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HOSPITAL WASTEWATER TREATMENT USING MIXED MEDIA BIOFILTER

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ABSTRACT

In this study, a lab scale system of integrated anaerobic-aerobic with Multi Stage Mixed media Biofilter (MMBF) is studied to treat a hospital wastewater to remove organic matter as well as nitrogen and phosphorus. The main goal was to evaluate the performance of the poly propylene (pp) membranes used to treat hospital wastewater. The experimental works are operated in two stages:

The first stage includes the batch system of pretreatment by using alum and lime (CaO) with various dosage. The effects of dosage amount and operation time on removal efficiency were studied. The results of continuous measurements and monitoring indicate that removal efficiencies of treatment with lime addition are more efficient at removing organic and inorganic matter than the treatment with alum addition.

The second stage is a continuous flow system (aerobic MBR system) to investigate removal efficiency in terms of chemical oxygen demand (COD), ammonium (NH_4^+), nitrite (NO_2), nitrate (NO_3), phosphorus (PO_4), total suspended solids (TSS), total dissolved solids (TDS), Turbidity (NTU) and electric conductivity (EC) by using three runs discharges (0.2, 0.3 and 0.4 m^3/hr.) Different results are obtained and show an increase in removal efficiency in all terms previously reported in the study.

Key words: Membrane Bioreactor (MBR), Hospital Wastewater, Nitrogen, Phosphorous**.**

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1. INTRODUCTION

Wastewater is referred to water that used by human, due to lose its quality and become unusable. This involves waste disposal from domestic, industrial, agricultural and commercial sectors (Ekhaise, and Omavwoya, 2008; Jolibois, and Guerbet1, 2005).Wastewater reusing become very essential around the world to detect natural water resources that are used for drinking water supply due to diminishing water supplies and increasing population growth. There is need to develop and analysis different treatment technologies on efficiency, design aspects, operational aspects, financial aspects and overall risks associated with treatment technologies by encourage environmental engineers, technologist and economists. Many treatment technologies have been developed to fill this gap of demand and supply with economical ways. Some of these technologies are described, Ozonation, Activated Sludge Process (ASP), Extended Aeration (E.A.), Sequential Batch Reactor (SBR), Fluidized Bed Reactor (FBR), Submerged Aeration Fixed Film (SAFF) Rector and Membrane Bio-Reactor (MBR) (Xianghua et al., 2004; Kajitvichyanukul and Suntronvipart, 2006; Qiaoling et al., 2010). The treatment by using technique of membrane bioreactor (MBR) is the wide usage in water reused in the world (Naghizadeh et al., 2008). Membrane bioreactor is a biological wastewater treatment process which uses membrane instate of the gravitational settling of conventional activated sludge process. MBR, in which biomass is strictly separated by a membrane, offer several advantages over the conventional activated sludge process including a biomass concentration is high, small footprint, reduction sludge production and high effluent quality, simple system operation and facility management over (CAS) (Van Dijk et al., 1997; Naghizadeh et al., 2008). Due to, MBR is widely applied to remove organic pollutants and nutrient from wastewater (Cicek, 2003). The oxygen demand and ammonia that result in a DO (dissolved oxygen) depletion of the receiving water body; nitrite and nitrate are represent the main cause of eutrophication (extraordinary growth of algae) and methemglobinemia (Metcalf and Eddy, 1991). Therefore, to avoid organics and nitrogen contamination to the environment, the removal of nitrogen from wastewater became very important treatment process.

Nitrogen Removal process became very important process to avoid organics and nitrogen contamination to the environment. Nitrogen as ammonia can be remove with using the Biological nitrogen removal (BNR) process of nitrification and denitrification. In nitrification, ammonium can be oxidized to nitrite (NO_2) with Nitrosomonas and finally to nitrate (NO_3) with Nitrobacter, which operate in present of oxygen (Sabalowsky, 1999 and K.N. Kadhim &Ahmed H. 2018). While denitrification process can convert nitrate to nitrogen gas that operate under anoxic condition.

