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Joanna WYCZARSKA-KOKOT[1*] and Anna LEMPART[1]

THE INFLUENCE OF THE FILTRATION BED TYPE IN THE POOL WATER TREATMENT SYSTEM ON WASHINGS QUALITY

WPŁYW RODZAJU ZŁOŻA FILTRACYJNEGO W UKŁADACH OCZYSZCZANIA WODY BASENOWEJ NA JAKOŚĆ POPŁUCZYN

Abstract: This paper presents the influence of the type of filtration beds, used in swimming pool water treatment systems, on the quality and possibility of reusing the washings. The research covered 4 pool cycles with sand, sand and anthracite, glass and diatomaceous beds. The degree of contamination of washings was assessed on the basis of physical, chemical and bacteriological tests. The possibility of drainage of washings into the natural environment was considered, and the results of the research were compared with the permissible values of pollution indicators for wastewater discharged to water or ground. A direct management of the washings from the analyzed filters proved impossible mainly due to the high content of TSS (total suspended solids) and free chlorine. The washings were sedimented and then the supernatant was stirred intensively. As a result of these processes, the quality of washings was significantly improved. This allowed planning to supplement the pool water installations with systems for washings management.

Keywords: filter beds, washings, swimming pool, sedimentation

Introduction

The main equipment of each water treatment systems, both from surface and underground intakes, are filters [1, 2]. The search for modern, yet simple and inexpensive filtration methods is currently one of the basic directions of water and wastewater treatment technologies development. The conducted research concerns mainly new methods and materials for filters construction, modification of their operation methods, effective beds and an extension of the filtration cycle time without reducing its efficiency [3-10].

The high effectiveness of modern filtration technologies is mainly related to the high capacity of materials used as filter beds, and therefore the necessity of their effective washing and thus the management of large amounts of washings [11, 12].

These issues also apply to the swimming pool water treatment systems. Closed circuits, in which specific contaminants are removed (disinfection by-products, micropollutants including the group of pharmaceuticals and personal care products [13-17]) require the use of highly effective filter beds. There is also a growing number of methods of filtration, washing and management of washings streams from swimming pools [18-20].

The potential of washing streams from swimming pools is hidden in its large volume (a proper washing of 1 m^2 of bed requires the use of 4-6 m^3 of water [21-23]) and the possibility of using simple treatment systems to recover supernatant [20, 24].

[1] Institute of Water and Wastewater Engineering, Silesian University of Technology, ul. S. Konarskiego 18, 44-100 Gliwice, phone +48 32 237 22 43, fax +48 32 237 10 47
[*] Corresponding author: joanna.wyczarska-kokot@polsl.pl
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The main purpose of the research was to assess the quality of washings from pool water filtration systems and the possibilities of their management depending on the type of their beds.

Research methodology

The research was carried out in 4 swimming pools equipped with filters with different types of filter beds. They were marked as FP (sand filter bed), FPA (filter with sand-anthracite bed), FAFM (activated glass filter bed), FD (filter with diatomite bed).

It has been assumed that the washings could be drained into waters or soil. For this purpose, the quality of washings was determined based on the physico-chemical and bacteriological analysis of pollution indicators. The results of the analyzes were compared with the admissible values according to the Polish Ordinance of the Minister of the Environment regarding conditions to be met when introducing sewage into waters or to the soil [25] and European directives on this matter [26, 27].

The research was carried out under operating conditions in 4 swimming pools. Samples of washings for tests, from each type of filter, were taken 5 times at intervals determined by the time of the filtration cycle. To obtain average samples, washings from pressure closed filters FP, FPA and FAFM were taken at the initial, middle and final washing stages. The samples from the open vacuum FD filter were collected at the point of the washings outflow to the sewage well. The total volume of each sample was about 5 dm^3.

The tested pollutant indicators were divided into basic (Fig. 1) and characteristic (Fig. 2). Indicators determining the possibility of draining the water to the ground or its discharge into a watercourse, that is BZT_5 - 5-day biochemical oxygen demand (dilution method, Oxi Top®OC 100), COD - chemical oxygen demand, total nitrogen, total phosphorus (spectrophotometry, DR5000 UV/VIS, HACH®), and total suspensions solids (TSS) and TSS in supernatant (gravimetric method) were considered "basic pollutants indicators". Indicators that result from the method of water treatment in swimming pool were considered "characteristic pollutant indicators". Due to the heating of the circulating water and constant pH correction, the temperature and pH of the samples were analyzed (potentiometric method, HQD HACH®). In view of the aluminum coagulant dosing before FP, FPA, FAFM, aluminum content in the washings was checked (spectrophotometry, DR5000 UV/VIS; HACH®). Because disinfection of water is obligatory, free chlorine content was measured (DPD method; POCKET Colorimeter II, HACH®) and as there is the possibility of salt ions concentration in the swimming pool systems, also the contents of chlorides and sulphates were tested (spectrophotometry, DR5000 UV/VIS, HACH®).

