

Hospital Wastewater Treatment by Integrated Fixed Film Activated Sludge, Using Rice Husk as Fixed Media

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Abstract Hospitals generate a significant amount of wastewater in a day from 400 to 1200 L by bed. These effluents are loaded with microorganisms, heavy metals, toxic chemicals and radioactive elements. Activated sludge process is commonly used for hospital wastewater treatment in Iran. The main objectives of this study were the performance assessment of integrated fixed film activated sludge using rice husk (Rice Husk Activated Sludge-RHAS) for hospital wastewater treatment and comparison of the efficiency of RHAS with conventional completely mixed activated sludge (CMAS). In this study the RHAS has been used in pilot scale for hospital wastewater treatment for one year and its performance was compared with (CMAS). The minimum effluent BOD₅ occurred in RHAS with 18 hr hydraulic retention time, where BOD₅ reached to less than 15 mg/L. In CMAS however the minimum BOD₅ at 18 hr HRT was about 45 mg/L. In RHAS system HRT has no significant effect on BOD₅ removal efficiency ($p < 0.01$) while in the CMAS system HRT has significant effect on BOD₅ removal efficiency ($p < 0.01$). comparatively, removal efficiency of RHAS was significantly greater than CMAS for all studied HRT ($p < 0.01$). The RHAS had more ability in the degradation of slowly biodegradable or recalcitrant compounds in hospital wastewater in comparison to CMAS. The VSS concentration in RHAS in all HRTs was more than 2 time greater than CMAS and reaches to 4008 mg/L at the maximum concentration. It is concluded that Rice Husk can be used as fixed media in IFAS system and it can be improved the performance and efficiency of hospital wastewater treatment without any additional costs.

Keywords Hospital wastewater, Rice husk, Activated sludge, Fixed film

1. Introduction

Hospitals generate a significant amount of wastewater in a day from 400 to 1200 L by bed.

These effluents are loaded with microorganism, heavy metal, toxic chemicals and radioactive elements [1]. Hospital waste could be dangerous to the ecological balance and public health. Pathological and infectious wastes, if left untreated could lead to outbreaks of communicable diseases [2, 3].

In countries that do not experience epidemics of enteric diseases and that are not endemic for intestinal helminthiasis, it is acceptable to discharge the wastewater from health-care establishments to municipal sewers without pretreatment, provided that the following requirements are needed: 1- the municipal sewers are connected to efficiently operated sewage treatment plants that ensure at least 95% removal of bacteria, 2- the sludge resulting from sewage treatment is subjected to digestion, leaving no more than one helminthes

egg per liter in digested sludge, 3- the waste management system of the health-care establishment maintains high standards, ensuring the absence of significant quantities of toxic chemicals, radionuclids, cytotoxic drugs and antibiotics in the discharged wastewater, 4- excreta from patients being treated with cytotoxic drugs may be collected separately and adequately treated [4, 5].

The absence of efficient sewage treatment plant in many cities of Iran and national discharge standards for hospital wastewater results in the necessity of hospital wastewater treatment to be a.

Activated sludge processes are commonly used for hospital wastewater treatment in Iran, as more than 78% of hospitals use different modification of that process for wastewater treatment [6, 7].

One of the most important limitations of this process for hospital wastewater treatment is the effect of toxic substances on microbial populations which leads to many difficulties in operation of activated sludge processes and may result in unsatisfied discharge standard becomes unsatisfied.

Integrated fixed film activated sludge combines the advantages of attached growth and suspended growth processes, therefore resistance against toxic material shocks

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will be increase in this treatment system [8, 9] and can be more efficient for hospital wastewater treatment than activated sludge. There is a limitation about using IFAS for wastewater treatment in developing countries by importing of fixed media wich is so expensive and build up the cost of wastewater treatment.

Searching for natural matters as fixed media for supporting microbial growth and replacement with synthetic media to decrease the cost of treatment is considered as an important act in low income communities.

