ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume LVIII 24 Number 2, 2010

PRIMARY TREATMENT AT THE WASTE WATER TREATMENT PLANT FROM THE POINT OF VIEW OF THE CURRENT LEGISLATION

M. Szostková, T. Vítěz

Received: January 18, 2010

Abstract

SZOSTKOVÁ, M., VÍTĚZ, T.: *Primary treatment of the waste water treatment plant from the point of view of the current legislation.* Acta univ. agric. et silvic. Mendel. Brun., 2010, LVIII, No. 2, pp. 205–212

This contribution focuses on an analysis of sand from nine different wastewater treatment plants in South Moravian Region. We conducted an analysis and evaluation of microbial properties of sand in accordance to Act No. 185/2001 Coll. on waste as amended, resp. Decree No. 381/2001 Coll. Content of following parameters were monitored, thermotolerant coliform bacteria, coliform bacteria, enterococci, total solid, ash free dry mass. We encountered several interesting findings, which pertained mainly to the content of microorganisms in sand. Knowledge of microorganism content should show, how the primary treatment of the wastewater treatment plant works, and should be very interesting indicator.

wastewater treatment, primary treatment, detritus tank, wastewater treatment sand, microbial contamination, mechanical properties

Primary treatment of domestic wastewater represents an extensive range of physical and chemical activities which directly or indirectly affect functionality of the treatment plant as a whole. The aforementioned effect might be rather significant in many respects. The respective matter proves to be highly underestimated (by both operators and designers) at many treatment plants. However, an incorrectly designed or operated primary treatment might result in an unnecessary increase of operating costs and should have a negative impact on the biological level or sludge treatment and disposal. A detritus tank proves to have a key role in the process of primary treatment. The principal task of a detritus tank is to collect the maximum possible amount of mineral substances from wastewater in a manner ensuring that organic substances will remain present in the uplift and they are to flow to the subsequent treatment level. The structure of a detritus tank is to ensure that solely sand without any organic substances will be settling down. However, it is highly complicated to achieve these conditions considering the high level of inflow irregularity, and therefore a high level of concentration of organic solids in the excavated material (Fujioka et al., 2001).

Furthermore, a detritus tank performs also a protective function, which means that it protects other equipment complexes against excessive wear and tear. A correctly rated detritus tank is supposed to catch all sand, i.e. mineral particles featuring the grain size above 0.2 mm and specific density of 2400 kg/m^3 or more (Claydong et al., 2001). This means that a detritus tanks is to be rated in a manner ensuring that wastewater will flow through it at a constant speed in all flow conditions. Should a detritus tank fail to function, the mixture of organic material and sand creates a sediment layer that causes major problems in the following stages of wastewater treatment. The scope, however, does not comprise solely damage caused to machinery (abrasion) but also problems or even elimination of correct functionality of – mainly – sludge treatment and disposal (sludge thickening, sludge digestion tanks, etc.) due to blocking of pipelines as well as sedimentation in tanks resulting in a more complicated stirring of tank content and limitation of their volume that feature numerous negative consequences as

regards of their operation. Cleaning of such tanks results in origination of major operating costs to be covered by the party operating the respective WWTP.

A solution to the matter of sand removal prior to discharge of rainwater in the sewerage system or inflow into storm tanks at WWTP represents a separate section. This matter proves to go beyond the scope of this contribution; however, it is to be emphasized that a failure to solve such a problem results not only in clogging of recipient channels by sand, thus limiting their profile, but also in introduction of organic substances that had often gone through a partial anaerobic decomposition and create sludge beds featuring a very long natural oxidation period in the water flow.

Sand separated in the wastewater treatment process may, however, contain pathogenic germs of microorganisms that would – in high concentrations – represent a risk pertaining to its subsequent treatment (Schroeder and Wuertz, 2003).

