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SURVEY ON BIOLOGICAL GROWTH IN IMPROVED ACTIVATED - SLUDGE SYSTEM BY PAC

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Key words: *Biological growth, oil refinery effluent , powdered activated carbon technology (PACT), AS system*

Abstract

In this research, the effects of the addition of powdered activated carbon (PAC) into the aeration zone of a activated-sludge (AS) system for treating Tehran Oil Refinery effluent, was investigated during more than 12 months in a PACT pilot-scale model. Besides the evaluation of organics removal efficiency and determination of basic design factors and kinetic coefficients, a series of experiments were conducted in order to study the variations in biological growth (especially bacteria and monocellular organisms) related to PAC additon. After sampling from mixed liquor and microscopical studies, adequate samples were filtered, dewatered and fixed. The samples were then coated by 100 A films of (Au) and were studied by scanning electron microscopy (SEM). Results showed significant improvement of bacteria and monocellular organisms in the presence of PAC, which may be arised from providing more contact surface and better nutrient availability for microorganisms , decreasing the effects of toxic shock loads and providing better conditions for microorganisms against intensive mixing. Electronic photomicrographs by SEM confirmed good attachments of ciliatea to PAC particles, along with appropriate efficiency of bacteria diffusion into its meso and micropores. Also, the comparison between the count number of protozoea in two pilots of PACT and AS, showed better conditions for growth of microoganisms, using PAC.

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Introduction

During the past two decades, wastewater treatment methods are developed, mainly because of the increase of knowledge about the impacts of new organic compounds on the environment.

Significant attention is paid to an imporved biological treatment method, called Powdered Activacted Carbon Technology (PACT), using PAC in the aeration zone of activated-sludge (AS) system, regarding its ability in stabilizing treatment performance, good removal efficiency of coloured and organic compounds, and decreasing sludge bulking (16).

Investigations carried out on Dupont Chemical Industry effluent (10) had also shown that the removal efficiency of more than 129 toxic chemicals was improved to 99% using PACT system. It also confirmed the possiblity of PAC recovery by thermal method. Studies of Exon Oil Company on this method, also demonstrated removal efficiency improvement of ammoniacal nitrogen, Oil and grease, BOD and COD, resistance increase to toxic shock loads, and improvement of sludge settling (14).

Following the use of activated carbons as powdered and granular in water and industrial waste treatment, biological growth on carbon particles was also considered. Primary studies showed that most bacteria have a tendency to move towards the interface of liquid and solid phases and concentrating there. In aerobic conditions, this leads to an increase of oxygen and nutrient consumption (11). Other studies confirmed that the surface of activated carbon particles provided appropriate environment for bacterial growth. In other words, the rates of bio-oxidation of organics and bacterial growth, increased with carbon surface area. These investigations emphasized that activated carbon shows selective adsorption for oxygen and nutrients, and that the existance of three factors of bacteria, organic compounds and oxyen, leads to an increase in bacterial growth (11). Although some researchers believe that the major factor of growth inhibition is the appropriate nutrient environment on carbon particles, and some others think that the carbon surface provides better conditions for a group of bacteria with slower methabolism rate, but they all agree in the improvement of biological growth in nutrient solutions at the presence of activated carbon particles (8).

Other studies showed that the rough surface of carbon particles provided good conditions for attached organism to resist against the pressure of liquid

mixing (6). It was also approved that the presence of operating groups on the surface of particles, facilitated the atachment of microorganisms (15). Furthermore, it was shown that the biological growth on the surfact of activated carbon particles in wastewater biological treatment systems increase organics oxidation (9), and decreased the number of times of carbon regeneration or replacement (4).

The use of PACT system for treating coloured weaving effluents demonstrated good bacterial growth on the external surfaces and the larger pores of carbon particles, with its continuous regeneration. It was also shown that the immunity of bacteria increased because of the decrease in entrance possibility of larger mono and multicellular organisms into the pores (5).

Studies on biological growth in activated carbon columns showed that biodegredation and physical adsorption take place, simultaneously. Observations by scanning electron microscopy (SEM) approved the presence of bacteria on the surface and within the pores , and monocellular organisms on the carbon body (12). Comparison between the biological growth on granular activated carbon (GAC) with other particles such as sand, polymeric adsorbents and ion-exchange resins showed significant growth of different bacteria and monocellular organisms on GAC particles, with their simultaneous bioregeneration (17). The review studies of the same researchers also showed two reversible and irriversible phases in the attachment of bacteria to solid surfaces; At the first phase, physical adsorption is done and during the second phase, attachment is taken place by the aid of cellular excretion of polymeric compounds and glucoprotiens (13).

The research presented in this paper was planned with the major objective of studying biological growth quality on PAC manufactured in Iran used for the treatment of Tehran Oil Refinery effluent by PACT system in a pilot-plant model, and comparing the results with theoritical principles, regarding that in none of other studies, the quality of biological growth on PAC added to the aeration zone of activated sludge (AS) system, was investigated, and that the existing judgements were all based on theories.