The general degree of bacteriological contamination of washings was also checked. The CFU (colony forming units) of microorganisms grown at 36 °C after 48 hours was determined (culture method on nutrient agar according to PN-EN ISO 6222: 2004 [28]).

In order to reduce the amount of suspensions in the samples from FP, FPA and FD, they were subjected to 2 hour sedimentation in laboratory conditions in an Imhoff funnel.

In addition, the supernatant water was subjected to a 15-minute fast stirring process (jar test, laboratory coagulator, 200 rpm, Velp Scientifica) in order to aerate it and thus to reduce the free chlorine concentration.

Results and discussion

The analysis of the washings quality showed that among the basic indicators (Fig. 1), the total nitrogen and total phosphorus (in the samples from FP and FPA - Fig. 1c and 1d), and TSS (in samples from FP, FPA and FD, Fig. 1e) did not meet the recommendations for sewage discharged into waters and soils [25-27].

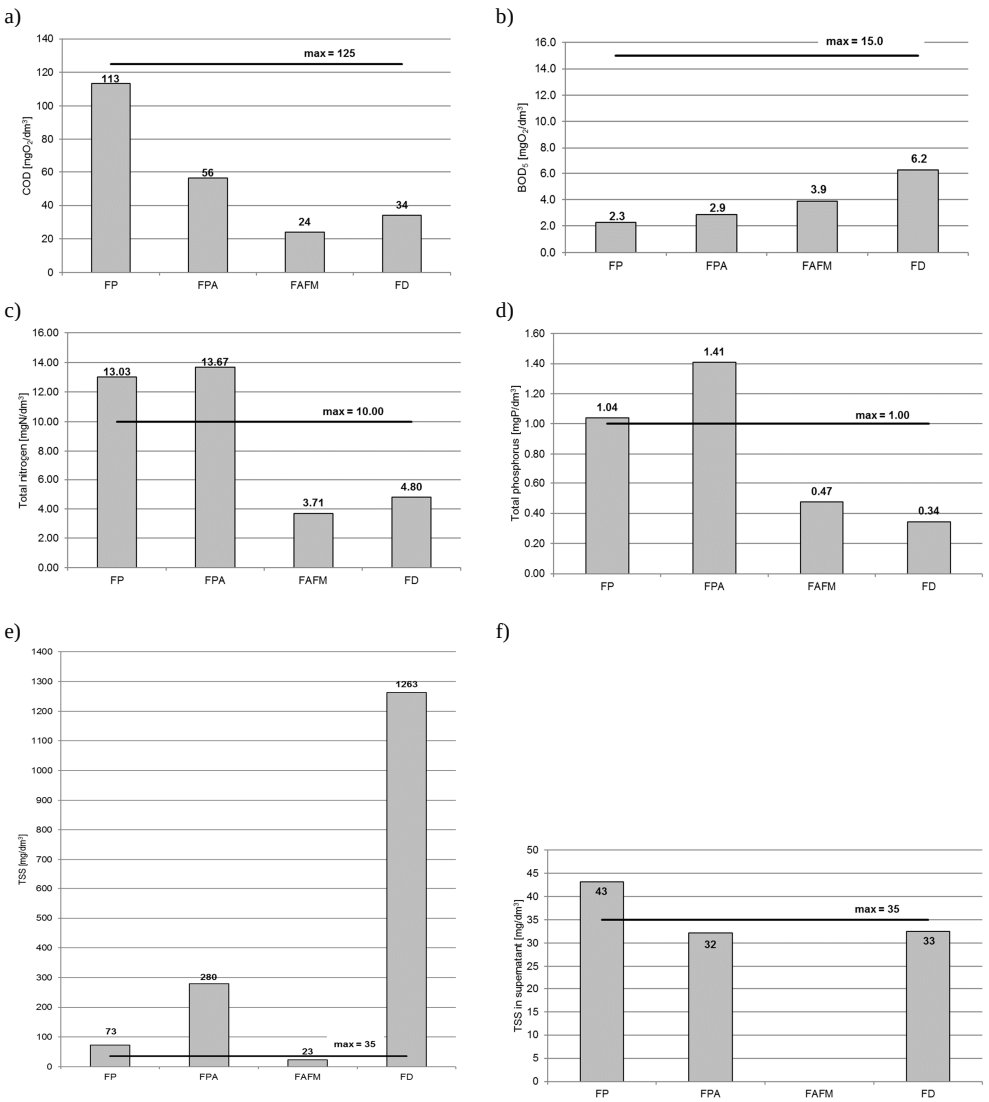

Fig. 1. Basic indicators of contaminations in the washings with limit values according to [25-27]: a) COD, b) BOD_5, c) total nitrogen, d) total phosphorus, e) TSS - total suspension solids, f) TSS in supernatant

