Role of Biofilm on Granular Wood Charcoal in Enhancing Primary Wastewater Treatment for Irrigation Reuse

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ABSTRACT

Increasing water scarcity necessitates safe reuse to narrow the gap between demand and supply of irrigation water. This study investigated the role of biofilm on two different particle sizes (0.5-1mm and 1-2 mm) of granular wood charcoal (GWC) in enhancing the effluent quality of primary wastewater treatment to develop a cost-effective wastewater treatment method. Granular wood charcoal (GWC) was characterized by surface area, pore volume, fourier transforminfrared (FTIR) and scanning electronmicroscopy (SEM) to demonstrate the physicochemical properties. Bench scale column experiments were conducted for the two different particle sizes column (1), 0.5 – 1mm, and column (2), 1-2 mm, with an average flow rate of 10 cm^3/min and 6.54 h as average empty bed contact time (EBCT). GWC biofilm formation was confirmed by SEM examination in voids and channels and on surfaces of the GWC. The role of biofilm on the GWC has demonstrated consistently removal organic matter as chemical oxygen demand (COD). COD was monitored with time and extended to 96 day to examine the performance of the biofilter column. COD tended to decrease with time for both columns. Slight increase in the removal efficiency of COD with time in column1 (91.36 %) in comparison to that of column2 (87.69 %) was observed. Such in crease could be due to difference in surface area of the two particles size. Effluent can be characterized as slight to moderate degree of guideline restriction in irrigation reuse for salinity and sodicity for both columns. For safe irrigation reuse, addition disinfection step may be needed even with obtained results of *Escherichia coli (E. coli)* removal efficiency more than 99%. The results indicated that biofilter process can be an efficient option for upgrading the primary wastewater treatment method.

Key words: Granular wood charcoal, biofilm, Wastewater, Chemical Oxygen Demand

INTRODUCTION

Egypt is facing severe water scarcity combined with the enormous challenges of population growth, and increasing food demand. It is imperative to reclaim wastewater to benefit public health, water pollution control, and irrigation reuse, especially with limited water resources. Water reuse has been dubbed as the greatest challenge of the 21st century (Metcalf and Eddy, 2003); and a paradigm shift from effluent disposal to water reuse is needed. In Egypt, the treated wastewater amounts about 3 billion m^3/year, mostly discharged to drains; with about 0.8 billion m^3/year disposed of to lakes, sea, and desert.The total quantity of reused treated wastewater in Egypt is estimated to be about 0.3 BCM in 2013(MWRI, 2014).The main impediment to irrigation reuse is that the treated effluents do not meet the stringent standards for disposal into irrigation canals.

A cost-effective approach is needed to clean large volumes of wastewater often discharged into surface waters (Jowett and McMaster, 1995; Agbanobi, 1999). Conventional wastewater treatment consists of amixture of physical, chemical, and biological processes and performances to remove solids, organic matter and nutrients from wastewater. In primary treatment, a physical operation, usually sedimentation is used to remove the floating and settleable materials found in wastewater. However, resulting achieved in primary treatment is the removal of portion of the suspended solids (50 to 70 percent) and organic matter (25 to 40 percent) from the wastewater (Masters, 1998; Metcalf and Eddy, 2003).

In view of the economic reality, it is crucial to develop a simple and cost-effective system to reclaim wastewater for pollution control and irrigation reuse especially in rural areas. One of the options for enhancing primary treatment is biofiltration technology. Biofiltration can be defined as" a biological pollution control technology that uses active microbial populations attached to a solid media to degrade pollutant" (Swanson and Loehr, 1997). Biofiltration is one of the most important separation processes that can be used to remove organic pollutants from air, water, and wastewater (Chaudhary et.al, 2003; Emelko et. al, 2006). The process relies on the mechanisms of adsorption, biodegradation, convection and diffusion (Swanson and Loehr, 1997; Liang et al., 2007). Contact time, mass loading, surface loading and removal efficiency are important design and performance parameters. Also, media properties, temperature, pH, toxicity, microorganisms, and acclimation are factors requiring careful consideration in the design and operation of the biofilter (Swanson and Loehr, 1997).

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Selecting the proper biofilter medium is an important step toward developing a successful biofiltration operation. Absorbent filter particles should combine, a light weight aggregate, low-density granules, large pore volumes with high surface areas, economical cost and is therefore an ideal growing medium. The physical properties of solid particles impose natural limits to microbial attachment means, contact time, aeration and therefore limit treatment performance. The performance of a biofilter column relies on the biomass attached to the media. The biomass development and its maintenance on surface of the media, on the other hand, relay generally on surface characteristics of the filter media itself (Chaudhary, 2003).Charcoal adsorbent has long being known as one of the most effective technologies at removing natural organic matter from water and wastewater. The good suitability recognized because of its large specific surface area and well developed porous structure, which provide a high sorption capacity towards organic molecules (Putz et al., 2005; Emelko et al., 2006; Seredyńska-Sobecka et.al, 2006; Aktaş and Çeçen, 2007; Buchanan et al., 2008; Simpson, 2008).