Materials and methods

In this research, the methods of the American Standards for Testing and Materials (2) were used to determine following parameters for PAC: humidity, density, total ash percentage, particle size distribution, solubility in water, acid and alchohol, and iodine number. Also the methods of porosimetry and nitrogen gas and mercury adsorption were used respectively to determine porosity distribution and active surface area (3).

Anionic and cationic impurities of PAC were determined using (3) and the standard methods for the examination of water and wastewater (1). In order to study the biological growth on carbon particles, method of SEM (17) and an improved method (13) were used after some small changes. Basic stages of this part were as follows:

1- A mixed sample of 5 ml was provided from the aerated reactor of PACT model;
2- The sample was filtered by Wattmann paper No. 44; the paper was then used in the next stages;
3- The Wattmann paper was put in a solution of 2% paraformaldehyde, 2.5% glutaraldehyde, and sodium phospate (0.1 molar), with pH =7.5, for 2 hours;
4- The paper was then put in a soluion of 10% osmium tetraoxide and sodium phosphate buffer (0.1 molar), with pH= 7.5, for 3 hours;
5- Dewatering was done using ethanol series of 50,60,70,80,90 and 100%;
6- The sample was then put in a solution of 1+1 ethanol and pure acetate amil for 30 minutes, to perform final fixing;
7- The sample was next put in a pure solution of acetateamil during one night. It was then dried rapidly (7), attached to Aluminum support and coated with a 100 A film of Au;
8- The samples was finally studied using SEM.

The above mentioned stages were repeated 3 times, and each time 10 samples were prepared. For the second and third repetitions, stainless-steel coupons were fixed in different points of the aeration reactor, took out after 24 and 48 hours. Then, all of the stages for biological fixtion, dewatering and final works were done.

Results and discussion

Table 1 and Figures 1 and 2 demonstrate the data about basic qualitative parameters of Tehran Oil Refinery effluent, used in this research.

Sepcifications of the PAC manufactured in Iran are shown in Table 2 and Figure 3. General view of PAC porosity is demonstrated in Figure 4.

Results showed that the rate of biological growth in the PACT model should

be suitable because of the increase in the effluent treatment efficiency in the persence of PAC in the aeration zone of AS system, Observation of mixed liquor smaples taken from the aeration zone of the PACT model by optic and scan electron microscopy, demonstrated that the presence of PAC increases the contact area and provides enough nutrients and dissolved oxygen. It also decreases the effects of toxic growth inhibitor shock loads, and increases the resistance and stabilization of microorganisms against intensive mixing and turbulence.

On the other hand, results of the comparison of count numbers of monocellular organisms per unit volume of the effluent for AS and PACT systems, showed more population of these types of organisms in the latter system. Even, with shock loads of phenol and furfural (with concentrations of 250 and 350 mg/l), the mixed liquor samples, form PACT system, showed more resistance.

This study also demonstrated a decreased in filamentus bacteria in the PACT system; because the rather heavy particles of activated carbon and in its role in producing larger flocs, led to better conditions of settling and caused less bulking problems.

Following this research, complementary studies may be recommended in order to obtain more data growth of cocus and filamentus bacteria around and within the macropores of PAC, rod bacteria on the external surface of PAC, compact biological growth on the external edge of PAC particles, and growth of cliatae on the surface of PAC are shown respectively in Figures 5,6,7 and 8.

Table 1- Mean and satandard deviation of PACT model influent, based on 34 samples and 60 days study

Parameters / Statistical data	COD	BOD_5	$N.NH_3$	$P.PO_4$	TSS	VSS
Mean (mg/l)	279	166	3.3	0.78	135	83
Standard deviation (mg/l)	52	28	2.37	0.73	49	35

Table 2- Specifications of PAC manufactured in Iran

Parameter	Quantity	Dimension
Fe Zn Cu Pb	0.04 0.0025 0.01 0.0029	% W
Apparent density	0.495	g/cm^3
Ash Content Miosture Water Solubility Acid Solubility Ethanol Solubility Weight Loss at 120°C Weight Loss at 550°C	4 2.8 0.37 1.2 0.26 2.8 7.1	%W
Active Surfact Area	540	m^2/g
Iodine Number Molasses Number Methylenblue Absorbed	500 650 85	mg/g