The washings from the filter filled with the activated glass bed FAFM were of the best quality. Previous studies have shown that TSS are the main pollutants that prevent direct discharge of washings into the ground or watercourses [19, 20, 24]. Meanwhile, the average content of TSS in raw washings from the FAFM was below the limit value (35 mg/dm^3) and amounted to 23 mg/dm^3. The highest concentration of TSS was determined for FD (1263 mg/dm^3). It was a sample of washings from the filter with diatomaceous earth where the entire filtration layer that had been flushed on the filter fabrics was removed together with the washing stream.

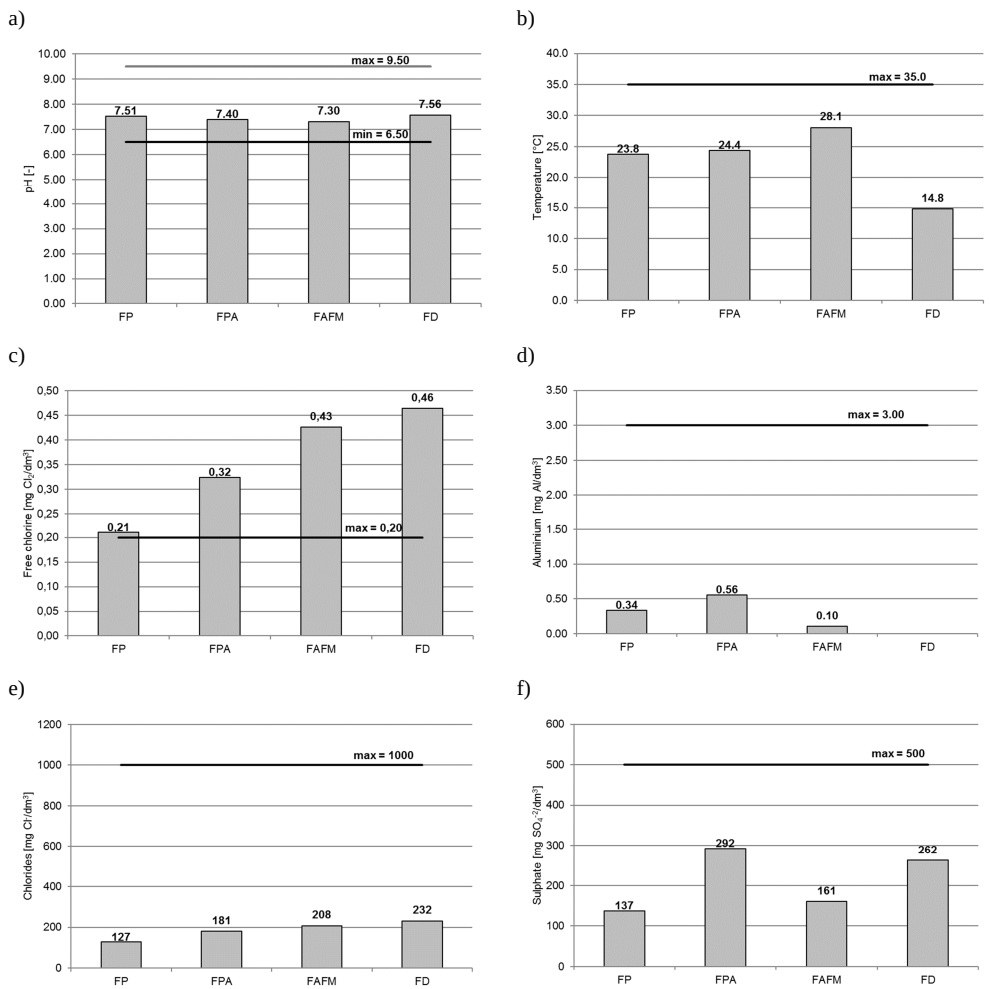

Fig. 2. Characteristic indicators of contaminations in washings with limit values according to [25-27]: a) pH, b) temperature, c) free chlorine, d) aluminium, e) chlorides, f) sulphate

As a result of the sedimentation applied for FP, FPA and FD, the amount of TSS decreased by 41, 88 and 97 % respectively. In FP supernatant, the amount of TSS was still greater than the permissible value and amounted to 43 mg/dm^3. In order to remove such TSS, the washing process can be intensified, e.g. by preceding sedimentation with coagulation, applying membrane ultrafiltration system or a combination of these processes [24]. Sedimentation also caused a significant decrease in the content of nitrogen and total phosphorus, from 30 % in FP washings to approx. 85 % in FD.