Legislative Requirements

As regards the legislation, the matter of treatment of sand from wastewater treatment plants is not thoroughly covered. Considering the valid legislation, principally Act No. 185/2001 Coll. on waste as amended, resp. Decree No. 381/2001 Coll. laying down the Catalogue of Wastes as amended, sand from a detritus tank is – in accordance with Annex No. 1 to the Decree – included in the Catalogue of Waste under the name of "Waste from detritus tank" and ref. No. 19 08 02 as other waste (O) and such sand is handled in the respective manner. This practice is enforced in spite of the fact that such waste might feature minimum one of the hazardous properties stipulated in Annex No. 2 to Act No. 185/2001 Coll. or contain one of the components due to which waste is regarded as hazardous in accordance with Annex No. 5 to Act No. 185/2001 Coll. The property referred to above is contingent contagiousness. Therefore, we conducted microbiological analyses of sand from wastewater treatment plants. As suggested above, an unambiguous procedure applicable to sand from wastewater treatment plants does not exist and due to this fact the guidelines applicable to handling of wastewater treatment sludge – more specifically Decree No. 382/2001 Coll. on conditions of the use of treated sludge on agricultural land as amended – were selected to serve as a basis. The aforementioned Decree stipulates the technical conditions applicable to use of sludge on agricultural land as well as limit concentrations of selected hazardous substances in sludge and soil including microbiological criteria. The Decree also stipulates admissible amounts of indicator microorganisms (Tab. I). The scope covers thermotolerant coliform bacteria, enterococci and *Salmonella* sp.

Considering the most common manner of sand removal by the means of disposal, it is necessary to face additional legislative requirements resulting from the valid judicial practice. The respective scope covers principally the conditions applicable to depositing of sand from a detritus tank in a landfill. They are governed by Decree No. 294/2005 Coll. on the conditions of depositing waste in landfills and its use on the surface of the ground (as amended). The aforementioned Decree expressly stipulates the conditions upon which sand from a detritus tank may be deposited in a landfill. As regards other waste, the Decree specifies three subgroups of landfills (S-OO1, S-OO2, S-OO3); sand from a detritus tank may be deposited in landfills labelled S-OO1 and S-OO2 – on the basis of expressly specified conditions that are stipulated in Annex No. 4 to Decree No. 294/2005 Coll. Considering the conditions stipulated in Annex No. 4 to Decree No. 294/2005 Coll., the most significant problem proves to be related to the total content of organic carbon (TOC) which should remain under 5%; in case of exceeding TOC, the problem pertains to dissolved organic carbon (DOC) which is monitored in the aqueous liquor of deposited sand and in case of which the value should not exceed 80 mg/l. The effort focused on prevention of depositing slowly organically decomposable materials in landfills resulted in incorporation of TOC and DOC parameters into our judicial practice and causes numerous problems. The most significant problem pertains to an exact definition of the respective terms as well as selection of a suitable analytical method applicable to determination of TOC and DOC – due to the fact that in practice it is possible to encounter diametrically dif-

I: *I: Microbiological criteria: Use of sludge on agricultural land*

Sludge category	Admissible amount of microorganisms (CFU*) in 1 gram of solids of applied sludge		
	Thermotolerant coliform bacteria	Enterococci	*Salmonella* sp.
I.		$< 10^3$	Negative
II.	10^3–10^6	10^3–10^6	Not determined

*CFU – colonies forming units

Legend:

Category I – Sludge that may be generally used on soils exploited in agriculture in case that the remaining provisions of the Decree are complied with.

Category II – Sludge that may be used on agricultural land to be used for growing of technical crop and on soils in which vegetables or intensively fertile fruit orchards are not to be planted within at least 3 years from the time of use of sludge – while complying with the principles of occupational health and safety as well as remaining provisions of the Decree.

ferent and mutually incompatible configurations and contents of the respective values in analyzed samples. The aforementioned fact was not resolved even by the Standard applicable to determination of TOC content (ČSN EN 13137 – Determination of TOC in waste, sludge and sediments) which stipulates the only proposed method of determination to be incineration of samples in oxygen at high temperatures.