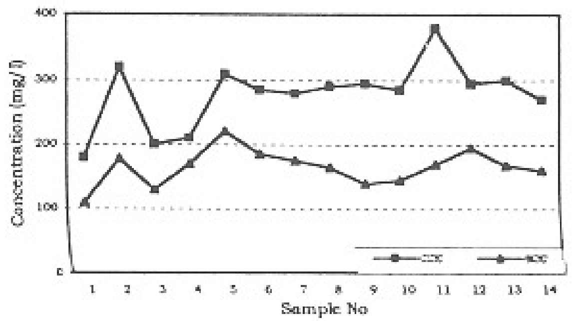

Fig. 1- Fluctuations of COD and BOD in raw effluent of Tehran Oil Refinery

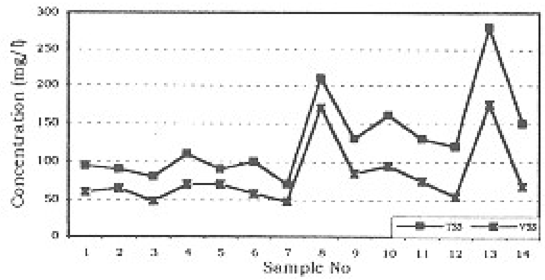

Fig. 2- Fluctuations of TSS and VSS in raw effluent of Tehran Oil Refinery

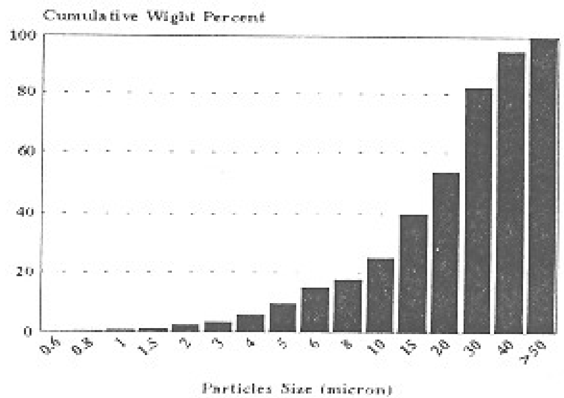

Fig. 3- Cummulative frequency of PAC particle size

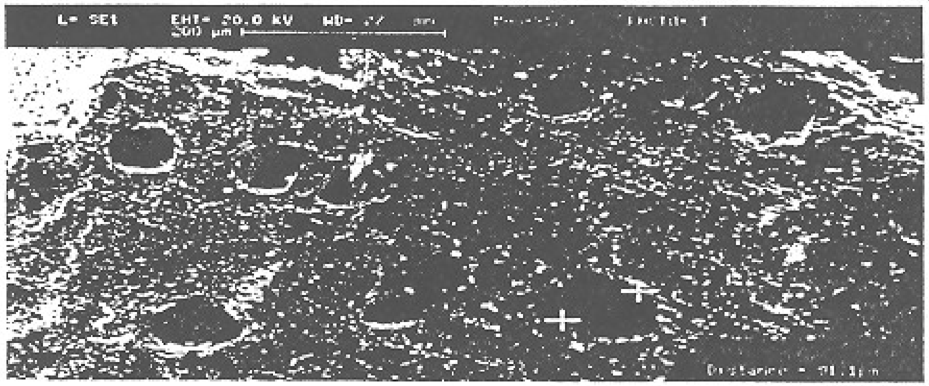

Fig. 4- General view of PAC porosity obtained by SEM

Fig. 5- Growth of cocus and filamentus bacteria on PAC macropores

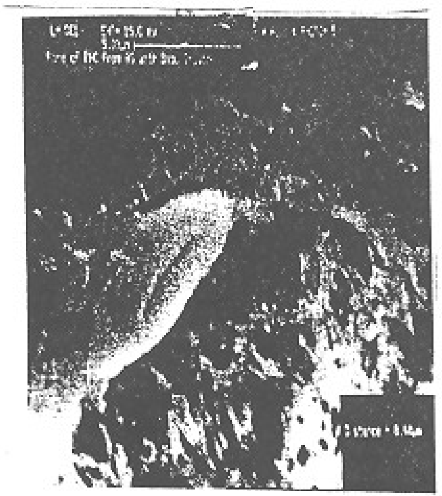

Fig. 6- Growth of rod bacteria (probably Kelebsiella sp.) on the surface of PAC.

Fig.7- Compact growth of bacteria on the external edge of PAC pores

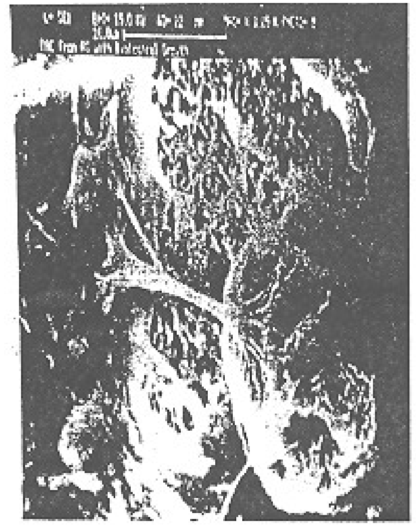

Fig.8- Growth of attached ciliatae on the surface of PAC

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