Rice husk with specific surface of $0.7 \text{ m}^2/\text{g}$, by-product of rice cultivation (consist of 20% of the seed weight) is a wonderful product with multifunctional features. It has many capabilities in water and wastewater treatment [10]. The potential of rice husk for adsorption of many environmental pollutants was reported by many researchers [11, 12]. It can be a hypothesis that rice husk can improve the activated sludge processes for hospital wastewater by adsorbing toxic substances and supporting microbial growth as fixed media and increasing microbial population.

With attention to the above-mentioned problems the present study was conducted in pilot scale and on real hospital wastewater. The main objectives of this study were the performance assessment of integrated fixed film activated sludge using rice husk for hospital wastewater treatment and comparison of the efficiency of IFAS with conventional completely mixed activated sludge at the same operational conditions. Finally the operational parameters such as: hydraulic retention time, organic loading and return sludge ratio for IFAS (rice husk Activated sludge- RHAS) system in hospital wastewater treatment were optimized and the corresponding results were discussed.

2. Materials and Methods

2.1. Hospital Wastewater Characteristics

The wastewater used in this study was taken from the final manhole for Resalat hospital wastewater network before discharging in a septic tank in the city of Masal located in Guilan province, Iran. This hospital with 50 beds generates of about 30 m^3 wastewater per day.

The results of 3 months survey on hospital wastewater quality are given in Table 1. All samples were collected as 8-hour cumulative sampling method for wastewater analysis

2.2. Analytical Methods

All chemicals were purchased from MERK company (Germany) and the purity of chemicals were 98% and higher. pH in equalization tank monitored with 826 Metrohm pH meter. Dissolved oxygen concentration in aeration tank was determined with a HQD (4od) probe DO meter from HACH Company.

All other analysis include: COD, BOD5, TSS, PO_4 3- P, $\text{NH}_4\text{-N}$ and MLVSS were conducted according to standard methods for water and wastewater examination [13]. The biomass was estimated by measurement of volatile suspended solids (VSS) according to the method of 2940E in standard method. For determining the attached biomass, the dry rice husk was weighed before placing it in aeration tank and at the end of experiments and then was tested the same as VSS according to standard method. The differentiation between dry rice husk's weight and tested VSS was considered as attached biomass. Total volatile solid (attached and suspend) in RHAS reactor reported as sum of suspended and attached volatile solids.

Table 1. Qualitative characteristics of hospital wastewater

parameter	pH	BOD5 (mg/L)	COD (mg/L)	TSS (mg/L)	$\text{NH}_4\text{-N}$ (mg/L)	PO_4 3- P (mg/L)
Value	6.4-8.1	320 SD=78	790 SD=127	385 SD=48	68 SD=9	18 SD=3

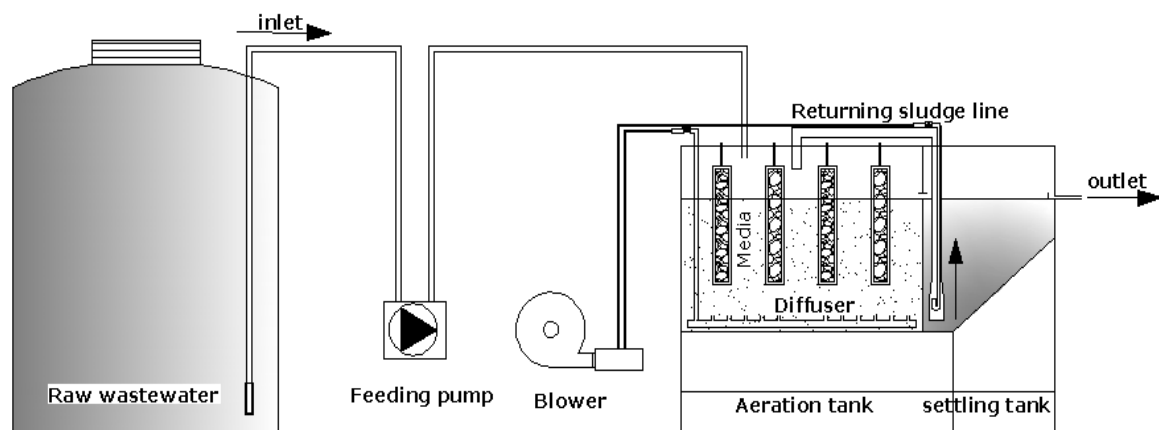


Figure 1. The experimental set-up of Rice Husk Activated sludge for hospital wastewater treatment