2. MATERIALS AND METHODS

Laboratory-scale experiment

The lab-scale MMBF system is composed of integrated anaerobic-aerobic with Multi Stage Mixed media Biofilter where the tubular-sheet membrane module is immersed, a photograph of this system shown in plate (1). The system includes four poly propylene sediments membranes filter with 5 microns are fixed and connected in series inside four symmetrical acrylic columns of (540 mm high, 145 mm internal diameter and 170 mm external diameter) (plate 1,e). Filter dimensions are (500 mm high, 60 mm external diameter and the internal

diameter 30 mm). The first reactor is filled with broken bricks (plate 1,a)**,** the second reactor is filled with thermo-stone (plate 1,b), and the third reactor is filled with activated carbon (AC) (plate 1,c), while the fourth reactor is filled with crushed granite(plate 1,d).

Raw hospital wastewater was prepared from domestic wastewater, leachate of an organic waste (Vegetables, Fruits), and some chemical substances. Then, all the waste has been mixed and stored in a 250 *L* tank for a few days. This waste has been pumped to the Inlet tank as influent to the system. During this stage, three operated runs with discharge of (0.2, 0.3 and 0.4 m^3/hr.) were conducted at different operation times. The parameters measurement are (Copper (Cu^{+2}), Chromium (Cr^{+2}), Iron (Fe^{+2}), Manganese (Mn^{+2}), Zinc (Zn^{+2}), phosphate (PO_4^{-3}), Ammonia (NH_3), Nitrate Nitrogen (NO_3^--N), Nitrite. An airlift was installed underneath the membrane module at a rate to maintained DO concentration of approximately 3.5±0.1 mg/L. The mixed liquor suspended solid (MLSS) remain constant through all experiments (8000∓ 200 mg/l). The ambient temperature throughout the operation period was 20-35 o C.

(a) Broken Bricks porous media

(b) Thermo-stone porous media

(c) Activated carbon (AC) porous media

(d) Granite porous media

Plate (1) Multi Stage MBR with different porous Media, Radial flow system (e) poly propylene cartridge

Analytical method

The Chemical oxygen demand (COD), Zn^{+2}, Mn^{+2} and Fe^{+2} are chemical elements measured by DR/850 Colorimeter. Dissolved oxygen concentration (DO) concentration was measured using DO Meter (WTW, Model 556, Germany) and the pH recorded were carried out by using Hanna Instruments, HI 98129 (a.K.a Combo 1) Digital PH/EC/TDS/Temperature Meter with Low Range EC). The pH measuring ranges from 0 - 14, with relative accuracy ±0.002. While the EC-meter ranges from 0 to 3999 µS /cm in this equipment. The analysis of total suspended solids (TSS), Ammonium (NH_4-N), NO_3-N, NO_2-N, and PO4-P are measured using the spectrophotometer (DR/850 Colorimeter). The measurement of mass liquor suspended solids (MLSS) follow standard [APHA, 2005]. The Copper test has been carried with use HI 96702 copper, high range, portable photometer. This instrument has ranges: 0.00 to 5.00 mg/L (ppm), while the Chromium VI test has been carried out by using HI 96749 Chromium VI, High range, portable photometer. This instrument has ranges: 0.00 to 1000 µg/L. The samples collected from the sampling port were analyzed on the same days.

3. RESULTS AND DISCUSSION

The results of the experimental work are obtained by two stages;

The first stage includes anaerobic Experiments (batch flow system) of pretreatment by using alum and lime (CaO) with various dosage added to 5000 ml of contaminated solution. The effects of dosage amount and operation time on removal efficiency were studied: A sets of experiments are planned to evaluate the removal efficiency of some heavy metals such as (Zn^{+2}, Mn^{+2}, Fe^{+2}, Cu^{+2} and Cr^{+3}).

3.1. Function of time

The performance of batch system depends upon many factors, the detention time is the basic parameter affect the anaerobic process. The reduction of heavy metals (Cu^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2}) by using alum with various dosage (1, 10, 20, 80) g added to 5000 ml of contaminated solution in absent of oxygen (anaerobic condition) for batch tests at 20ºC. The removal percentage of the contaminants significantly increases with increasing function of time as shown in Figs.(1-4). The kinetic data show that the removal percentage are 73%, 60%, 57% and 63% for Cu^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2} are respectively.

