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Evaluating GAC for Detergent Removal from the Secondary Effluent of Ghods Wastewater Treatment Plant

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Abstract: A laboratory adsorption study had been conducted to evaluate the feasibility of adsorption by GAC for removing detergents from the secondary effluent of a municipal wastewater treatment plant (Ghods in Tehran). The configuration used for GAC application was a single-down-flow fixed bed column with 80 cm effective height. Samples were collected in six successive stages during six months and were passed through the GAC column at a volumetric flow rate of 8 L h^{-1}. Detergent concentrations had been determined by a standard spectrophotometer method called methylene blue active substances and reported as mg L^{-1} MBAS. Results showed that detergent removal ranges from 38.8 to 50%. Although this level of efficiency shouldn't be considered good but was quite sufficient for polishing the effluent samples studied, mainly because of the insignificant initial concentrations. Results also revealed that adsorption of detergent on GAC can be better described by Freundlich isotherm.

Key words: Municipal wastewater, GAC adsorption, detergent, ghods wastewater treatment plant

INTRODUCTION

By manufacturing the first synthetic detergents, commonly called ABS (alkyl benzene soulfonates) in 1916 in Germany, the soap consumption considerably reduced because of the extra advantages that these new materials exhibited for cleansing[1,2]. But by introducing the residual of these detergents into the wastewater treatment plants and final discharge into the aquatic environments a series of new problems arose mainly because of the no biodegradable nature of ABS and the production of foam. For these reasons, public health organizations established an ABS concentration limit of about 0.5 mg L^{-1} in their drinking water standards[3,4]. Then, in 1967, the second generation detergents namely linear alkyl benzene soulfonates (LAS) were manufactured by the industry which in contrast to previous materials were considered to be soft, In fact, LAS is readily degradable under most acerbic conditions, besides its use has helped relieve the most serious problems of detergent foaming[5,6]. However, unlike common soap, it is resistant to degradation under anaerobic conditions Besides, LAS may not degrade under some aerobic conditions in which high concentrations of other materials with more biodegradability are present. This is the main reason of remaining some of these detergents in the secondary effluents of conventional treatment plants[5,6].

Granular Activated Carbon (GAC) which is an effective means of removing trace organic contaminates from drinking water sources may also be applied for treating wastewater effluents.

This study is based on an effort for use of GAC in removing residual detergent from the secondary effluent of Ghods treatment plant and determines adsorb ability of this pollutant by presenting data collected by a lab-scale GAC contactor and isotherms. It should be explained that in spite of the efforts for substituting ABS by LAS, many manufacturers in Iran still prod use ABS. So detergents are the commonly found contaminants in the wastewater effluents; of many treatment plants.

MATERIALS AND METHODS

The most comm. GAC application in effluent treatment is the downflow fixed-bed configuration in parallel operation. So, for this study a single Lab-scale GAC adsorbed made of glass was setup and put in operation in the laboratory. The operational parameters

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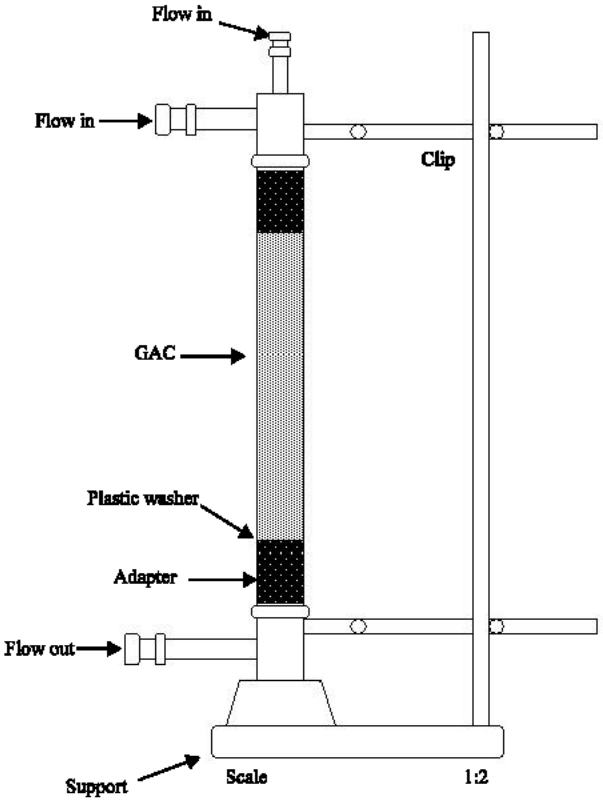