MATERIAL AND METHODS

Samples of sand were collected at 9 wastewater treatment plants (WWTP) in the South Moravia Region. On average, 3 samples were collected at each WWTP in the time period of September – December 2008. The collection of samples was based on ČSN-ISO Standard No. 10381–6: 1998 Soil Quality – Sampling – Section 6. On the days of collection the respective samples were transported to a laboratory in sterile sample containers (at a temperature not exceeding 5 °C), thus preventing their secondary contamination. The samples were weighed immediately after receipt; the content of solids and ash-free dry mass were determined and a microbiological analysis was conducted. The methodology applicable to physical and chemical analysis of sand, i.e. determination of the total content of solids annealing residue and ash-free dry mass is stipulated in ČSN Standard No. 83 0550 (Section 3). Total solid content and ash-free dry mass in sand samples were determined by use of electric muffle furnace LMH 07/12 which is designed to measure incineration processes, drying, degradation, re–heating, thermal treatments etc. Analytical laboratory balances Radwag AS 220/X, has been used for precise weighing, readability to 0.0001g. A well-mixed sample (10 g) was evaporated in a weighed dish and dried to constant weight in an electric muffle furnace at the temperature 103 °C to 105 °C. The increase in weight over that of the empty dish represents the total solids TS [%]. After total solid assessment the dish with sample is put back to electric muffle furnace at 550 °C. The increase in weight over that of the dish after total solid assessment represents the ash–free dry mass [%].

The sample preparation for the estimation of microbiological parameters

The suspension was prepared by homogenizing of 20 g sample of sand in 150 ml of sterile quarter-strength Ringer solution in a blender for 20 minutes. After filtration (Whatman Gr.1, Merci, CZE) the suspension was used for all following microbiological tests.

Thermotolerant coliform bacteria

A standard method according to ČSN ISO 4832: 1995 was used for the detection and identification of thermotolerant coliform bacteria in the sand samples. Dilution of suspension was made according to ČSN ISO 6887 – 1. Petri dishes with m–FC agar (Merck, Germany) were inoculated with 100 µl of the sample and consequently incubated at 44 °C ± 1 °C for 18–24 hours. Thermotolerant coliform bacteria were indicated by the presence of dark blue colonies on agar, when visualised by eye.

Coliform bacteria

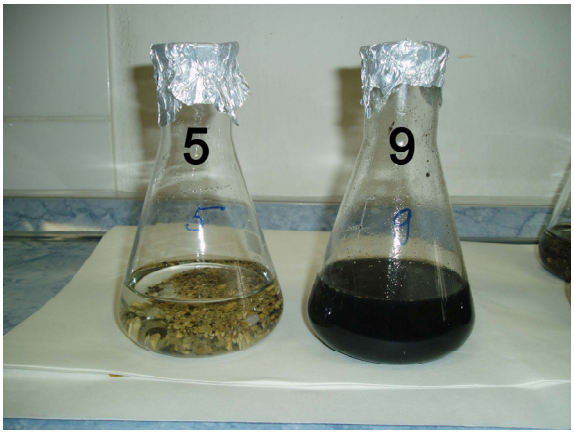
A standard method according to ČSN ISO 4832: 1995 was used for the detection of all coliform bacteria in the sand samples. Dilution of suspension was made according to ČSN ISO 6887 – 1. Petri dishes with ENDO agar (Merck, Germany) were inoculated with 100 µl of the sample and consequently incubated at 37 °C ± 1 °C for 24–48 hours. Coliform bacteria were indicated by the presence of white or red colonies on agar, when visualised by eye.

Enterococci

A standard method according to ČSN EN ISO 7899–2: 2001 was used for the detection and identification of intestinal enterococci in the sand samples. Petri dishes with m- Enterococcus selective agar according to Slanetz and Bartley (Merck, Germany) were inoculated with 100 µl of the sample. Dishes with sample were incubated in an inverted position at 37 °C ± 1 °C for 4 hours and consequently at 44 °C ± 0.5 °C for 20–44 hours. Enterococcus was indicated by the presence of pink to maroon colonies on agar, when visualised by eye.