Charcoal surface can be occupied by microorganisms which may finally create active biofilm (Kasuga et al., 2007; Huang and Chen, 2004; Velten et al., 2011). Biomasses attached onto the media as biofilm oxidize most of the organics and utilize it as an energy supply and carbon source (Chaudhary et al., 2003). Biofilm composition and activity are two important parameters for the successful process and manage of fixed film processes in water and wastewater treatment. The biofilm composition is a function of physico-chemical conditions, as well as cell morphology (Lazarova and Manem, 1995). Derlon et al. (2013) reported that the increase of the soluble fraction in organic substrate increased biofilm accumulation on membrane surface. However, the rate and quantity of biofilm structure depends on a lot of factors including water quality, type of filter media, hydrauliccircumstances, temperature, backwashing management, among others(Zhu et al., 2010; Urfer and Huck, 2001;Velten et al., 2011).

The limitations associated with decreasing the efficiency of the biofilm in biofilter columns are clogging of biofilters and saturation of packing media with organic matter overtime(considered to be ‘‘exhausted’’ (Scholz and Martin, 1997)). Applying periodic backwashes will prevent the progressive irreversible clogging of biofilter columns and recovery of the hydraulic performance and ensure long-term performance of the biofilters(Zhuet al., 2010; Zheng et al., 2011; Putz et al., 2005).Since, backwashing does not get rid of organic matter adsorbed to the granular particles; the exhausted media should be replaced or thermally regenerated in order to restore its efficient filtering capabilities (Ghosh et al., 1999).The study did not extend to reach the stage of column clogging or need to regenerate the packing media (granular wood charcoal).

The study comprised of monitoring and evaluating the role of biofilm developed on GWC in enhancing the quality of primary wastewater treatment using COD as an indicator. In order to achieve this goal, two bench scale columns were conducted and extended to 96 day. Evaluation of the effluent water quality for irrigation reuse potential was studied with assessed the effects of two particles size (0.5-1and 1-2mm) of GWC as packing media.

MATERIALS AND METHODS

Characterization of charcoal

Commercial wood charcoal was used in the study; grinded and sieved to two target particle size (0.5-1and 1-2 mm), then stored in plastic jars. Total carbon, nitrogen and hydrogen content in charcoal were 71.33%, 0.3%, and 2.51%, respectively, and were determined by CHNS analyzer (Saleh et. al., 2016). Some characteristics of GWC were recorded in Table 1.

GWC surface area measurements were obtained from N_2 adsorption isotherms at 77 K using a gas sorption analyzer (Beckman Coulter SA(TM) 3100 Surface Area and Pore Size Analyzer). The samples were outgassed at 473 K under vacuum for 6 h previous to conducting adsorption measurements. Specific surface areas were obtained from Brunauer–Emmett–Teller (BET) adsorption isotherms equation. The Barrett–Joyner–Halenda (BJH) method was used to determine the pore size distribution from the N_2 desorption isotherms (Nader, 2015).

The Fourier transform-infrared (FT-IR) spectra were recorded the range 400–4,000 cm^{-1}using infrared spectrophotometer; model FT/IR-5300, JASCO Corporation, Japan.

Table1. Some characteristics of GWC used in this study

Particle size mm	pH (1:2.5 H_2O)	Total $CaCO_3$ %	Surface area m^2 /g	Total pore volume mm^3/ g
0.5 - 1	8.35	4.02	5.349	0.0120
1 - 2			2.080	0.0088

A small amount of powder charcoal sample was amounted on a potassium bromide (KBr) disc which had been previously scanned as a background in the FT-IR analysis.

Scanning electron microscopy (SEM) was performed by using a Jeol JSM-5300 scanning electron microscope and was operated between 15 and 20kV. Before analysis, samples were gold-coated in a sputter-coating unit (JFC-1100 E). The micrographs were recorded at various magnification scales using photographic techniques to characterize the morphology of charcoal which were dried overnight at approximately 105 ^{o}C under vacuum before SEM analysis. Also, SEM images for GWC samples with biofilm were examined with various magnifications. Samples were taken from upper third of the column after 32 day of the experiment. For this purpose samples were treated with $_4F_1G$ (40% formalin and 25% glutaraldehyde) for 24 hour in order to fixthe biofilm culture. After fixation, samples dehydrated at 4^{o}C through a graded series of ethanol (30, 50, 70 % and absolute) three times for 10 min for each concentration.

Column set-up and operation

Laboratory experiment was conducted using PVC columns (1m length, 10 cm inner diameter) packed with 50 cm granular wood charcoal as biofiltration media (Fig. 1-a). Granular wood charcoal was packed in the column with density 0.48 and 0.41 g/cm3 for particle size 0.5 –1mm(column 1)and 1 - 2mm(column 2), respectively. Ten cm layer of crushed and washed stones were placed on top and at the bottom of the columnsin order to improve influent distribution and effluent drain. Columns were loaded discontinuously during experiment time at flow rate 10cm^3/ min.Wastewater feeds were obtained from primary treatment effluent of Alexandria East treatment plant (AETP). Some characteristics of water taken from AETP, used for feeding of biofiltration columns, are presented in Table (2).