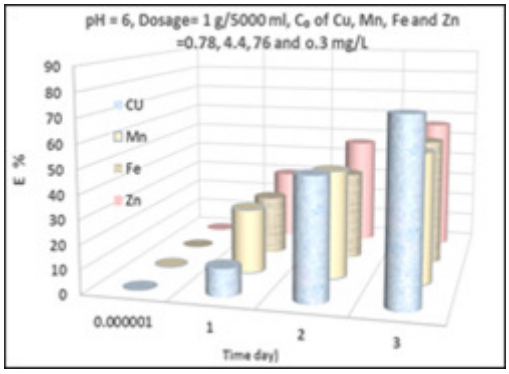

Fig. (1) Removal efficiency of Cu^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2} with function of time at dosage 1g (alum)

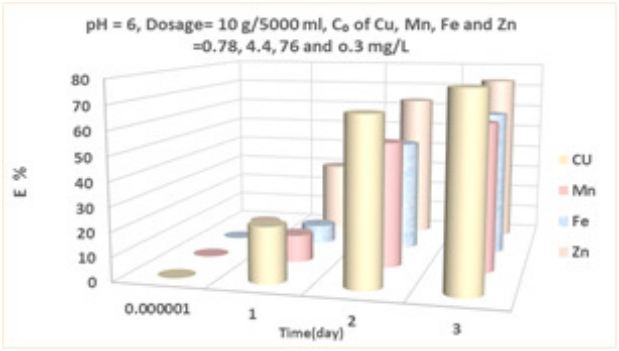

Fig. (2) Removal eff. Of Cu^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2} with function of time at dosage 10 g. (alum)

While by using lime (CaO) with values ranged from 2 to 80 mg added to 5000 ml of contaminated solution in absent of oxygen for batch tests at 20ºC. The figure demonstrates that the removal percentage of the contaminants significantly increases with increasing time. The kinetic data show that the removal percentage are 90%, 92%, 91% and 93% for Cu^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2} are respectively.

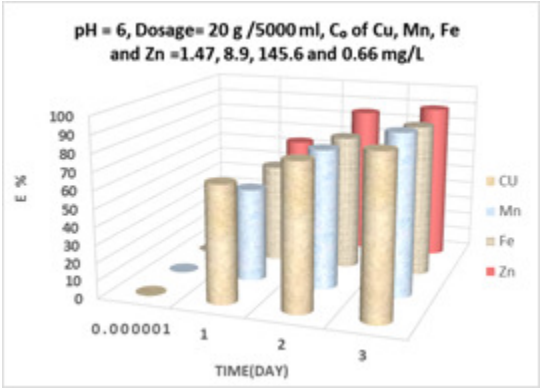

Fig. (3) Removal efficiency of Cu^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2} with function of time at dosage 20g (lime)

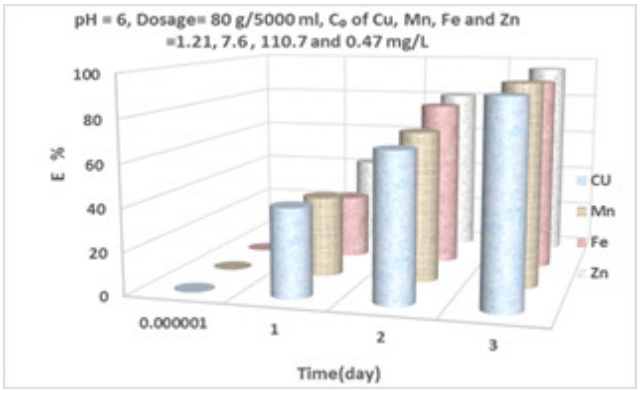

Fig. (4) Removal efficiency of Cu^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2} with function of time at dosage 80g(lime)

3.2 The dosage

The removal efficiency of concentration (Cu+2, Mn+2, Fe+2 and Zn+2) was studied with different weight dosage of alum from (1 to10) g and from (2 to 80) mg of lime (CaO) added for every 5000 ml of contaminated solution. As shown in Figs.(5) and (6), the increasing in dosage lead to increase in removal efficiency of heavy metals.