Among the characteristic indicators, only the free chlorine concentration, regardless of the type of filter bed, was greater than the limit value (0.2 mg Cl_2/dm^3) for sewage introduced into waters or into the soil (Fig. 2c). After leaving the samples to stand for 120 minutes, the free chlorine concentration decreased by approx. 20 %, and after a further 15 minutes of intensive stirring of the supernatant by 48-54 %. As a result, 0.11 mg Cl_2/dm^3 (FP) to 0.22 mg Cl_2/dm^3 (FD) was determined in the supernatant water.

Despite the fact that for wastewater discharged into waters or soil it is not required to determine the CFU of mesophilic microorganisms, the result of such analysis gives a general view on the degree of bacteriological pollution. The highest number of CFU bacteria was determined in the sand-anthracite bed (FPA, $1.6 \cdot 10^5$ CFU/1 cm^3) and filters with diatomaceous earth (FD, $2.0 \cdot 10^5$ CFU/1 cm^3), and the lowest in the activated glass filter bed (FAFM, $5 \cdot 10^3$ CFU/1 cm^3).

Summary and conclusions

Both the quality and volume of washings depend on many factors, including the type of filtration system, type of bed, time of the filtration cycle, size and function of the swimming pool, number of swimmers. Therefore, for individual washing streams, individual research programs should be developed to assess the possibilities of their utilization.

The analysis of how the filtration bed type influences the quality and possibility of washings management through discharging them to the soil or to a watercourse, allowed to formulate the following conclusions:

- Direct drainage of the investigated washings into waters or soil was not possible due to too high contents of: total suspension solids (except for FAFM samples), free chlorine (in all samples), total nitrogen and total phosphorus (in FP and FPA samples).
- An attempt to improve the quality of washings by the use the sedimentation process and subsequent intensive stirring of the supernatant proved to be very effective. As a result of sedimentation, the content of TSS decreased from 41 (FP) to 97 % (FD).
- In FP supernatant, after sedimentation, the number of TSS was still higher than the permissible 35 mg/dm^3 and was equal to 43 mg/dm^3. In order to remove such suspension solids, the sedimentation process should be preceded by coagulation, a membrane ultrafiltration system or a combination of these processes.
- Samples of the washings from the filter filled with the activated glass bed (FAFM) were characterized by the lowest content of total suspended solids (23 mg/dm^3) and the lowest number of mesophilic bacteria ($5 \cdot 10^3$ CFU/1 cm^3).
- After leaving the washings to stand for 120 minutes, the free chlorine concentrations decreased by approx. 20 %, and after a further 15 minutes of intensive stirring of the

supernatant by 48-54 %. As a result, the free chlorine content ranged from 0.11 mg Cl_2/dm^3 (FP) to 0.22 mg Cl_2/dm^3 (FD).

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WPŁYW RODZAJU ZŁOŻA FILTRACYJNEGO W UKŁADACH OCZYSZCZANIA WODY BASENOWEJ NA JAKOŚĆ POPŁUCZYN

Instytut Inżynierii Wody i Ścieków, Politechnika Śląska, Gliwice

Abstrakt: Przedstawiono wpływ rodzaju złóż filtracyjnych, stanowiących wypełnienie filtrów w układach oczyszczania wody basenowej, na jakość i możliwość zagospodarowania popłuczyn. Badaniami objęto 4 obiegi basenowe, w których zastosowano złoża: piaskowe, piaskowo-antracytowe, szklane oraz okrzemkowe. Stopień zanieczyszczenia popłuczyn oceniono na podstawie badań fizyczno-chemicznych i bakteriologicznych próbek popłuczyn. Rozważono możliwość odprowadzania popłuczyn do środowiska naturalnego, a wyniki badań porównano z dopuszczalnymi wartościami wskaźników zanieczyszczeń dla ścieków odprowadzanych do wód lub ziemi. Bezpośrednie zagospodarowanie popłuczyn z analizowanych filtrów okazało się niemożliwe przede wszystkim ze względu na duże zawartości zawiesin ogólnych oraz chloru wolnego. Z tego względu popłuczyny poddano sedymentacji, a wodę nadosadową intensywnemu mieszaniu. W wyniku tych procesów jakość popłuczyn uległa znacznej poprawie. Pozwoliło to planować uzupełnianie instalacji wody basenowej o układy zagospodarowania popłuczyn.

Słowa kluczowe: złoża filtracyjne, popłuczyny, basen, sedymentacja