Table 2. Characteristics of feeding wastewater

Parameter	Concentration range
pH	7.31 -7.92
EC, dS/m	2.67-2.93
DO, mg/L	0
COD, mg/L	68.2 – 229.13
E. coli, CFU/ 100ml	12x 10^5 – 15x10^5

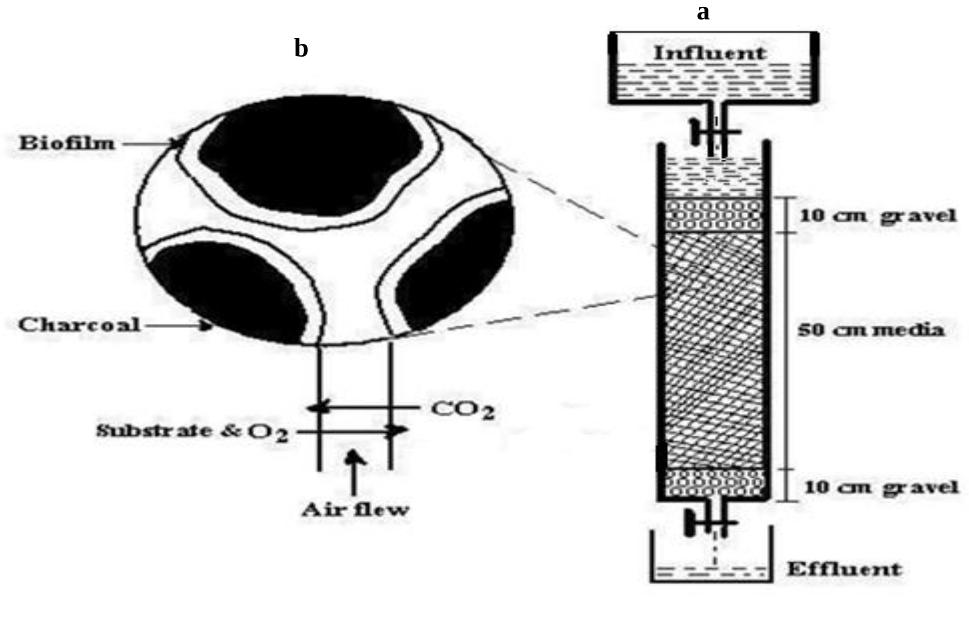


Fig. 1. Schematic of laboratory experiment column

Hydrodynamic parameters are important in design and operation biofilter column. A constant water head (approx. 20 cm) was used above the surface of the biofilter column to control the flow rate as illustrated in Figure (1-a). The flow rate was 10cm^3/min, corresponded to an average hydraulic loading rate of 7.6cm/h. The contact time, usually expressed as empty bed contact time (EBCT), is a key design and operating parameter of a biofilter. Sufficient EBCT is necessary to allow transport and degradation of the pollutant to occur, (Chaudhary et al., 2003). EBCT is simplified, relative measure of chemical residence time in the biofilter column. It would be calculated from equation (1) (Swanson and Loehr, 1997):

$$EBCT = \frac{V}{Q} \qquad (1)$$

Where V is the biofilter volume (cm^3) and Q is influent flow rate (cm^3/min).For the two columns, the average EBCT was 6.54h.

Analytical methods

Essentially, the methods used were those described in the Standard Methods (STM, 1995). Influent and effluent water of laboratory experiment column were characterized by pH, electrical conductivity (EC), soluble cation and anion, dissolved oxygen (DO), Chemical Oxygen Demand (COD) and *Escherichia coli*. The oxygen equivalent of organic matter that can be oxidized (COD) is measured by a strong chemical oxidizing agent (potassium dichromate) in an acidic medium, was periodically monitored to evaluate the removal of organic matter by GWC bioflim in the biofilter column. The closed Reflux method that described in the Standard Methods (STM 5220C, 1995) was used. Vessels containing acidified samples with oxidizing agent heated to 150°C and reflux (using HACH COD Reactor) for 2 h. After cooling to room temperature, samples titrated with ferrous ammonium sulfate. Removal efficiency is the operating parameter that often used to judge the success of the biofliter, and likely to be of paramount interest to regulator. Removal efficiency (Re) percentage would be calculated as following:

$$Re\ (\%) = \frac{(C_i - C_e)}{C_i} X\ 100 \qquad (2)$$

Where C_i, is the influent concentration (mg/L) and C_e is the effluent concentration (mg/L).

DO was determined by Winkler iodometric titrimetric method and its azide modification (STM 4500-O/C). The pH and EC values were determined using a glass electrode and conductivity cell (Rhoades, 1996; Thomas, 1996). Compleximetric EDTA titration was employed for determining calcium and magnesium simultaneously and individually (Lanyon and Heald, 1982). Sodium and potassium were determined by flame photometer. The sodium adsorption ratios (SAR) were calculated as:

$$SAR = [Na^+] / [Ca^{2+} + Mg^{2+}]^{1/2} \qquad (3)$$

where Na^+, Ca^{2+} and Mg^{2+} represent millimolar concentrations (mmol L^{-1}) of respective ions (Essington, 2004).

