Journal of Environmental Sciences, 2014; Vol. 43, No. 2 : 211-223

USING OF CONDUCTIVITY MEASUREMENTS IN MONITORING THE PROCESSES IN ANAEROBIC WASTEWATER TREATMENT

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ABSTRACT

This study is based on electrical conductivity measurements during the process of anaerobic decomposition of organic waste in order to study the possibility of using values of electrical conductivity as indicator to judge the efficiency of the performance of anaerobic treatment reactors of organic materials and the possibility of using this indicator to judge the level of quality monitoring and control systems in anaerobic treatment on an industrial scale. This study has been using a laboratory unit consists of two reactors connected in series with working volume of 1.5-liter . The synthetic wastewater unit contained a sugar cane molasses as a source of organic carbon and treatment lonely relied on anaerobic bacterial decomposition of organic waste. The study found an inverse relationship between the change in electrical conductivity values and efficient removal of organic material, and notes that the rate of change in the values of electrical conductivity in the second reactor is greater than the first reactor. In total, the study on the possibility of using the values of electrical conductivity as a simple, fast and practical indicator of to control and monitor the efficiency of anaerobic reactors as an alternative to many of the tests the most complex and expensive.

Key words: *: synthetic wastewater, anaerobic treatment, electrical conductivity, measurements.*

INTRODUCTION

In recent decades, the role of anaerobic biological processes in wastewater treatment has increased significantly (Reyes *et al.,* 1999). The efficiency of anaerobic biological processes depends on the configuration of the reactor, the operating conditions and the wastewater characteristics (Mohan *et al.,* 2007). Recently, anaerobic treatment of industrial wastewater over a wide spectrum of wastewaters has improved (Lettinga *et al.,* 1983; Iza *et al.,* 1991; Milan *et al.,* 2001; Borja *et al.,* 2001; Cresson *et al.,* 2006). Generally anaerobic treatment needs simultaneous observation specially for decomposition, hydrolysis, fermentation (or acidogenesis) and methane formation (or methanogenesis). In hydrolysis, solid material is broken down by enzymes into soluble molecules. The use of reactors as a suitable option for wastewater treatment processes has more advantages in comparison with the suspended growth system for various reasons: (1) less sludge production; (2) optimal usage of sludge as a biofilm in the reactor; (3) high solid retention times (SRT) and low hydraulic retention times (HRT); (4) simple and low cost operation; (5) methane production as an energy source and low energy demand; (6) high removal efficiency in organic removal for refractory substances (Rodgers *et al.,* 2006). The properties of multistage reactor systems are: better resilience to hydraulic and organic shock loadings, longer biomass retention times, lower sludge yields, and the ability to partially separate between the various phases of anaerobic catabolism (Barber and Stuckey, 1999).

The latter cause higher resistance to changes in environmental parameters such as pH and temperature. The greatest advantage of this type of reactors is, probably, its ability to separate acidogenesis and methanogenesis longitudinally down the reactor, allowing the reactor to behave as a two-phase system without the associated control problems and high costs. Two-phase operation can increase acidogenic and methanogenic activity by a factor of up to four, as acidogenic bacteria accumulate within the first stage and different bacterial groups can develop under more favorable conditions (Barber and Stuckey, 1999).

The low value of the electrical conductivity can be explained as follows:The decrease in the value of COD by bacteria means there representation diet of organic materials using bacteria which leads to an increase in the size of cells of bacteria which calls for the withdrawal of a large quantity of salt and minerals from the waste water into the cells of bacteria which leads to lack of concentration of salts and minerals in wastewater Which in turn leads to a decrease in the value of electrical conductivity. The opposite is true in the case of non-existence of COD values sufficient to revive the bacteria lead to her death and subsequent degradation of bacteria in the water, leading to increased minerals and salts in wastewater which gives an increase in the electrical conductivity results.

During fermentation, the soluble molecules are degraded by acid former bacteria into acetate, hydrogen and CO_2. Finally, two groups of methanogens produce methane from either acetate or hydrogen plus CO_2. More detailed descriptions of the anaerobic process may be found in various texts, including Shilton (2005) and Metcalf & Eddy (2003), but the following points are important: The acid-formers produce volatile acids and other products which can cause objectionable odors if the methane-formers do not metabolize them. Anaerobic processes are sensitive to pH (methanogen activity is limited below 6.8) and to inhibitory substances such as ammonia, sulphide, copper, zinc and alkaline salts. The methane-formers have very slow growth rates, with a doubling time of days compared with hours for the acid formers. Large increases in the organic loading rate that exceed the capacity of the methane formers to complete the stabilization of the fermentation products may cause incomplete anaerobic decomposition with increased odor emissions the likely result. In the present study, the studies were carried out on the effect of conductivity and the effect of hydraulic retention time staging on organic removal.