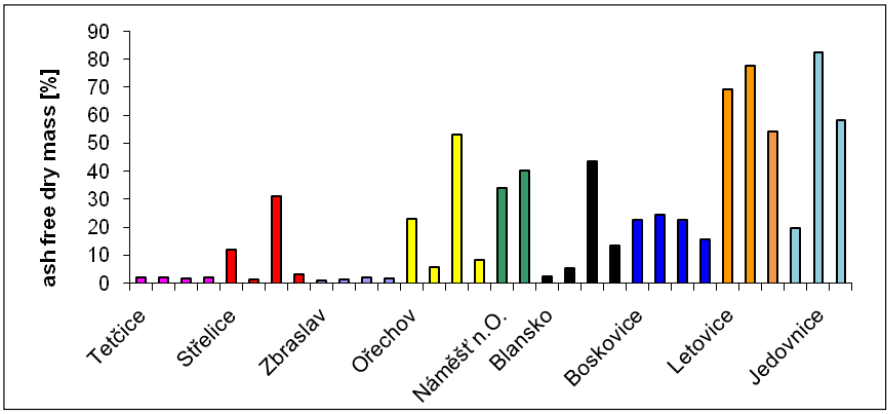
RESULTS AND DISCUSSION

Samples of wastewater treatment sand collected at various WWTP showed (at first sight) different amounts of organic content. Fig. 1 documents the aforementioned differences using samples collected at WWTP Zbraslav (5) and WWTP Ořechov (9). Sample No. 5 is clear, it contains 95% of solids and its ash-free dry mass is only 1.2%. Quite on the contrary, sample No. 9 is conspicuously turbid, it contains only 68% of solids and its ash-free dry mass was determined to reach 23%.

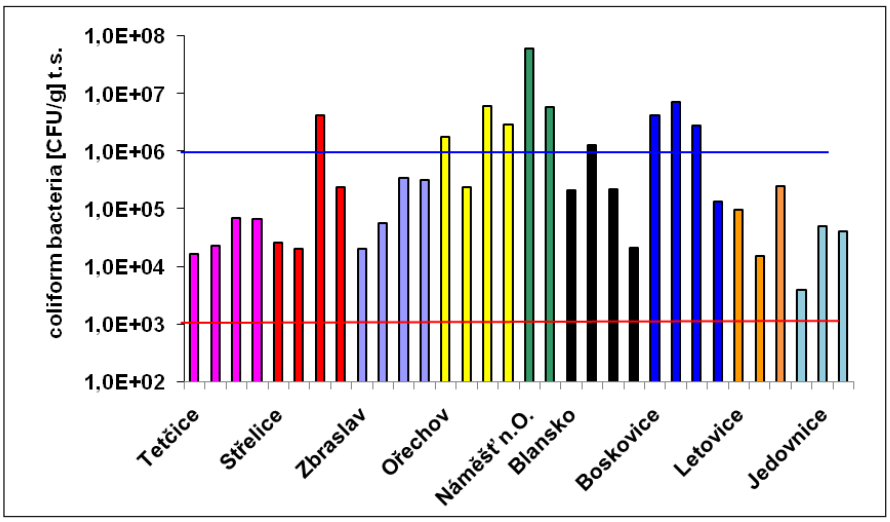


1: *Samples of sand after 20 minutes of stirring in distilled water (Photograph created by the author)*

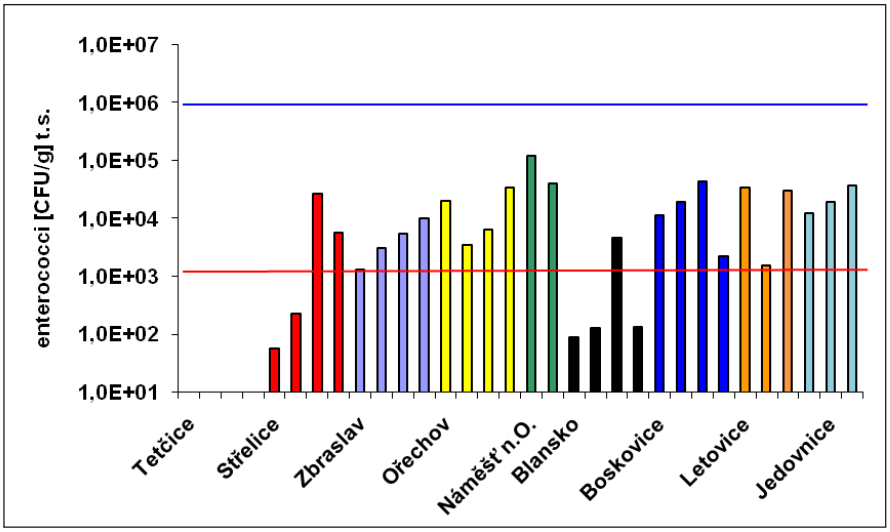
All the collected samples were also subject to microbiological analysis focused on indicator groups of microorganisms that are commonly determined in wastewater treatment sludge prior to its contingent use on agricultural land. The scope covers coliform bacteria including *Escherichia coli*, enterococci and faecal coliform bacteria (Fig. 3, 4 and 5).