E. coli enumeration conducted to ensure that water was microbiologically safe at the end of the experiments. *E. coli* is recommended as an indicator of the potential presence of pathogens (Benham and Zeckoski, 2005; Blaustein et al., 2013) and used as disinfection efficacy for wastewater treatment (Elmund et al., 1999). Oxoid MacConkey Agar No.3 medium was used for enumerating the lactose fermenter *E. coli*, appearing as pink colonies. *E. coli* concentrations were determined by inoculating directly onto the surface of MacConkey Agar medium. Inoculated plates were incubated aerobically for 24 hours at temperature of 40 ±1°C. Culturable *E. coli* were counted by the plate count technique as colony-forming units (CFU) per 100ml (Guber et al. 2005 and El Refaey, 2008).

Statistical analyses include means for different analytical parameters and correlation coefficients between effluent and influent COD and its removal efficiency with time were estimated.

RESULTS AND DISCUSSION

Characterization of GWC

Surface area and pore analysis

The BET technique is the most common method for determining the surface area of powders and porous materials due to its simplicity and reasonable forecasts (Giles &Trivedi, 1969; Girgis et al., 2011). Figure (2) presents N_2-adsorption isotherms for the studied GWC with particle size 0.5-1mm and 1-2mm. The N_2 adsorbed per gram was plotted versus the relative vapor pressure (P/Po) of N_2 and exhibiting a smoothed lap rising up at high relative pressures with varyingde grees of slope. This revealed a mixed porosity nature (micro-/mesoporous).The term “apparent” refers to the well-known limitation of the BET N_2multi-layer adsorption model in micropores and to the limited accessibility of N_2 molecules to narrow micropores (Cazorla- Amoróset al., 1998 and Gibert et.al, 2013). Obviously, the amount of adsorbed N_2 at relative pressures (Ps/Po) increased continuously, with higher values in 0.5-1 mm compared with 1-2 mm particle size (Figure 2). Therefore, the apparent specific surface area of 0.5-1 and 1-2 mm particle sizes were 5.349 and 2.080 m^2 /g, respectively due to different in particle size (Table 1). Total pore volume of 0.5-1 mm particle size (0.0120 mm^3/ g) was relatively higher than 1-2 mm particle size (0.0088 mm^3/ g).

The International Union of Pure and Applied Chemistry (IUPAC) categorized the pore size mainly into three types: micropore (poresize <2 nm), mesopore (2-50 nm), and macropore (poresize >50 nm) (Williams and Reed, 2006). Desorption BJH pore size distribution for the two particles size (0.5 -1 mm and 1 – 2 mm) of GWC were identified in Table (3). Pore size distribution in 0.5 -1 mm was similar to 1 – 2 mm except in the range less than 6 nm. Whereas, the pore size distribution that related to microporous formation in 0.5 -1 mm particle (21.02%) was higher than 1-2 mm particle size (15.22%). Micropores contribute mainly to surface area, while macropores contribute as a channel to micropore surfaces (Yahya et. al., 2015).

FTIR analysis

FTIR analysis was used to determine the availability of certain surface functional groups as part of the structure of any sorbents. The FTIR spectra of GWC are presented in Fig. (3). The FTIR spectrum of GWC exhibits more intensive bands at the following wavenumbers: 3419.56, 1599.84, 1438.80, 1072.35, 781.12 and 510.14 cm^{-1}, corresponds mainly to the presence O–H (hydroxyl), asymmetric C-H and aromatic C-C O-O-H bend (carboxylic acids), C-N stretch (aliphatic amines), C-H aromatic and alkyl halide stretch (e.g, C-Cl), respectively (Saleh et.al, 2015 and El Refaey, 2016).

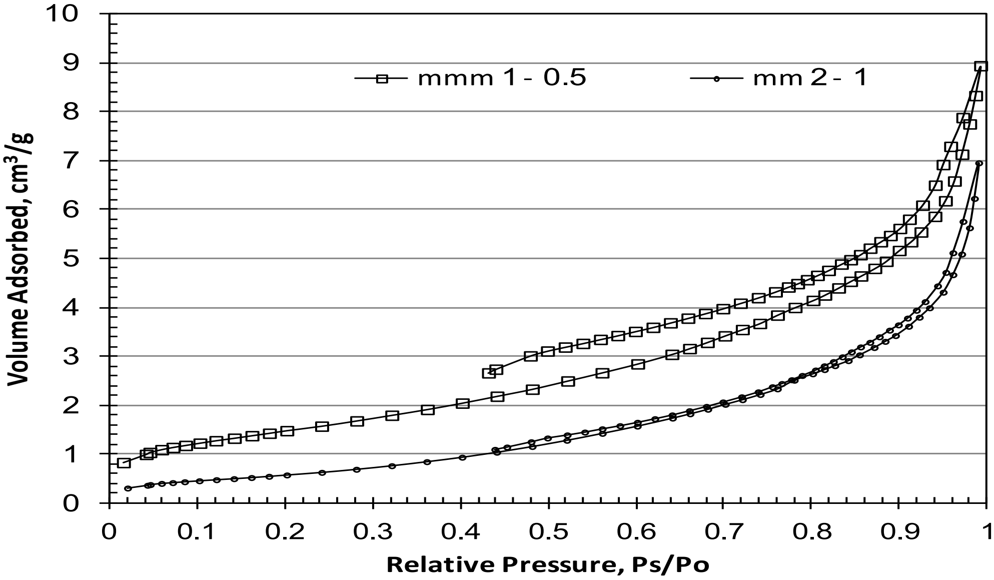


Fig. 2. N_2-adsorption isotherms of GWC with two different particle size(0.5-1 and 1-2mm)