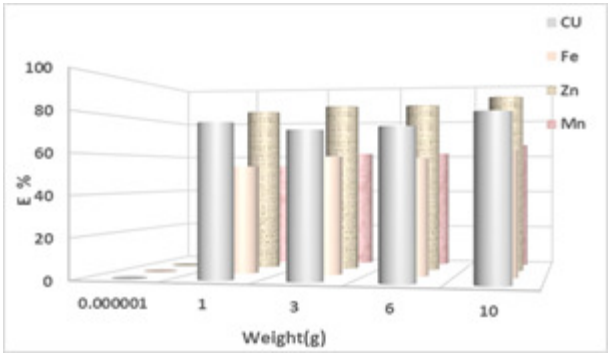

Fig. (5) Effect of alum dosage on removal efficiencies of Cu^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2}

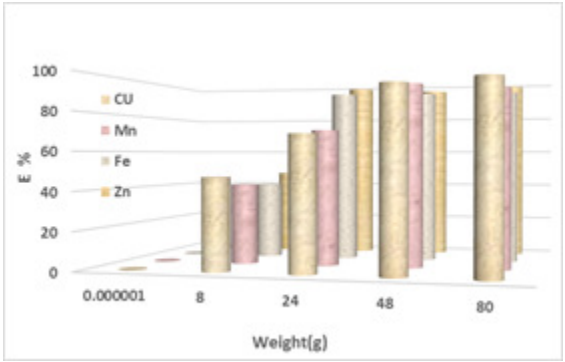

Fig. (6) Effect of lime dosage on removal efficiencies of Cu^{+2}, Mn^{+2}, Fe^{+2} and Zn^{+2}

The second stage is a continuous flow system (aerobic MBR system) to investigate removal efficiency in terms of chemical oxygen demand (COD), ammonium (NH_4^+), nitrite (NO_2), nitrate (NO_3), phosphorus (PO_4), total suspended solids (TSS), total dissolved solids (TDS) by using three runs discharges (0.2, 0.3 and 0.4 m^3/hr.) Different results are obtained and show an increase in removal efficiency in all terms previously reported in the study.

COD Removal Performance: The MBR influent COD varies in a range of 398-601.4 mg/l in the period of experiments. Figs. (7-18) shows the COD concentration of the influent, effluent at different discharges during the experimental period. The effluent COD after 20 days was

always lower than 130 mg/l and the average removal was 75 %. The results show that removal efficiency of COD is decreased with increased flow rate.

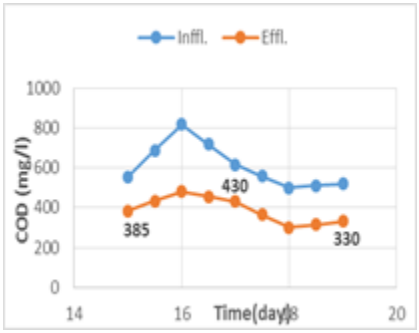

Fig.(7) The variation of COD concentrations between Influent and effluent at Q=0.4m3/hr (broken bricks)

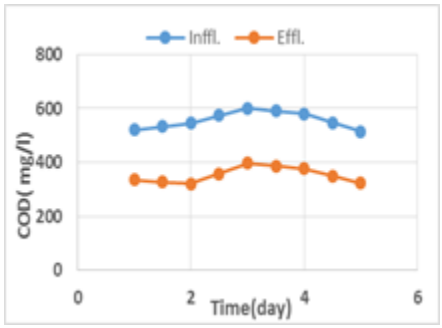

Fig.(8) The variation of COD concentrations between Influent and different at Q=0.3 m3/hr (broken bricks)

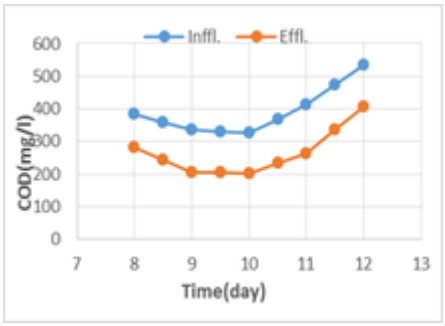

Fig.(9) The variation of COD concentrations between Influent and different at Q=0.2 m3/hr (broken bricks)

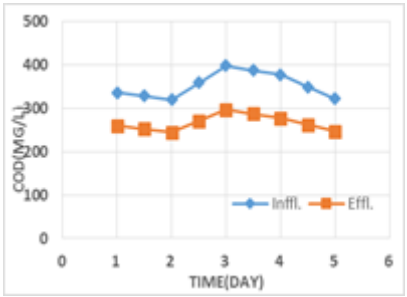

Fig.(10) The variation of COD concentrations between Influent and different at Q=0.4 m3/hr for therm.