2.3. Experimental Set up and Methods

In this study the Integrated Fixed Film Activated Sludge using rice husk as fixed media (Rice Husk Activated Sludge-RHAS) was used in pilot scale for hospital wastewater treatment for one year and its performance was compared with Completely Mixed Activated Sludge (CMAS).

Figure-1 shows the experimental set up consisting of Integrated Fixed Film (Rice Husk) Activated Sludge (RHAS). A Completely Mixed Activated Sludge (CMAS) with same dimensions as RHAS was used as control and operated in parallel with RHAS with same operational condition.

Both reactors were made up of stainless steel with the same dimension, aeration tank (0.8*0.5*0.8 m) and sedimentation tank (0.4*0.5*0.8 m).

As shown in figure 1, hospital wastewater was equalized in a equalization tank with 1000 liter volume and wastewater was fed in two reactors with same flow rate by two dosing pumps which were adjustable on 10 positions of flow rate.

The rice husk was placed in a plastic net with 0.2 mm mesh and suspended in aeration tank by stainless steel bar. 1 kg rice husk by five 200g packages were used at the beginning of the experiment. All packages were replaced only one time during the experiments.

Figure 2 shows a picture of rice husk package with attached biomass after 3 months operation. In order to determine optimum operational condition the HRT was sequentially reduced from 18 to 9 and finally to 4 hr through the study. Return sludge flow rates for RHAS were equal to CMAS and were 100% of inlet wastewater flow rate.



Figure 2. Picture of rice husk package with attached biomass after 3 months operation

Sampling was done from effluent of settling tank for BOD₅ and COD analysis. Samples were filtered into glass tube with teflon caps and stored at 4°C until analysis. For VSS analysis sampling was done from aeration tanks.

The frequency of analysis varied from 1 to 3 times a week except for VSS that was measured at the end of each operational condition (HRT).

To determine the optimum rice husk weight as an important parameter for design and operation of this system, different weights of rice husk (0.5, 1 and 1.5) kg were used in the pilot and BOD₅ removal efficiency at different weights was evaluated.

3. Results and Discussion

Figure-3 shows the effluent BOD₅ concentration of RHAS and CMAS at different hydraulic retention times. It can be seen that the minimum BOD₅ occurs in RHAS with 18 hrHRT, where BOD₅ reaches to less than 15 mg/L. In CMAS, however the minimum BOD₅ at the corresponding HRT was about 45 mg/L.

Analysis of average BOD₅ removal efficiencies by RHAS at studied HRT (4, 9 and 18 hrs) indicates that HRT has no significant effect on BOD₅ removal efficiency ($p < 0.01$) while in the CMAS system HRT played an appreciable effect on BOD₅ removal efficiency ($p < 0.01$). From the above-mentioned result it can be concluded that in RHAS, retention time in aeration tank can be decreased without losing efficiency which could be translated as decrease of treatment costs.

Comparison of average of BOD₅ removal efficiencies at different HRTs between RHAS and CMAS shows that in all HRT removal efficiency of RHAS is significantly greater than CMAS ($p < 0.01$). Other studies investigated on fixed film activated sludge with synthetic media have reported similar results [14].

Figure-4 shows effluent COD from RHAS and CMAS at different HRT comparatively. It can be seen that COD changes in effluent had approximately the same behavior as BOD and in all operational conditions COD of effluent from CMAS was greater than RHAS. Comparison of Average of COD removal efficiencies at different HRTs between RHAS and CMAS shows that in all studied HRT, the removal efficiency of RHAS was significantly greater than CMAS. Comparison of observed differences between BOD₅ and COD removal efficiencies of RHAS and CMAS implies on a considerable point can be found.