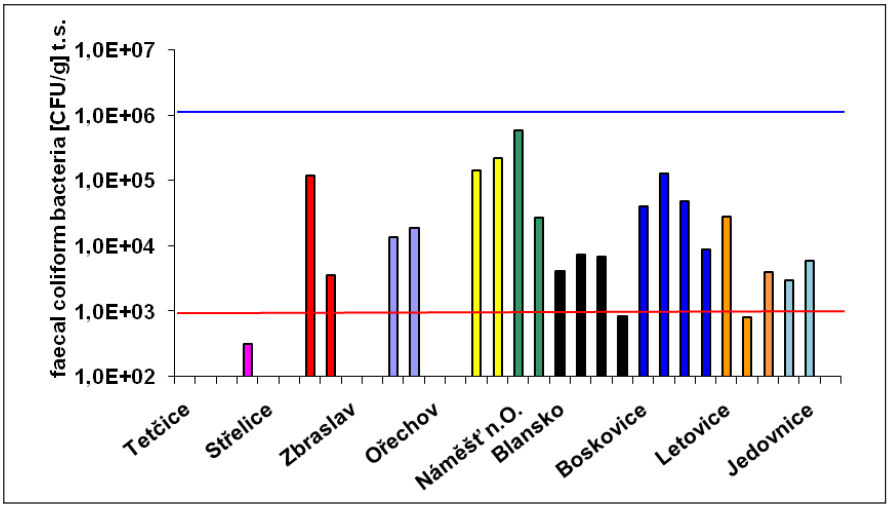
2: *Ash-free dry mass of samples of sand from various WWTPs*



3: *Coliform bacteria in samples of sand from various WWTPs*



4: *Enterococci in samples of sand from various WWTPs*



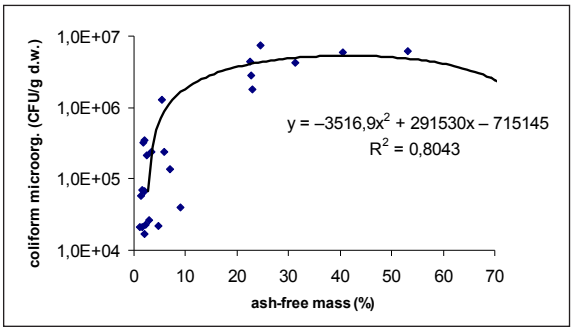
5: *Faecal coliform bacteria in samples of sand from various WWTPs*

The charts in Fig. 3, 4 and 5 contain colour lines that mark limit values for Category I (red) and Category II (blue) of sludge.

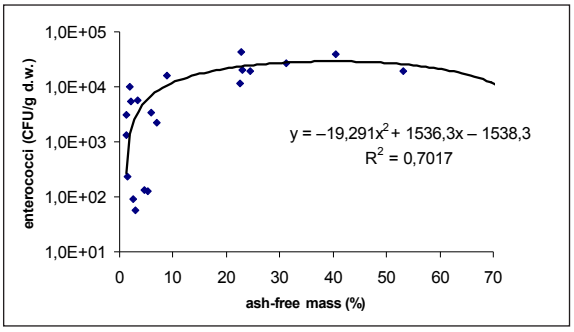
The measured data was graphically compared (Fig. 6, 7 and 8) in order to evaluate the dependence of organic solids content on contamination of samples by indicator groups of microorganisms.

The dependence of the content of solids (percentage) on ash-free dry mass was compared for individual samples. The chart in Fig. 9 documents a high level of correlation between the two parameters.