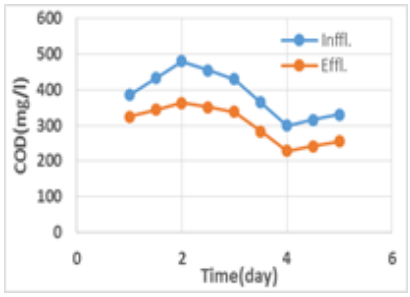

Fig. (11) The variation of COD concentrations between Influent and different at Q=0.3 m3/hr for therm.

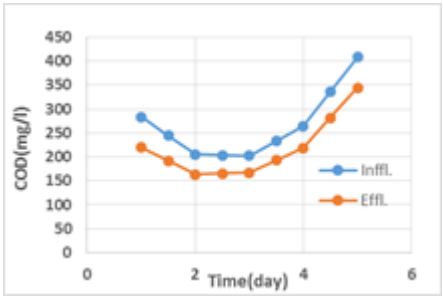

Fig. (12) The variation of COD concentrations between Influent and different at Q=0.2 m3/hr for therm.

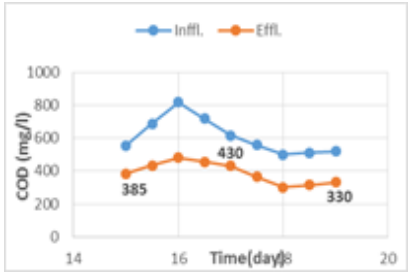

Fig. (13) The variation of COD concentrations between Influent and different at Q=0.4 m3/hr (AC)

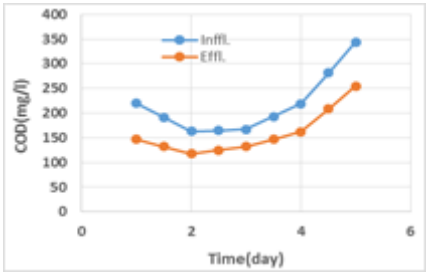

Fig. (14) The variation of COD concentrations Between Influent and different at Q=0.3 m3/hr (AC)

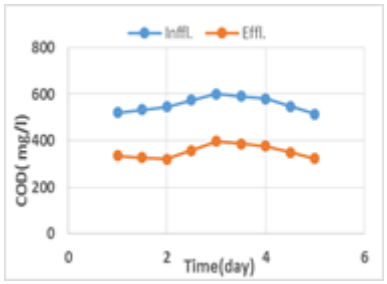

Fig.(15) The variation of COD concentrations Between Influent and different at Q=0.2 m3/hr (AC)

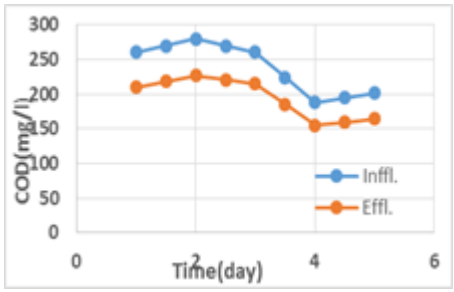

Fig.(16) The variation of COD concentrations between Influent and different at Q=0.4 m3/hr (Granite)

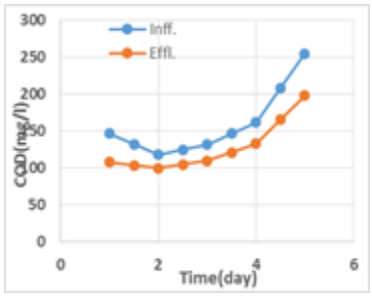

Fig.(17) The variation of COD concentrations between Influent and different at Q=0.3 m3/hr (Granite)

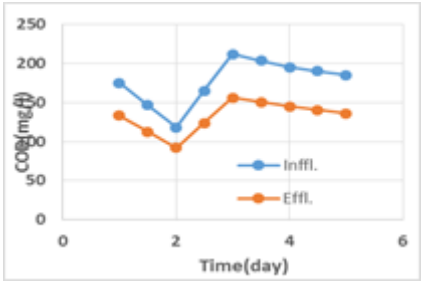

Fig.(18) The variation of COD concentrations between Influent and different at Q=0.2 m3/hr (Granite)

These results are summarized in table (1).