Table 2. Comparison of average of removal efficiencies

Type of system	Average of BOD ₅ removal efficiency (A)%	Average of COD removal efficiency (B)%	$A_{RHAS}-A_{CMAS}$ (%)	$B_{RHAS}-B_{CMAS}$ (%)
RHAS				
HRT=4hr	89.85	88.25	21.56	22.64
HRT=9hr	92.31	91.36	16.40	17.10
HRT=18hr	96.23	95.86	13.75	15.87
CMAS				
HRT=4hr	68.2	65.6		
HRT=9hr	75.91	74.25		
HRT=18hr	82.47	79.99	----	----

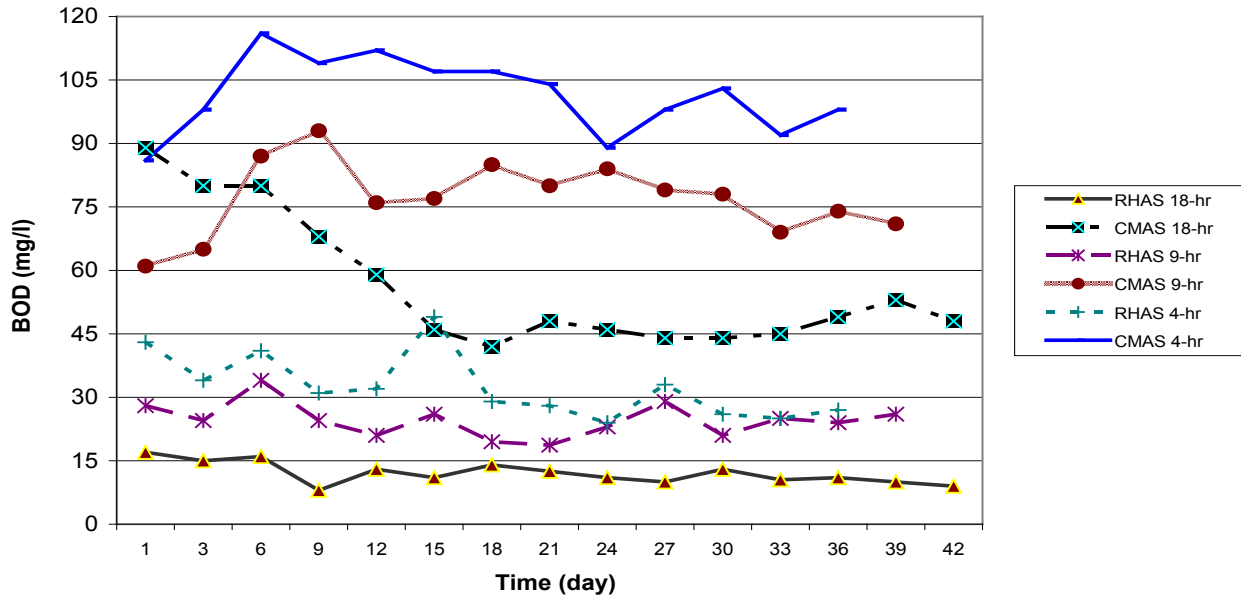


Figure 3. Effluent BOD from RHAS and CMAS in different Hydraulic retention time after steady state