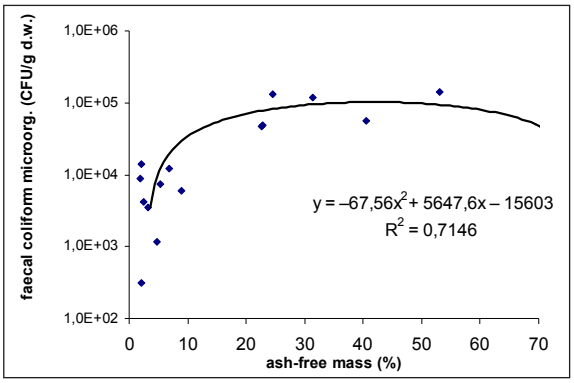
Totally missing information on microbial contamination of sand from wastewater treatment plants led us to develop a unique work not published in scientific journals yet. Microbial contamination of sand from selected wastewater treatment plants is evident from submitted results. For statistical evaluation will be necessary to extend the data and perform further analysis to confirm the results obtained in tests car-



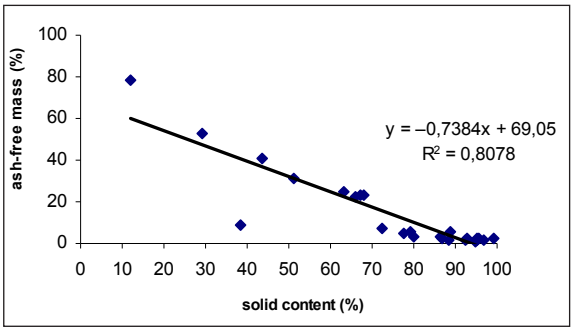
6: *Relation between contamination of samples by coliform microorganisms and the organic solids content*



7: *Relation between contamination of samples by enterococci and the organic solids content*



8: *Relation between contamination of samples by faecal coliform microorganisms and the organic solids content*



9: *Relation between the solids content and ash-free dry mass – samples of sand*

ried out. Samples collected gradually – in the course of 4 months – sometimes proved to feature similar parameters (e.g. WWTP Tetčice) while the values determined at other WWTPs featured major fluctuations. For example, at WWTP Střelice the difference between individual samples represented 160 times higher amounts of coliform microorganisms and 470 times higher amounts of enterococci (Fig. 3 and 4). The respective results reflect the technological equipment at individual WWTPs, rainfall prior to collection of samples as well as numerous other factors that might affect the quality of inflowing wastewater, thus affecting its microbial contamination as well. The chart in Fig. 3 shows a rather high level of contamination of samples by coliform bacteria. More than one third of the samples does not comply with the microbiological criteria applicable to use of Category II sludge on agricultural land (Tab. I). However, as regards the presence of enterococci and faecal coliform bacteria, all the analyzed samples of wastewater treatment sand prove to comply with the above-mentioned criteria (Fig. 4 and 5).

Certainly it is possible to confirm the microbial contamination in all tested samples with very different content of microorganisms, which is mainly due to different content of organic material in individual samples of sand. Crossing the limits for the sewage sludge (according to Decree No. 382/2001 Coll.) was confirmed in several samples of sand and it is mainly due to high content of organic material in the sand. Dependence of the content of microorganisms in the sand on the ash free dry mass, respectively the organic solids is evident from the correlation coefficients for tested samples 0.80 (coliform), 0.70 (enterococci), 0.71 (faecal coliform).

SUMMARY

This contribution deals with the microbial properties of sand from waste water treatment plants. Currently the sand is classified as other waste pursuant to Decree Law 185/2001 Coll., on the waste, as amended. And even though the sand, depending on the technology used, contain a high amount of organic material, causing contamination of pathogenic microorganisms and may lead to a qualification of the sand as dangerous waste. Also, the organic material is causing problems in handling, especially with regard to the requirements for depositing waste at landfills. In this article the parameters of sands of nine waste water treatment plants in the South Moravian region have been reported and observed. All samples were evaluated by plate count (faecal coliform bacteria, coliform bacteria, enterococci), content of total solid and ash free dry mass. In accordance to expected an relation between total solid, ash free dry mass and content of microorganism in waste sand was approved. This relation should be used for waste sand processing, especially when sand is land filled and it is necessary to know TOC and DOC content. We have earned a valuable and unique information about the properties of sand that can be used in practice to improve the management system of sewage sands.