Table 3. Desorption Barrett-Joyner-Halenda (BJH) pore size distribution of two particle size (0.5 -1 and 1 – 2 mm) of GWC used in the study

Pore diameter range nm	Pore volume			
	(0.5 - 1mm)		(1 - 2 mm)	
	ml / g	%	ml /g	%
> 80	0.00104	9.20	0.00135	12.95
20 - 80	0.00447	39.44	0.00411	39.29
16 - 20	0.00076	6.71	0.00071	6.75
12 - 16	0.00071	6.24	0.00074	7.10
10 - 12	0.00060	5.33	0.00062	5.95
8 - 10	0.00052	4.56	0.00053	5.05
6 - 8	0.00085	7.51	0.00080	7.63
< 6	0.00238	21.02	0.00159	15.22

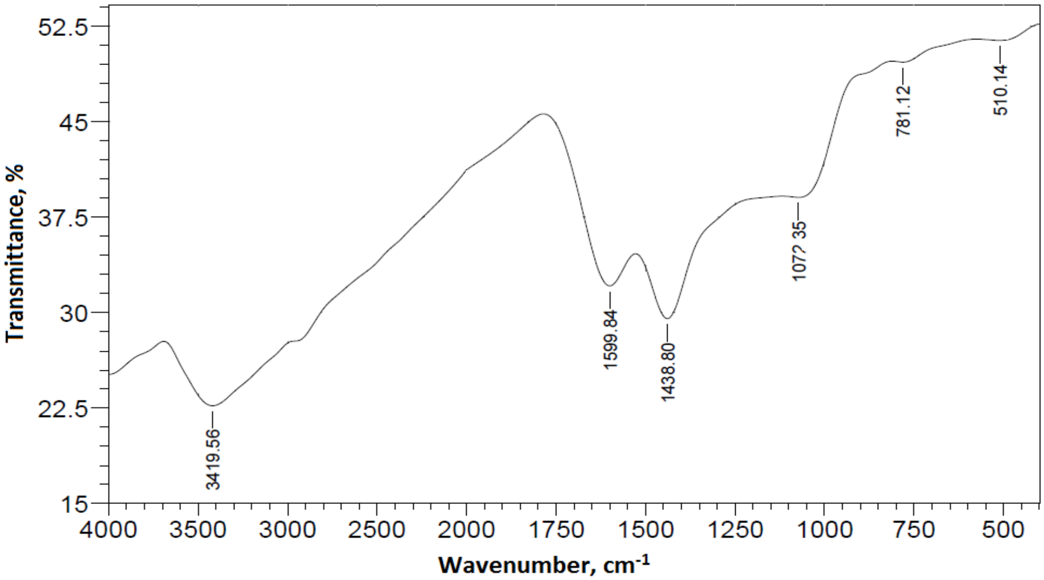


Fig. 3. FTIR spectra of the granular wood charcoal (GWC)

Scanning electron microscopy (SEM)

The surface structure of porous GWC was characterized by SEM (Fig 4). SEM produces an actual clear image, which is useful for obtaining the topographical and elemental information of the solids with a virtually large depth of field, allowing different specimen parts to stay in focus at a time.(Gupta and Rastogi, 2008). However, the SEM technique also has limitations on its lowest detectable particle size. Porous structure is a factor that determines to a great extent both the rate and degree of bioregeneration in biofilter system (Klimenko et al., 2002). Actual porous structure of GWC was observed in SEM (Fig 4 a and b). Also, GWC biofilm was confirmed by SEM examination, which revealed a complex morphological diversity composed of diverse of substrates and microorganisms in voids and channels of GWC(Fig. 4 c and d) and on irregular surfaces of the GWC (Fig. 4 e and f). Also, organic filaments closely similar to fungal hyphae were found to be a common feature through out the GWC surface (Fig. 4 g and h).

COD removal and biofilm efficiency

Two biofilter column were characterized by start-up period of 96 days for column (1) and column (2) with changes of organic load as chemical oxygen demand (COD) (Fig.5A and B). Concentration of effluent COD has been fluctuated with every new batch of influent, giving correlated and significant relationship between them (Fig. 6). COD tended to decrease to less than 13, and 16 mg/L for column (1) and (2), respectively (Fig. 5-A and B). As well, the surface area, irregular creviced, porous particle shape (as seen in Fig. 4-a and b) and slightly electro-positively charged of GWC can absorb specific water contaminates such as dissolved organic matter (Scholz and Martin, 1997). Dussert and Van Stone (1994) and Rhim (2006) reported that during the transit through the percolator, the wastewater is purified by processes of physical adsorption, concurrent adsorption/biological degradation and biological degradation, respectively. Simpson (2008) defined the process of breaking down and removing adsorbed substances by the attached microbial as ‘biodegradation’’.Microorganism’s masses attached onto the GWC as biofilm oxidize most of the organics and use it as an energy supply and carbon source, as illustrated in Fig. (1-b).The processes started with an acclimation period. Acclimation period is the biofilter start-up time during which removal efficiencies progressively increase until they achieve a sustained maximum value. This phenomenon occurs and it is often measured as the time necessary to reach 40 - 90% or more of some maximum removal capacity (Swanson and Loehr, 1997;Rhim, 2006).As shown in figures (5- A and -B) with smoothing, removal percent tends to significantly increase with time to reach 91.36and 87.69% for column (1) and (2)after 96 day, respectively. The slight increase in the removal efficiency in column (1) suggests that it can be explained by high surface area of particle size for column (1) than in column (2). Liang et. al.(2007) suggested that decreasing of the particle size causes in more substrate diffusing across the biofilm, and increases the ratio of adsorption rather than biodegradation.