Column diameter (cm)	4.5
Particle diameter (mm)	1.5
Bulk Bed density (g cm^{-3})	9.4
Flow direction	down flow
Column total height (cm)	95
Column effective height (cm)	80
Volumetric flow rate (1 h^{-1})	8
EBCT (min)	9.5

Fig. 1: Schematic diagram of the GAC contactor

Table 1: Characteristics of the used GAC*

Characteristic	amount	Characteristic	amount
Mesh size (mm)	1.5	Ash produce in 600 C	<5%
Density (g cm^{-3})	0.4	Heavy metals	<1%
Solubility (in water)	<2%	Hexane adsorption	>30%

*The Merck Catalogue, 1996

and the physio-chemical characteristics of the GAC used are summarized in Table 1 and shown in the legend of Fig. 1. German type GAC from Merck Co. has been used for the experiment.

The secondary effluent samples were collected in six successive stages during six months from the Ghods wastewater treatment plant which is located in the west part of Tehran. As this plant is conventional and produces a typical effluent, the tests were confined to the determination of defer gent concentration. According to a visible spectrophotometer procedure outlined in Standard Methods[12], the anionic surfactant content of all effluent samples had been specified and reported as metylenblue active substances. On this basis, concentrations are expressed in mg L^{-1} MBAS[7].

The period of this experimental study was from spring to the end of summer 2003.

RESULTS

Data provided by treating the secondary effluents from six stages of sampling are shown in Fig. 2 to 7. Figure 8 shows the single-solute laboratory isotherm which had been conducted in effluent sample from the forth stage of this experiment. The Fig. 8 had been prepared by contacting the effluent to different amounts of GAC at ambient temperature (about 25°C).

DISCUSSION

According to Fig. 2 to 7, the reported removals of detergent range from 49.1-50% (stage 1), 48.2-48.6% (stage 2), 38.8-41.2% (stage 3), 42.9-44.1% (stage 4), 45.4-46.4% (stage 5) and 45.3-46.7% (stage 6). These ranges which may be considered to be from medium to fairly good are not as it was expected.

One explanation is that the minimum empty-bed contact time (EBCT = column volume occupied by GAC divided by the volumetric flow rate) used in this study has been less than 15 min which is the minimum time required for treating secondary effluents having COD concentrations of 10 to 20 mg L^{-1}[8].

However, regarding the reported high efficiencies of detergent removal during the primary and secondary stages of treatment in Ghods Plant which were at least 90.3% during the period of the study[9], the contact time

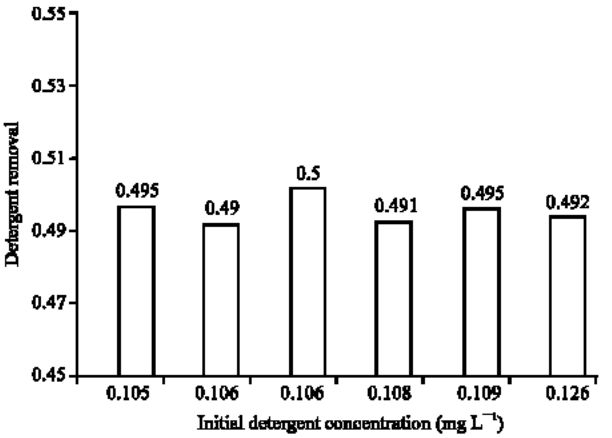

Fig. 2: Detergent removal by GAC adsorption at 8 L h^{-1} volumetric flowrate (stage 1)