Table 1 COD removal efficiency for different Q

Parameter COD (mg/l) Average for	**Q**	Q=0.4 m^3/hr	Q=0.3 m^3/hr	Q=0.2 m^3/hr
Broken bricks	Influent	601.4	398	553
	Effluent	385	272.4	350.6
	Re %	29.8	31.5	36.6
Thermo-stone	Influent	385	272.4	350.6
	Effluent	301.8	208.8	265.2
	Re %	21.6	23.3	24.3
Activated carbon	Influent	301.8	222.6	265.2
	Effluent	237.8	162.8	177.0
	Re %	21.2	26.9	33.0
Granite	Influent	237.8	162.8	177.0
	Effluent	194.2	129.8	132.4
	Re %	18.33	20.3	25.2

Nitrogen removal: The concentration influent and effluent value of NH_4-N were varied between 0.326 to 0.252 mg/L and 0.094 – 0.083 mg/L, respectively (25% of NH4-N was oxidized) is shown in Figs. (19-30). this indicates that the nitrification process which oxidized the influent ammonia that entered in the aerobic reactor into nitrate. While the effluent concentration of NO3-N and NO2-N was 0.072 and 0.026 mg/L, respectively, giving effluent concentration of 0.052 and 0.023 mg/L respectively. Table (2) indicates removal efficiency for different dischrges.

Table 2 Nitrogen removal efficiency for different Q

Para-meter	Q	0.4 m^3/hr				0.3 m^3/hr				0.2 m^3/hr			
		break	Thermo-stone	AC	granite	break	Thermo-stone	AC	granite	break	Thermo-stone	AC	granite
NH_4-N (mg/l) Avg.	Infl.	0.252	0.154	0.126	0.116	0.192	0.116	0.09	0.07	0.326	0.124	0.146	0.111
	Effl.	0.154	0.126	0.116	0.094	0.116	0.09	0.07	0.054	0.194	0.146	0.111	0.083
	Re %	38.9	18.2	8.2	18.95	39.5	22.4	22.4	22.9	40.5	24.7	24.0	25.2
NO_3-N (mg/l)	Infl.	0.15	0.116	0.1	0.081	0.116	0.092	0.074	0.060	0.166	0.124	0.104	0.086
	Effl.	0.116	0.1	0.081	0.069	0.092	0.074	0.060	0.052	0.124	0.104	0.086	0.072
NO_2-N (mg/l)	Infl.	0.061	0.038	0.033	0.029	0.052	0.040	0.032	0.028	0.064	0.042	0.034	0.030
	Effl.	0.038	0.033	0.029	0.028	0.040	0.032	0.028	0.023	0.042	0.034	0.030	0.026

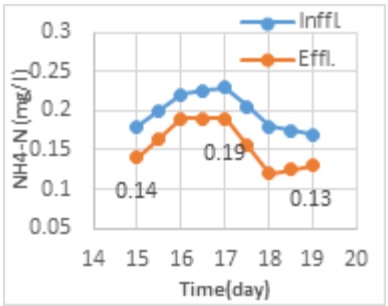

Fig. (19) Influent and effluent NH4-N concentrations variation with time at Q=0.4 m3/hr (broken bricks)

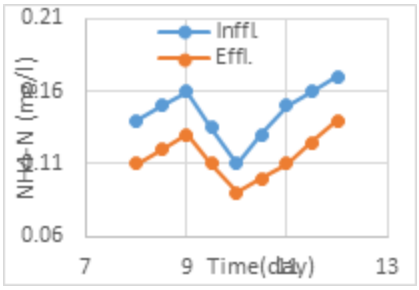

Fig. (20) Influent and effluent NH4-N conc. variation with time at Q=0.3 m3/hr (broken bricks)

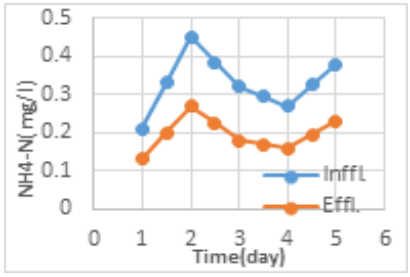

Fig. (21) Influent and effluent NH4-N conc variation with time at Q=0.2 m3/hr (broken bricks)

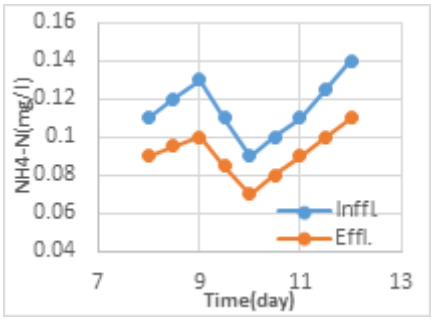

Fig. (22) Influent and effluent NH4-N conc. variation with time at Q=0.3 m3/hr (for thermostone)