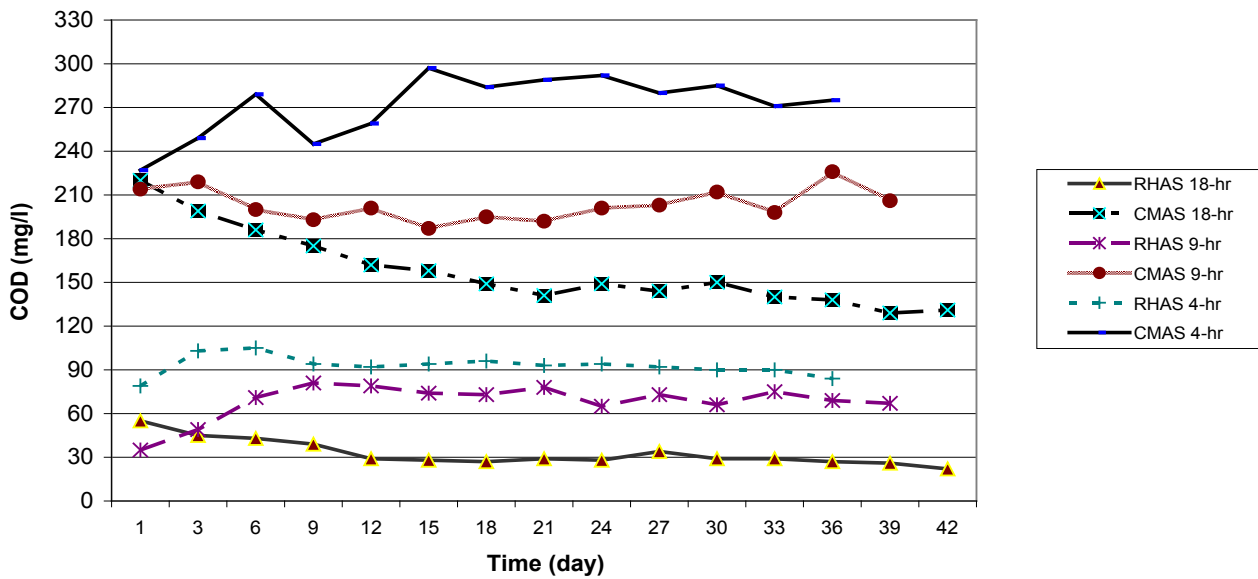


Figure 4. Effluent COD from RHAS and CMAS in different Hydraulic retention time after steady state

Table 3. VSS concentration in RHAS and CMAS at different HRT

HRT(hr)	VSS in RHAS (mg/L)	VSS in CMAS (mg/L)	MCRT of RHAS (day)	MCRT of CMAS (day)
18	3376	1327	21	8.2
9	3921	1512	24.3	9.4
4	4008	1634	24.9	10.1

As shown in Table 2, the maximum and minimum differences of BOD₅ and COD removal between RHAS and CMAS is related to 4-hr and 18-hr retention times and differences between COD removal is always greater than BOD₅ removal, therefore it can be resulted that RHAS has more ability for degradation of slowly biodegradable or recalcitrant compounds in hospital wastewater, such as

conventional IFAS with synthetic media on the other hand it is possible that a part of COD removal in RHAS be attributed to adsorption, therefore additional research about pollutant adsorption by RHAS is needed to distinguish removal paths.

Table-3 shows the concentration of VSS in RHAS and CMAS at different HRT. It can be seen VSS concentration in RHAS at all HRT is more than 2 time greater than CMAS this.

Other studies on SBR system with and without biofilm give similar results [15, 16].

With attention to maximum VSS concentration it can be calculated that the maximum biomass production by Rice Husk is about 1.2 kg biomass/ kg Rice Husk.

The initial Rice Husk was 1 kg therefore [4008 mg/L (VSS concentration)] * [320 L (volume of aeration tank)]/106

mg/kg = 1.28 kg

The minimum and maximum VSS concentration was determined in 18-hr and 4-hr retention time respectively.

It can be due to this fact that with increasing of aeration time, organic loading decreases and microbial population shifts to death phase consequently yield coefficient and biomass formation decreases.

This point must be considered that the differences between removal efficiencies may be due different MCRT (Mean Cell Residence Time) in RHAS and CMAS. Wasted sludge and concentration of VSS in wasted sludge in both of systems was approximately equal and with attention to higher concentration of VSS in RHAS it must be expected that MCRT in RHAS was often greater than CMAS. The MCRT of the two systems was calculated according to the equation below

$$MCRT = \frac{V * X}{Q_w * X_w + Q_e * X_e}$$

Where: V, reactor volume; X, average biomass concentration of the reactor (mgVSS/l); Q_w , excess sludge (l/d); X_w , concentration of the excess sludge (mgVSS/l); Q, wastewater flow rate (l/d); X_e effluent concentration (mgVSS/l).

