of the microorganisms should increase.

Conclusions

1. When using a biocharge mixture of natural and synthetic materials and considering their physical features the efficiency of the biofilter can be increased and at the same time the duration of its operation can be prolonged.

2. In reference to the received results, it may be stated that the highest number of microorganisms was discovered during the 7th and 8th weeks of investigation. The biofilter charged in such way with sustained temperature of +30 °C, neutral pH and humidifying the biofilter with a saline solution in it will operate most efficiently in 7–8 weeks after the end of its activation.

3. Partition of the VOCs is mostly affected by bacteria (the mould fungus and bacteria cultures were discovered in the biofilter, the ratio of which respectively was 5.3% and 94.7% of the overall number of discovered colonies), the number of which affects the efficiency of the filter.

4. In reference to the investigation results, it was determined that the number of microorganisms was decreasing gradually when the biofilter cassettes were going up. Most of the microorganisms were discovered in the 1st biofilter cassette – $10.53 \cdot 10^7$ cfu/g, and the least – V – $3.85 \cdot 10^7$ cfu/g. Such distribution of micro organisms was determined by the uneven pollution concentration in separate cassettes.

5. The most favourable faction for microorganisms to grow were the activated foam cubes. In the end of research the highest number of microorganisms was discovered – $19.01 \cdot 10^7$ cfu/g. The most stable in regard to microorganism growth was the wood shavings faction. In total during the entire research the number of microorganisms changed by about ~ 1.6 times.

6. The research proves that the zeolite faction is not the best medium for growing micro organisms; however, by using its physical features, it is possible to increase the effectiveness and durability of the biofilter.

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ORO VALYMO BIOFILTRO MIŠRIOS ĮKROVOS KIEKYBINIŲ IR KOKYBINIŲ MIKROBIOLOGINIŲ PARAMETRŲ TYRIMAI

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Santrauka

Mikroorganizmų biofiltro mišrios įkrovos kiekybinių ir kokybinių parametrų tyrimai leidžia tikslingiau įvertinti vienos iš efektyviausių ir pigiausių LOJ (lakiųjų organinių junginių) valymo iš oro technologijų – biofiltracijos proceso parametrus. Biofiltracijos proceso esmė – LOJ skaidymas vykstant mikroorganizmų metabolizmui. Siekiant užtikrinti palankiausias sąlygas jiems augti, kaip biofiltro bioįkrova panaudota ceolito, porolono ir medienos drožlių mišinys. Į įrenginį buvo leidžiamas LOJ mišinys, į kurio sudėtį įėjo: ketonų grupei priklausantis acetonas; alkoholių grupei – butanolis ir aromatinių angliavandenilių grupei – ksilenas. Oro valymo įrenginyje buvo palaikoma optimali 30 °C temperatūra, neutrali vandenilio jonų koncentracija (pH 6,9–7,1), bioįkrovos mišinys drėkintas mineralinių druskų tirpalu. Tyrimų rezultatai rodo, kad biofiltras efektyviausiai veikia praėjus 8 savaitėms nuo jo aktyvinimo. Užaugus pelėsinių grybų ir bakterijų kultūroms (jų procentinis pasiskirstymas įrenginyje yra 5,3 % ir 94,7 % visų užaugusių kolonijų atžvilgiu) nustatyta, kad palankiausios sąlygos augti pirmoje biofiltro kasetėje. Pelėsiams tinkamiausia ceolito granulių frakcija, o bakterijoms – suaktyvinti sintetiniai porolono kubeliai.

Reikšminiai žodžiai: oro valymas, mikroorganizmai, metabolizmas, biofiltracija, LOJ, įkrova, efektyvumas.

ИССЛЕДОВАНИЕ КОЛИЧЕСТВЕННЫХ И КАЧЕСТВЕННЫХ МИКРОБИОЛОГИЧЕСКИХ ПАРАМЕТРОВ ВОЗДУХООЧИСТНОГО БИОФИЛЬТРА ПРИ СМЕШАННОЙ ЗАГРУЗКЕ

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Р е з ю м е

Исследование количественных и качественных параметров микроорганизмов при смешанной загрузке биофильтра позволяет совершенствовать параметры одной из самых эффективных и дешевых технологий по очистке воздуха от летучих органических соединений (ЛОС) – процесса биофильтрации. Суть процесса биофильтрации заключается в расщеплении ЛОС в процессе метаболизма микроорганизмов. В целях обеспечения самых благоприятных условий для их роста биофильтр загружался биологической смесью из цеолита, поролона и древесной стружки. В устройство вводилась смесь ЛОС, в состав которой входил ацетон (группа кетонов), бутанол (группа спиртов) и ксилен (группа углеводородов). В воздухоочистном устройстве поддерживалась оптимальная температура (30 ^{o}C), нейтральная концентрация ионов водорода (pH 6,9–7,1), биологическая загрузочная смесь смачивалась раствором минеральных солей. Полученные результаты свидетельствовали о том, что наиболее эффективно биофильтр работает спустя 8 недель после окончания его активизации. После того, как культуры грибков плесени и бактерий, процентное распределение которых в устройстве соответственно было равно 5,3% и 94,7% относительно всех выращенных колоний, выросли, наиболее благоприятными для роста оказались условия в первой кассете биофильтра. Для плесени наиболее приемлемой оказалась фракция гранул цеолита, а для бактерий – активизированные кубики синтетического поролона.

Ключевые слова: очистка воздуха, микроорганизмы, метаболизм, биофильтрация, ЛОС, загрузка, эффективность.

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