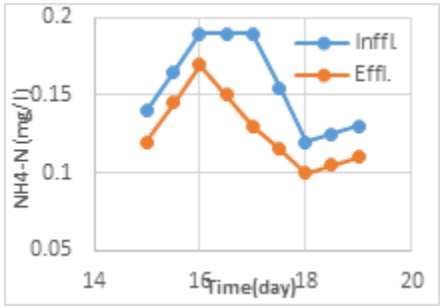

Fig. (23) Influent and effluent NH4-N conc. variation with time at Q=0.4 m3/hr (for thermostone)

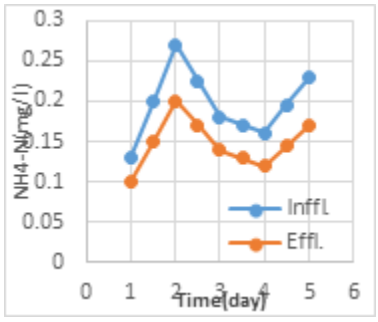

Fig. (24) Influent and effluent NH4-N conc. variation with time at Q=0.2 m3/hr (for thermostone)

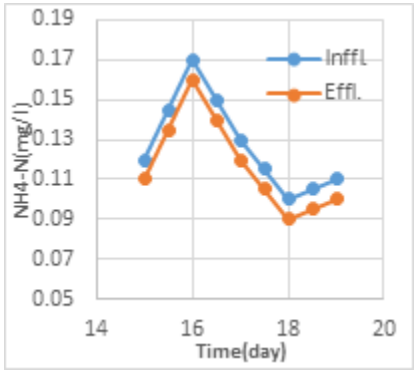

Fig. (25). Influent and effluent NH4-N conce. Variation with time Q=0.4 m3/hr (AC)

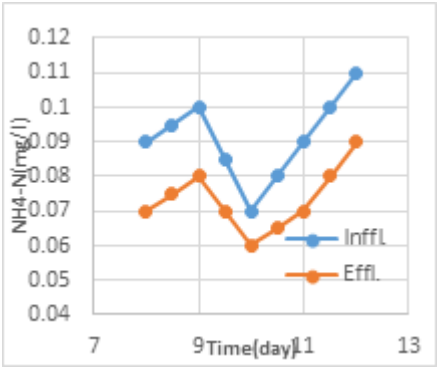

Fig. (26) Influent and effluent NH4-N conc. variation with time at Q=0.3 m3/hr (AC)

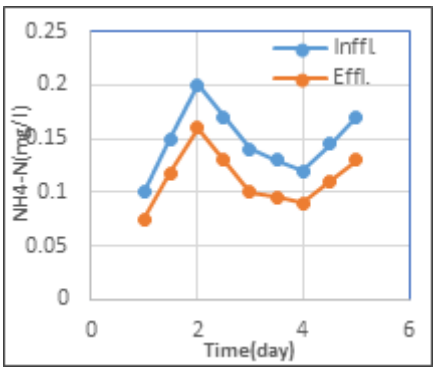

Fig. (27) Influent and effluent NH4-N conc. variation with time at Q=0.2 m3/hr (AC)

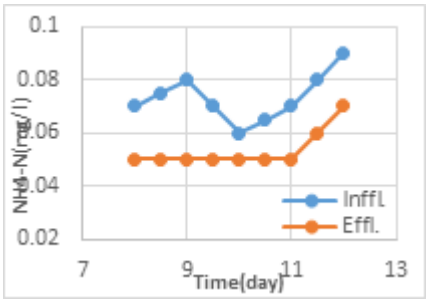

Fig. (28) Influent and effluent NH4-N conc. variation with time at Q=0.2 m3/hr (granite)

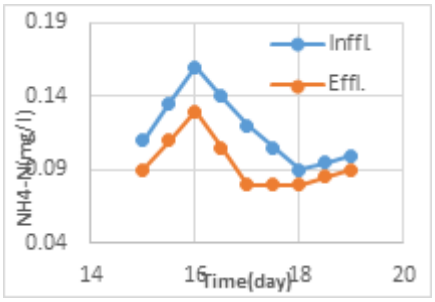

Fig. (29) Influent and effluent NH4-N conc. variation with time at Q=0.3 m3/hr (granite)