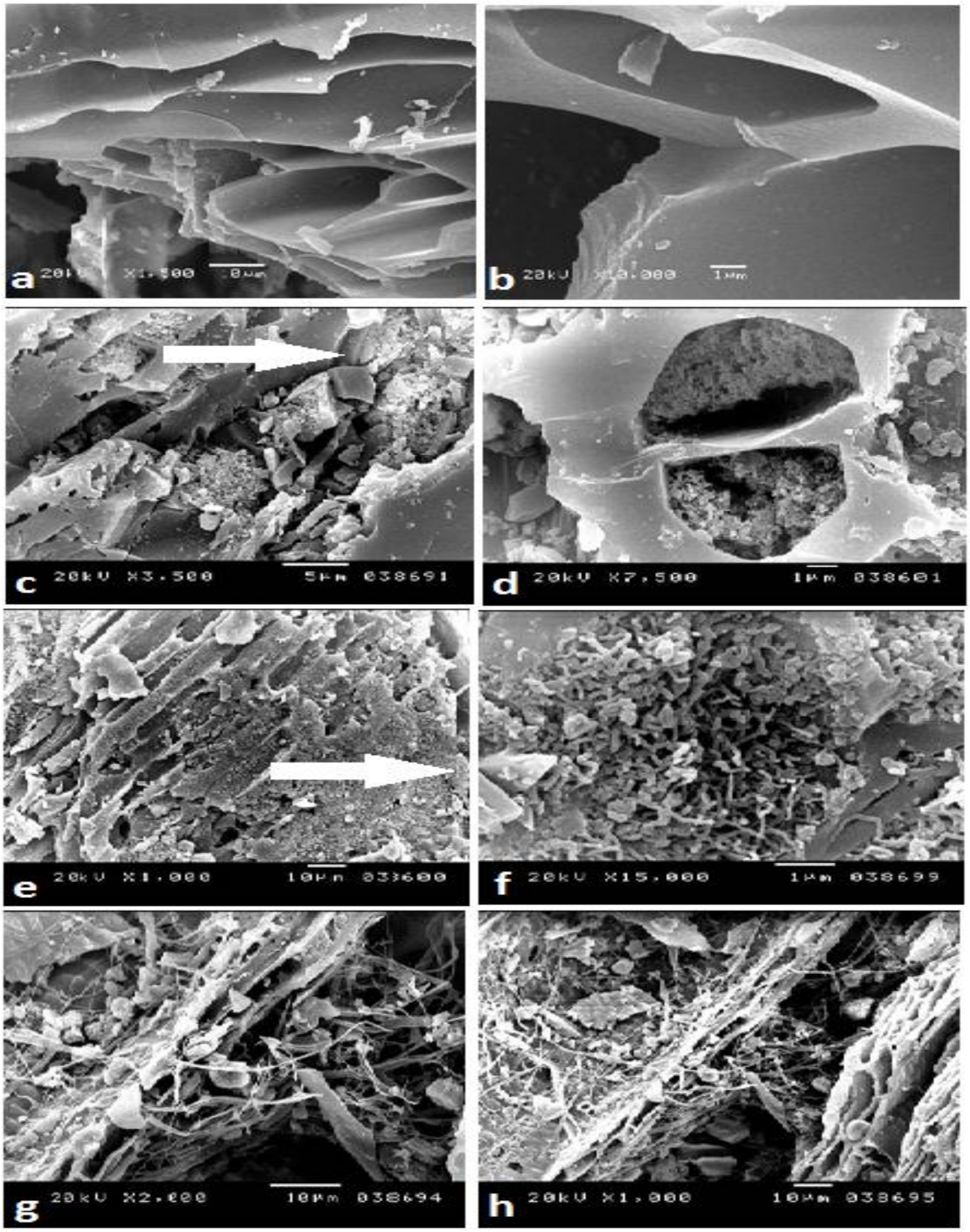
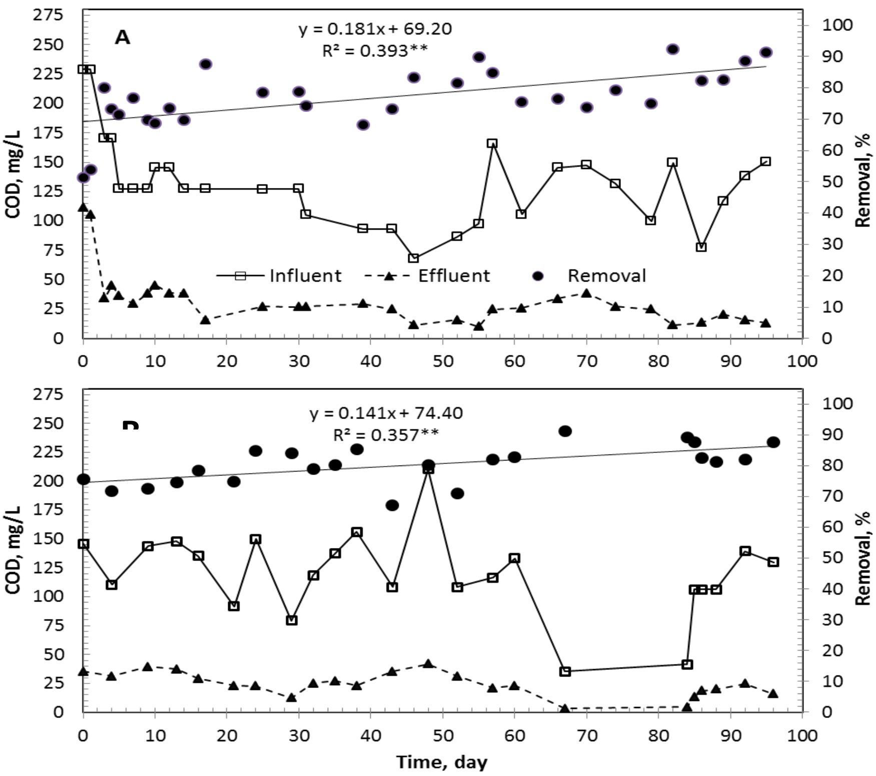
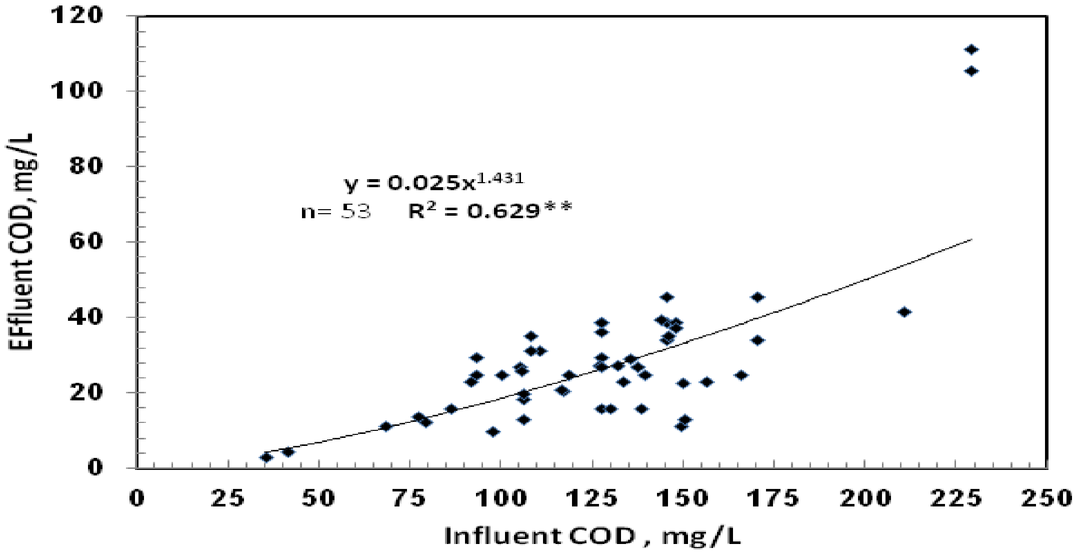


