Reactive materials for P control in outdoor pools and bathing ponds

Agnieszka BUS, Agnieszka KARCZMARCZYK

e-mail: agnieszka_bus@sggw.pl, agnieszka_karczmarczyk@sggw.pl

Warsaw University of Life Sciences – SGGW

Faculty of Civil and Environmental Engineering, Department of Environmental Improvement

Introduction

Outdoor pools and bathing ponds (swimming ponds) are artificially created water bodies that are separated from surface water and groundwater and have no chemical disinfection or sterilization system. Swimming ponds are natural, friendly alternative of traditional swimming pools or ponds. Water treatment is carried out through mechanical techniques, biological filters and plants growing in the system (fig.1&2).

The aim of the study is to select and asses the best reactive material for removing phosphorus and implementation in the outdoor pools or bathing ponds based on the kinetic and sorption equilibrium studies.

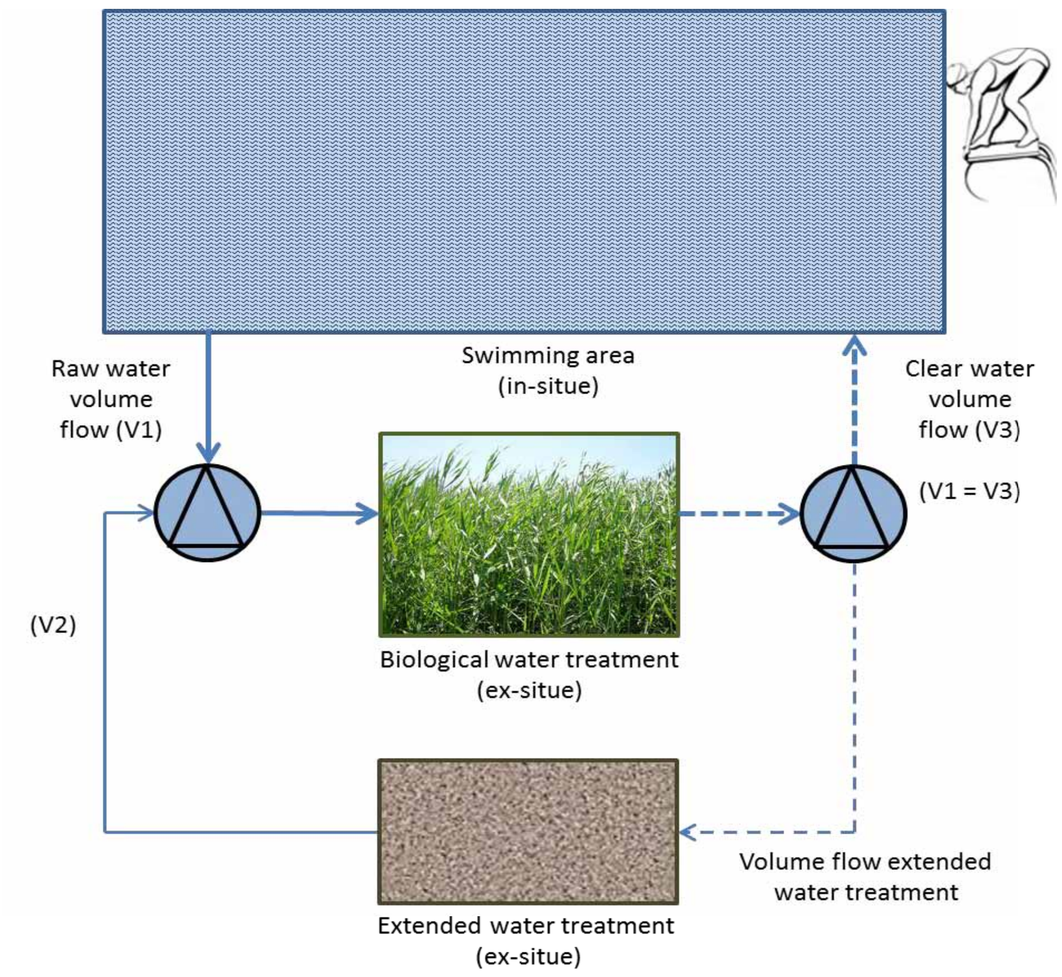

Figure 1. Scheme of outdoor pool / bathing pond

Materials and methods

Seven different reactive materials were used as a adsorbents: opoka_1, opoka_2, opoka_3, opoka_4, oolite_DE, oolite_PL and FerroSorp® (table 1) Opoka_1 and opoka_2 were extracted in eastern Poland, and were heated at temperature of 950°C and 800°C, respectively. Opoka_3 and opoka_4 were extracted in south-east part of Poland, both heated at temperature of 900°C. The material varied only in used fraction. Oolite is a sedimentary rock formed from ooids, spherical grains composed of concentric layers, used material come from Germany (ooloite_DE) and Poland (oolite_PL). FerroSorp® is a commercial product used to remove phosphate from water and wastewater.

The kinetic tests were performed at various contact times (5-300 min) and the constant P solution concentration of 2.0 mg $P\text{-}PO_4$/L. The sorption equilibrium tests were performed at various P solution concentrations (2.066-864.20 mg $P\text{-}PO_4$/L) and a constant time (1 h).