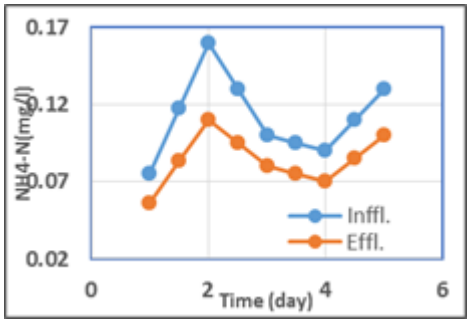

Fig. (30) Influent and effluent NH4-N conc. variation with time at Q=0.4 m3/hr (granite)

4. CONCLUSIONS

Based on the result that obtained from the study, the following conclusions can be drawn:

1. The results show that using dosage of lime (CaO) and alum, the removal efficiency of heavy metals (Mn^{+2}, Cu^{+2}, Zn^{+2} and Fe^{+2}) was improved.
2. The efficiency of removal can arrange as (Mn^{+2}> Cu^{+2} > Zn^{+2} > Fe^{+2}) when using dosage 20 mg/5L of CaO and are arranged as (Cu^{+2}> Fe^{+2} >Zn^{+2} > Mn^{+2}) when using dosage 40 mg/5L and are arranged as (Zn^{+2} >Mn^{+2}>Cu^{+2} >Fe^{+2}) when using dosage 80 mg/5L of CaO. While the removal efficiency are arranged as (Cu^{+2} > Zn^{+2} >Mn^{+2}>Fe^{+2}) when using dosage 10mg of alum per 5 liters.
3. Removal efficiency via using porous media of broken bricks is greater than that via using other porous media (activated carbon, granite, and thermo-stone).
4. Results of continuous measurements and monitoring indicate that removal efficiencies of treatment with lime addition are more efficient at removing organic and inorganic matter than treatment with alum addition.

REFERENCES

[1] Cicek, N. (2003). "A review of membrane bioreactors and their potential application in the treatment of agricultural wastewater" Canadian Biosystems Engineering, 45, p 6.37-6.49.

[2] Ekhaise, F. and B. Omavwoya, (2008). Influence of Hospital Wastewater Discharged from University of Benin Teaching Hospital (UBTH), Benin City on its Receiving Environment. American-Eurasian J. Agric. and Environ. Sci., 4(4): 484-488.

[3] Jolibois, B. and M. Guerbet1, (2005). Hospital Wastewater Genotoxicity. Ann. Occup. Hyg. pp: 1-8. Chin KK, Wong KK. (1981), Palm oil refinery wastes treatment. Water Res; 15:1087.

[4] Kajitvichyanukul, P. and N. Suntronvipart, (2006). Evaluation of biodegradability and oxidation degree of hospital wastewater using photo-Fenton process as the pretreatment method. Journal of Hazardous Materials, B, 138: 384-391.

[5] Kadhim Naief Kadhim and Ahmed H. (Experimental Study of Magnetization Effect on Ground Water Properties). Jordan Journal of Civil Engineering, Volume 12, No. 2, 2018

[6] Metcalf and Eddy, (1991). "Wastewater Engineering. Treatment, Disposal, Reuse". 3rd edition, McGraw-Hill Int. Ed., Singapore.

[7] Naghizadeh, A., Mahvi, A. H., Vaezi, F., Naddafi, K., (2008). "Evaluation of hollow fiber membrane bioreactor efficiency for municipal wastewater treatment", Iran. J. Environ. Health. Sci. Eng., Vol. 5, No. 4, pp. 257-268.

[8] Qiaoling, L., Z. Yufen, C. Lingyun and Z. Xiang, (2010). Application of MBR for hospital wastewater treatment in China. Desalination, 250: 605-608.

[9] Sabalowsky, A.R. (1999). An investigation of the feasibility of nitrification and denitrification of a complex industrial wastewater with high seasonal temperature, Master thesis, Virginia Polytechnic Institute and State University, (1999).

[10] Van Dijk, L. and Roncken, G. (1997). Membrane bioreactors for wastewater treatment: the state of the art and new developments. Water Science and Technology 35(10), 35–41.

[11] Xianghua, W., D. Hangjiu, H. Xia and L. Ruopeng, (2004). Treatment of hospital wastewater using a submerged membrane bioreactor. Process Biochemistry, 39: 1427-1431.