Fig. 4. SEM imagesshowing porous structure of granular wood charcoal (a and b), diverse of substrates and microorganisms in the voids of the porous (c and d), on irregular surface (e and f) and (g and h) organic filaments closely similar to fungal hyphae observed on a GAC sample collected from the upper third of the column after 32 days of the experiment



**: significant at the 0.01 probability level

Fig. 5. Changes in chemical oxygen demand (COD) and removal efficiency of the influent and effluent for column (1) and (2) with time



**: significant at the 0.01 probability level

Fig. 6. Relationship between effluent and influent of the biofilter columns expressed as chemical oxygen demand (COD)

Evaluation of effluent qualityand irrigation reuse potential

Table (4) shows effluent characteristics for column (1) and (2) with two different particle size 0.5-1 mm and 1-2mm, respectively. Two keys for soil and water related constraints that need to be addressed when dealing with irrigating reuse are salinity and sodicity. According to irrigation water quality guidelines by Ayers and Westcot (1985), the available effluent characteristics can be categorized as slight to moderate degree of restriction use for both columns. Wastewater reuse application usually governed by the needed to protect public health and the environment. Final effluent of COD was in acceptable level (< 60 mg/L) of the Egyptian law 48/1982, where the results were 13 and 16 mg/L for column (1) and (2), respectively. *E. coli* concentrations were15x 10^2 and 11x10^3 CFU/100ml for column (1) and (2), respectively. Although *E. coli* removal was more than 99% for both columns, slight increase in column 1 (99.86%) was found than in column 2 (99.20), but still beyond WHO guidelines for the use of wastewater in agriculture and aquaculture (10^3 fecal coliform (FC) 100ml^{-1}). Addition disinfection step may be needed after biofiltration columns. Most rivers in Europe have mean FC counts of 10^3-10^4 100ml^{-1}, and yet there are no restrictions on the use of such water (Shuval and Fattal, 2003). More relaxed guideline of 10^4 FC 100ml^{-1} has been suggested (Carr et al., 2004), but should be supplemented by other health protection measures. Thus safe irrigation reuse of biofiltration system can cost- effectively attained through the acceptable level of risks developed in practices.