Table 1. Characteristic of used reactive materials

Adsorbents	Grain size [mm]	Bulk density [g cm^{-3}]	Porosity [%]	pH [-]
Opoka_1	1-5	0.62	67.9	11.9
Opoka_2	1-5	0.68	68.1	10.8
Opoka_3	5-12	0.69	59.2	9.4
Opoka_4	1-5	0.64	63.5	9.2
Oolite_PL	1-3	0.97	57.4	9.0
Oolite_DE	5-12	1.29	50.7	9.5
FerroSorp®	1-3	4.12	70.1	8.8

Figure 2. Bathing pond (www.stawy-kapielowe.pl)

Results

The kinetic sorption sequence of tested reactive materials is as follow: opoka_1>opoka_2> FerroSorp®>opoka_4>opoka_3>oolith_DE>oolith_PL, and ranged from 0.147 mg/g to 2.066 mg/g. To sorption equilibrium studies opoka_1, opoka_2 and FerroSorp® were selected because of the best kinetic properties.

The experimental data obtained for opoka_1, opoka_2 and FerroSorp® were fitted to the Freundlich and Langmuir adsorption isotherms. Opoka_1 and opoka_2 are characterized by good adjustment to the Langmuir isotherm (0.9855 and 0.8615) while FerroSorp® to the Freundlich isotherm (0.8747). Maximum sorption capacities (S_{max}) calculated on the base on the Langmuir isotherm for opoka_1 and opoka_2 are 46.98 mg/g and 13.87 mg/g, respectively.

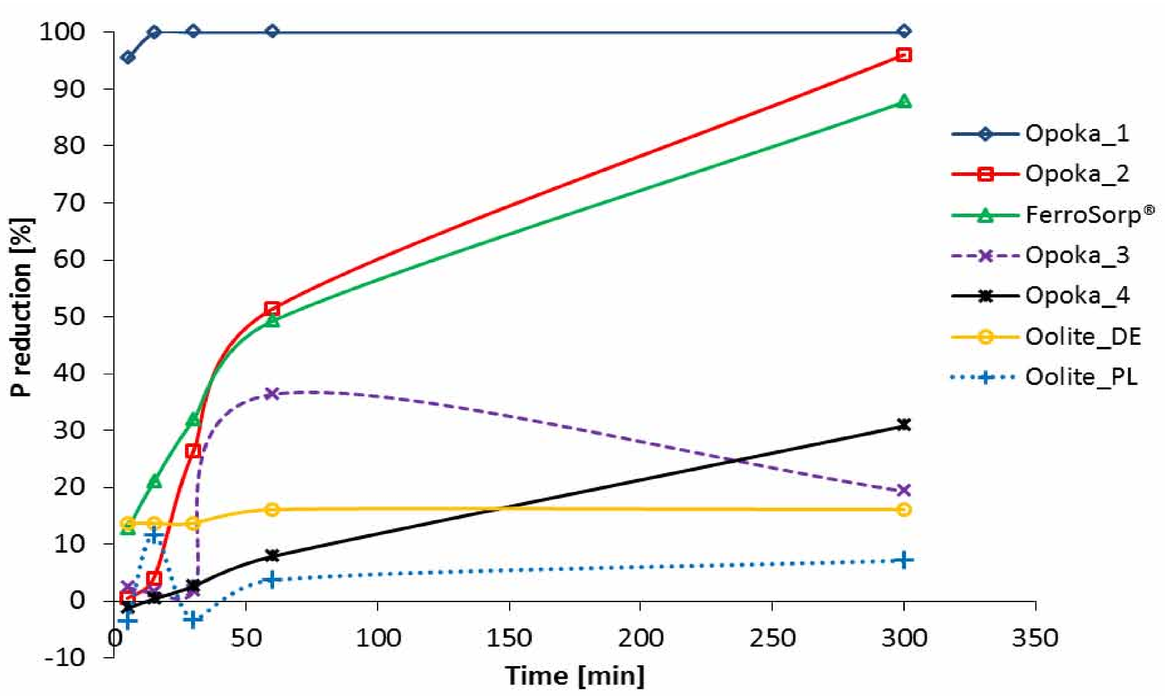

Figure 3. The phosphorus ion reduction [%] in the time

Table 2. Values of the Langmuir and Freundlich isotherms approximation constants .

Adsorbent	The Langmuir isotherm				The Freundlich isotherm		
	K_L [L/g]	a_L [L/mg]	R^2	S_{max}	a_F [L/g]	b_F [-]	R^2
Opoka_1	0.0046	0.2161	**0.9855**	46.98	0.3060	0.3449	0.9593
Opoka_2	4.4122	0.318	**0.8600**	13.87	0.4227	0.5355	0.6748
FerroSorp®	1.2321	0.6731	0.7559	1.83	0.5962	0.6873	**0.8747**

Conclusions

The use of reactive materials in outdoor pools or bathing ponds in the form of extended filter for water treatment is indispensable step to remove phosphorus from water and to protect it against undesirable alga grow. The recommendation value of phosphorus to protect pools and bathing ponds against eutrophication is limited to 0.001 mg/L (FLL 2011).

Reference: Fll 2011, Richtlinien für Planung, Bau, Instandhaltung und Betrieb von Freibädern mit biologischer Wasseraufbereitung (Schwimm- und Badeteiche), 2011

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