SOUHRN

Mechanické čištění odpadních vod z pohledu současně platné legislativy

Příspěvek se zabývá bakteriálním osídlením písků z čistíren odpadních vod. V současnosti jsou písky klasifikovány jako ostatní odpad podle vyhlášky k zákonu č. 185/2001 Sb., o odpadech ve znění pozdějších předpisů, přestože písky, v závislosti na použité technologii, obsahují vysoký podíl organických materiálů, což způsobuje kontaminaci patogenními mikroorganismy a mohlo by vést ke kvalifikaci písku jako odpadu nebezpečného. Také obsah organického materiálu způsobuje problém při nakládání s nimi, především s ohledem na požadavky při deponování odpadu na skládky. V tomto článku byly popsány a zjištěny hodnoty ukazatelů u písků z devíti čistíren odpadních vod v Jihomoravském kraji. U všech vzorků písků byly vyhodnoceny obsahy mikroorganismů (fekální termotolerantní koliformní bakterie, koliformní bakterie a enterokoky), obsah sušiny a organické sušiny. Podle očekávání byla potvrzena závislost mezi obsahem sušiny, ztrátou žíháním a obsahem mikroorganismů v písku. Zjištěné závislosti mohou pomoci pro klasifikaci a nakládání s písky z čistíren odpadních vod. Této skutečnosti je možno využít při nakládání s pískem, především při jeho deponování na skládky odpadů a to z pohledu překročení parametrů TOC a DOC. Získali jsme tak cenné a jedinečné informace o vlastnostech čistírenských písků, které bude možné v praxi využít pro zlepšení systému nakládání s tímto materiálem.

čištění odpadních vod, mechanické čištění, lapák písku, čistírenský písek, mikrobiální kontaminace

Příspěvek byl zpracován s podporou Výzkumného záměru č. MSM6215648905 *Biologické a technologické aspekty udržitelnosti řízených ekosystémů a jejich adaptace na změnu klimatu* uděleného Ministerstvem školství, mládeže a tělovýchovy ČR.

REFERENCES

Acta hygienica, epidemiologica et microbiologica. Prague: National Institute of Public Health in Prague, 2001, ISSN 0862-5956.

BITTON, G., 2005: Wastewater Microbiology. 3rd ed. Gainesville: Wiley-Interscience, 746 p., ISBN 978-0-471-65071-3.

CLAYDONG, P., DANTERAVANICH, S., SIRIWONG, C., UAKRITDATHIKARN, S., 2001: Bacteriophages, coliform and faecal coliform bacteria in wastewater in southern Thailand, Advances in Water and Wastewater Treatment Technology, pp. 119–127

FUJIOKA, R. S., BYAPPANAHALLI, M. N., 2001: Microbial ecology controls the establishment of faecal bacteria in tropical soil environment, Advances in Water and Wastewater Treatment Technology, pp. 273–283.

GERARDI, M. H., ZIMMERMAN, M. C., 2004: Wastewater Pathogens. Gainesville: Wiley-Interscience, 179 p. ISBN 978-0-471-20692-7.

GODFREE, A., 2003: Health constraints on the agricultural recycling of wastewater sludges, Handbook of Water and Wastewater Microbiology, pp. 281–298.

SHUVAL, H., FATTAL, B., 2003: Control of pathogenic microorganisms in wastewater recycling and reuse in agriculture, Handbook of Water and Wastewater Microbiology, pp. 241–262, ISBN 0-12-470100-0.

SCHROEDER, E., WUERTZ, S., 2003: Bacteria. In: *The Handbook of Water and Wastewater Microbiology*. D. Mara, N. Horan (Eds.), Academic Press. London, pp. 57–68.

Address

Mgr. Monika Szostková, Ph.D., Ústav agrochemie, půdoznalství, mikrobiologie a výživy rostlin, Ing. Tomáš Vítěz, Ph.D., Ústav zemědělské potravinářské a environmentální techniky, Mendelova univerzita v Brně, 613 00 Brno, Česká republika, e-mail: szostkov@mendelu.cz