MCRTs at different HRT are given in table 3 it can be seen that sludge age at all HRTs of RHAS is greater than CMAS. It must be considered that with changing the wasted sludge amount the MCRT can be change and this is an important point.

However the increasing of VSS by Rice Husk is less than synthetic media such as Rope-Type,

Sheet Media and Polypropylene Finned Cylinder [17], but from economical point of view it can be better choose because its price is approximately zero while for example 1 m³ of Polypropylene Finned Cylinder media has price about 1000 \$ in Iran.

To determine the optimum rice husk weight as an important parameter for design and operation of this system,

different weight of rice husk (0.5, 1 and 1.5) kg were used in pilot and BOD₅ removal at different weight was evaluated.

Figure 5 shows the averages BOD₅ removal efficiencies at different weight of rice Husk. Operation of the system with 0.5 kg of (rice husk) in the retention time of 9 hours, showed the moderate BOD₅ removal of 72.4 percent. 2-In the same condition, the reactor with 1 and 1.5kg (rice husk) showed average BOD₅ removal of 92.3 and 94.6 percent respectively.

Due to insignificant differences for BOD₅ removal, between 1 kg and 1.5 kg ($p < 0.01$) for preventing too much Reservoir volume occupation by Media, the options 1 kilograms of rice husk was selected as the optimum weight. With attention to volume of aeration tank (0.32 m³) it can be concluded that 3.125 kg/ m³ is the optimum ratio of Rice Husk/ volume of Aeration Tank.

4. Conclusions

One of the most important limitations of activated sludge process for hospital wastewater treatment is the effect of toxic substances on microbial populations which makes many problems in operation of activated sludge processes and decreases the removal efficiency. Integrated fixed film activated sludge is more resistant against toxic material than conventional activated sludge. It can be a hypothesis that rice husk can improve the activated sludge processes for hospital wastewater by adsorbing toxic substances and supporting microbial growth as fixed media and increasing microbial population.

Results from this study indicate that removal efficiency of RHAS is significantly greater than CMAS. Optimum conditions for performance of this system for hospital wastewater treatment are 9 hr of HRT and 3.125 of kg Rice Husk / volume of Aeration Tank. It is concluded that Rice Husk can be used as fixed media in IFAS system and it can be improved the performance and efficiency of hospital wastewater treatment without any additional costs.

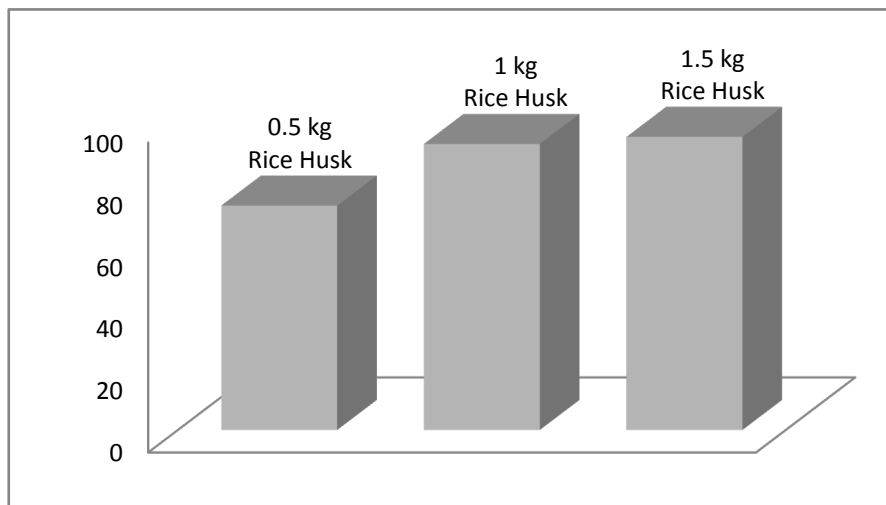


Figure 5. Comparison of the averages of BOD₅ removal efficiencies in the systems with different weights of rice husk (Aeration time of 9 hours)