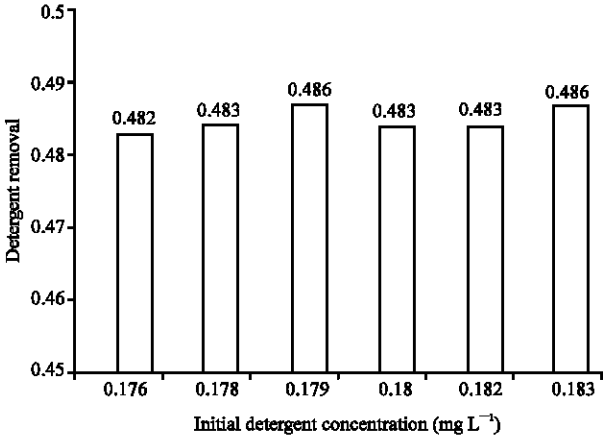

Fig. 3: Detergent removal by GAC adsorption at 8 L h^{-1} volumetric flowrate (stage 2)

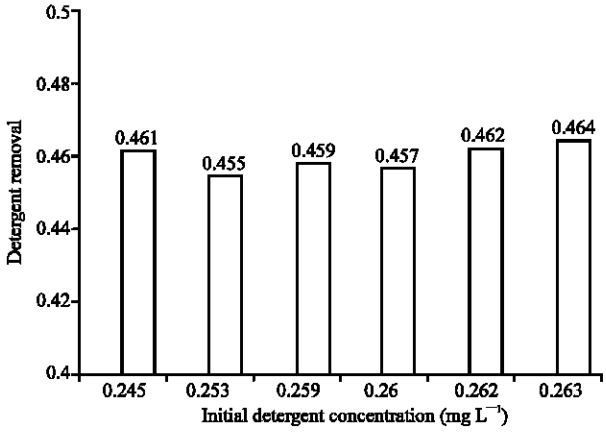

Fig. 6: Detergent removal by GAC adsorption at 8 L h^{-1} volumetric flowrate (stage 5)

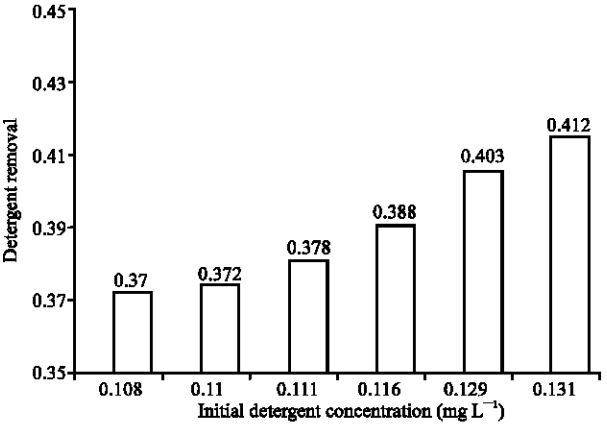

Fig. 4: Detergent removal by GAC adsorption at 8 L h^{-1} volumetric flowrate (stage 3)

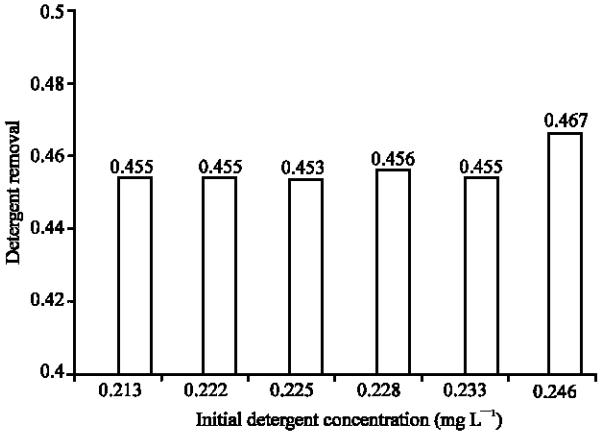

Fig. 7: Detergent removal by GAC adsorption at 8 L h^{-1} volumetric flowrate (stage 6)