Table 4. Final Effluent characteristics of column (1) and (2) with two different particle size 0.5-1 and 1-2mm, respectively

parameter	Effluent		
	unit	column (1)	column (2)
pH		8.05	8.09
EC	dS/m	3.13	3.17
DO	mg/L	2.70	2.50
COD	mg/L	13.00	16.00
Na^+	mg/L	16.52	16.96
K^+	meq/L	2.05	2.18
Ca^{++}	meq/L	3.00	3.25
Mg^{++}	meq/L	5.77	6.60
$HCO^{=}_3$	meq/L	5.75	5.80
Cl^-	meq/L	20.00	20.00
SAR		7.89	7.64
E. coli	CFU/ 100ml	15x 10^2	11x10^3

CONCLUSION

The study investigated the effect of biofilm developed on two different particle sizes (0.5-1mm column (1) and 1-2 mm column (2)) of granular wood charcoal in enhancing the primary wastewater treatment. SEM images confirmed that the bioflm of diverse microorganisms is found on surface, voids and channels of GWC. COD in final effluent decreased to 13, and 16 mg/L for column (1) and (2), respectively after 96 days with slight increase in the removal efficiency of column (1). Characterization with surface area and pore size distribution gave the different properties of the two particle sizes of GWC and could explain the difference in removal of organic matter. Evaluation of effluent quality and irrigation reuse potential were performed at the end of the experiments. The final effluent characteristics can be categorized as slight to moderate degree of restriction use for both columns. *E. coli* removal was more than 99% for both columns with slight increase in column 1 (99.86%) than in column 2 (99.20%), but *still beyond* WHO guidelines.Addition disinfection may be need after biofiltration columns.

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الملخص العربي

دور الاغشية الحيوية المتكونة على سطح حبيبات الفحم المصنع من الاخشاب فى تحسين المعالجة الابتدائية للمياه الصرف الصحي للاعادة الاستخدام فى الرى

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تزايد ندرة المياه يتطلب إعادة الاستخدام الآمن للمياه لتضييق الفجوة بين العرض والطلب على مياه الري. تهدف الدراسة الحالية الى التحقق من دور الغشاء الحيوى (Biofilm) المتكون على سطح حبيبات الفحم المصنع من الاخشاب (GWC) والمعده بأقطار متباينه لايجاد طريقة معالجة منخفضة التكاليف تقوم بتحسين نوعية المياه المعالجة ابتدائيا لمياه الصرف الصحى. وتم دراسة خواص حبيبات الفحم من حيث السطح النوعى وحجم المسام والتحليل الطيفي بالأشعة تحت الحمراء (FTIR) وتحت الميكروسكوب الالكترونى لتوضيح الاختلافات فى الخصائص الفيزيائية والكيميائية. أجريت تجارب اعمدة معملية معبأه بحبيبات الفحم المصنع من الاخشاب باقطار متباينه حيث ان عمود(١) اختص باقطار حبيبات ٠,٥ – ١مم وعمود(٢) اختص باقطار حبيبات١-٢ مم وتم تغذيتهم بمعدل سريان ١٠سم/ دقيقة من المياه المعالجة الابتدائى بمتوسط فترة بقاء ٦,٥٤ ساعة. وتم تتبع الاكسجين المستهلك كيميائيا(COD) للمياه الخارجة من الاعمده لفترة امتدت الى ٩٦ يوم لفحص كفائة أداء تلك الاعمده. وتم التاكد من تكون الاغشية الحيويه فى الفراغات والقنوات وسطح حبيبات الفحم وذلك بفحصها تحت الميكروسكوب الالكترونى، وتاكيد دورها من خلال استمرار ازالة المادة العضوية بدلالة قياس COD مع الوقت.حيث أظهر COD ميلا للانخفاض مع الوقت. أظهرت النتائج زيادة في كفاءة إزالة COD مع مرور الوقت في العمود (١) الى حوالى٩١,٣٦٪ والى ٨٧,٦٩٪ فى العمود (٢)، مع اقتراح بأن يكون ذلك راجع الى الاختلاف فى السطح النوعى للحجمين المستخدمين من حبيبات الفحم. وتم تقييم المياه الخارجه من عملية المعالجة، واظهرت امكانية إعادة استخدامها في الري مع وجود محاذير بسيطه الى معتدلة من حيث معايير الملوحة والصودية. ولتاكيد الاستخدام الامن فى الرى يمكن اضافة خطوة تعقيم وذلك على الرغم من توصل النتائج لقيم ازالة للميكروبات (*E. coli*) اعلى من ٩٩%. وأوضحت النتائج فى نهاية التجربة ان عملية الترشيح البيولوجية يمكن أن تكون خيار أوبديل فعال لرفع كفاءة المعالجة الايتدائية لمياه الصرف الصحى.

الكلمات الكشافة: حبيبات الفحم المصنع من الاخشاب- الاغشية الحيوية- مياه الصرف الصحي- الاكسجين الكيمائى المستهلك.