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REFERENCES

- [1] Sonia Suarez, Juan M. Lema and Francisco Omil 2009, Pretreatment of hospital wastewater by coagulation-flocculation and flotation, *Bioresource Technology* (100) 2138-2146.
- [2] V. Chitnis, S. Chitnis, K. Vaidya, S. Ravikant, S. Patil and D.S. Chitnis. 2004. Bacterial population changes in hospital effluent treatment plant in central India. *Water Research*. 38, 441-447.
- [3] Somwang Danchaivijitir, Wichai Wongchanapai, Susan Assanasen and Duangporn Jitanothaitavorn. 2005. Microbial and heavy metal contamination of treated hospital wastewater in thailand. *J Med assoc Thai*. 88, 59-63.
- [4] A. Rezaee, M. Ansari, A. Khavanin, A. Sabzali and M. M. Aryan 2005. Hospital wastewater treatment using an integrated anaerobic aerobic fixed film bioreactor. *American journal of Environmental sciences* 1 (4) 259-263.
- [5] E. Tumeo, H. Gbaguidi, I. Patry, X. Bbetrand, M. Thouverez and D. Talon. 2007. Are antibiotic-resistant *Pseudomonas aeruginosa* isolated from hospitalised patients recovered in the hospital effluent? *Int. J. Hyg. Environ. Health*. Article in press.
- [6] M Majlesi, A R Yazdanbakhsh, 2008, Study on wastewater treatment systems in hospital in Iran, *Iranian J Environmental Health Science and Engineering*, 5, (3), 211-215.
- [7] Farrokhi, M., M. Hajrasoliha, G. Meemari, M. Fahimi, M. Talebi and M. Kohansal, 2008. Thecreation of management system for funding priorities in wastewater projects in rural community in the Islamic Republic of Iran. *Water Sci. Technol.*, 58: 1181-1186.
- [8] Tchobanoglous G, F. L. Burton and M.D Stensel. 2003, *Wastewater Engineering*, Metcalf and Eddy.
- [9] Jou G J G and Huang G G, 2003, A pilot study for oil refinery wastewater treatment using affixed film bioreactor, *Adv. Environ. Res*, 7, 463-469.
- [10] Alleman, J. E., 2000, "The History of Fixed-Film Wastewater Treatment Systems", Article-Biofilmhistory. html.
- [11] N. Khalid, A. Rahman, S. Ahmad, A. Toheed and J. Ahmed, 2006, Adsorption behavior of rice husk for the decontamination of chromium from industrial effluents, *Journal of Radioanalytical and Nuclear Chemistry*, 240 (3), 775-781.
- [12] Hsu ST and Pan TC, 2007, Adsorption of paraquat using methacrylic acid-modified rice husk, *Bioresource Technology*, 98 (18), 3617-3621.
- [13] APHA, 1995. Standard method for the examination of water and wastewater. 19 th ed. Washington D C, American Public Health Association.
- [14] Xiangua Wen, Hangjiu Ding, Xia Huang and Ruopeng Liu. 2004. Treatment of hospital wastewater using a submerged memberane bioreactor. *Process Biochemistry*, 39, 1427-1431.
- [15] Altinbas U, 2001, Nutriant removal from low strength domestic wastewater in sequencing batch biofilm reactor, *Wat. Sci. Technol.*, 44, 181-186.
- [16] Nipapun Kungskulniti, Suvit Shmmumsirivath and udomasak Kongmuang. 2000. the SBR system without reaeration in its prolonged idle period for treatment of hospital wastewater. *Int.J. Sc. Tech*. 5 (1), 50-55.
- [17] Brentwood Industries Inc, 2005, Integrated fixed film activated sludge (IFAS), available at: http://www.brentwood_ind.com/water/ifas.