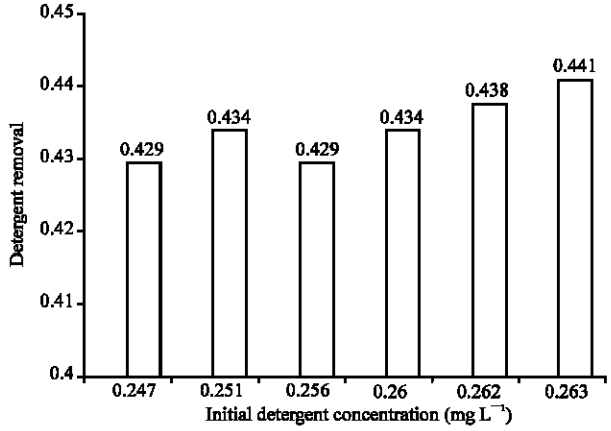

Fig. 5: Detergent removal by GAC adsorption at 8 L h^{-1} volumetric flowrate (stage 4)

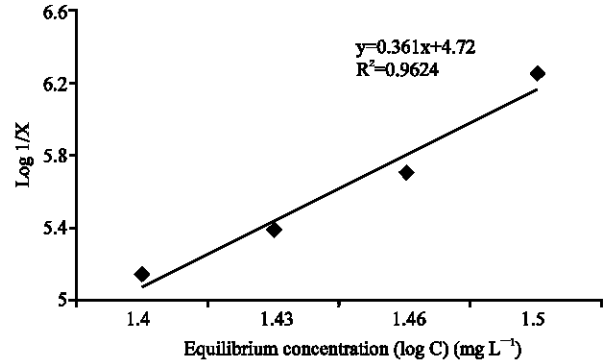

Fig. 8: Freundlich adsorption isotherm [X=x/M (mg ABS removed/mg carbon)]

used was enough to deliver a high quality effluent with respect to detergent (the maximum concentration after

GAC treatment is 0.161mg L^{-1} MBAS, for below the discharge limit to aquatic environments).

Figure 8 illustrates the detergent adsorption isotherm. As it is evident, this adsorption by GAC follows Freundlich isotherm and the linear equation of this adsorption is y=0.5864 x-0.0389. So, similar to many other compounds found in water and wastewater, the Freundlich isotherm can be used to describe the adsorption characteristics of GAC and to predict the required amount of this adsorbent for any treatment.

Finally, it should be noted that studies ever since performed to assess the ability of activated carbon in removing detergents from water or wastewater are only limited to few works and according to literature the removal ranges reported are considered to be from poor to fairly good[10,11].

For the removal of surfactants as a dissolved organic constituent many treatment methods can be used. Among these the adsorption process has not been used extensively in wastewater treatment, but demands for a better quality of treated effluent, have led to an intensive examination of adsorption process especially by use of GAC. Although, surfactants have-not been classified as readily adsorbed organics by many adsorbents because of high solubility in water, use of GAC may be considered as a fairly good polishing process for these pollutants and the results of this study showed that about 50% reduction is possible even by 9.5 min contact with this adsorbent. Considering the need to remove other residual organic and inorganic matter from municipal effluents and the high capacity of GAC in completing this treatment, use of GAC may by recommended for all municipal treatment plants which are obliged to meet new discharge standards. Of course, for achieving a better efficiency of detergent removal, contact time to GAC (or the amount of adsorbent) should be increased.

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