MATERIALS AND METHODS

This study was performed using set up inside the sanitary laboratory in the faculty of engineering, Mansoura University. For Investigation of the electrical conductivity (EC) measuring in anaerobic treatment, bench-scale model used in this study as shown in (Photo.1) and (Fig.1). It consisted of a simplified two anaerobic reactors was used connected in series and was installed in an environmental chamber with temperature set at room temperature during the experimental period. Both reactors made up of Plexiglas of volumes a 1.5 liter for each reactor.

Photo (1) : Experimental set up

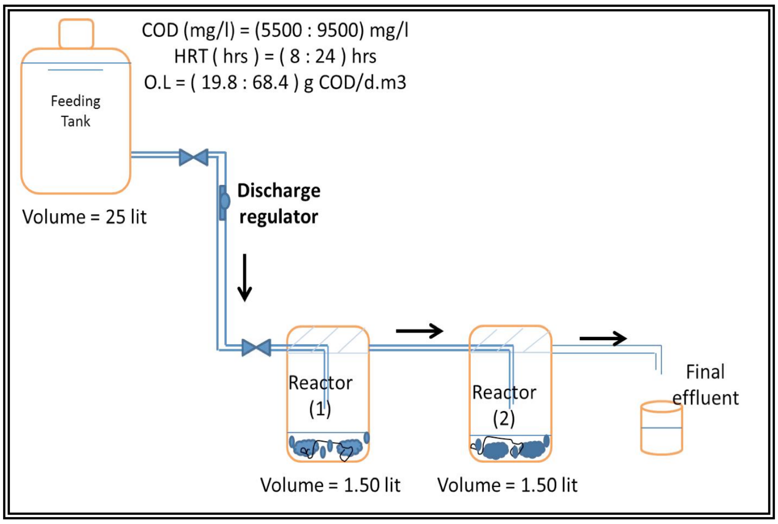

Fig (1) : Schematic diagram of the laboratory model system

Synthetic wastewater and start-up operation:

At the beginning of the startup, the reactor was run in batch mode. During this time, the two reactors were both seeded with anaerobic sludge obtained from local septic tank. The reactors were fed with synthetic wastewater containing molasses as a carbon source. It was made up freshly every day by diluting molasses with tap water to achieve the COD concentration required for each loading rate. The feeding tank was first filled with approximately 25 L of a synthetic wastewater.it consisted of diluted molasses, urea, and KH_2PO_4.The ratio of COD/N/P: 200/5/1 was used throughout the study. Urea and KH_2PO_4 were used as sources of nitrogen and phosphorus, respectively. In order to prevent the build-up of localized acid zone in the reactor, sodium bicarbonate was used for supplementing the alkalinity. The major characteristics of the synthetic wastewater which contains 1 ml molasses in 1 liter of tap water results to COD ≈ 860 mg/l, BOD ≈ 350, TOC ≈ 245 mg/L, sulphate ≈ 245 mg/L and chloride ≈ 20 mg/L. The hydraulic retention time (HRT) for both reactors of 30 hrs, was used during the start up. During the start-up period, COD concentration of the feed was approximately 5500 mg/l; its pH was between (7.0 to 8.0) in the reactor after adjustment with sodium bicarbonate. The temperature was ranged from 28 to 32°C. The start-up period lasted for 2 months to acclimatize the cells in the reactors and reach to steady state. Tests performed in this study include EC, TDS, COD, TOC, pH and organic loading. The test procedures described in APHA (1998) were followed. The present study was conducted in the laboratory of sanitary engineering, Public works engineering department, Faculty of engineering, Mansoura University. Samples of Synthetic wastewater were collected from the processing units located in sanitary laboratory. A part of these samples was prepared for those analyses, which were considered to be done immediately. The influent and treated effluent was collected at the end of each HRT ranged from 8 to 24 hrs.

RESULTS AND DISCUSSION

The samples were collected from raw synthetic wastewater, after first reactor and the second reactor. The results obtained for EC, TDS, COD and TOC are shown in figures below.

The relation between conductivity and total dissolved solids:

In the laboratory model, conductivity measurements from the influent (raw wastewater), effluent of first reactor and effluent of second reactor as shown in Fig. 2. The EC is increasing by increasing hydraulic retention time. The values of conductivity ranges from (4000-5000) (μs/cm) at retention time = 8 hrs to (7000-8000) (μs/cm) at retention time = 24 hrs. Similarly, Fig. 3 shows the variation of TDS values with hydraulic retention time. The trend of conductivity is the same as TDS for anaerobic reactors as shown in Fig. 3. TDS is the product of the biochemical transformations; it is of utmost interest in the conversion processes, since the TDS becomes the substrate for the acedogenic and methanogenic microorganisms as shown in Fig. 4. Fig.5 (a,b,c) shows the good correlation between conductivity and TDS for each stage with R≈ 0.99 in the influent, effluent 1 and effluent 2.

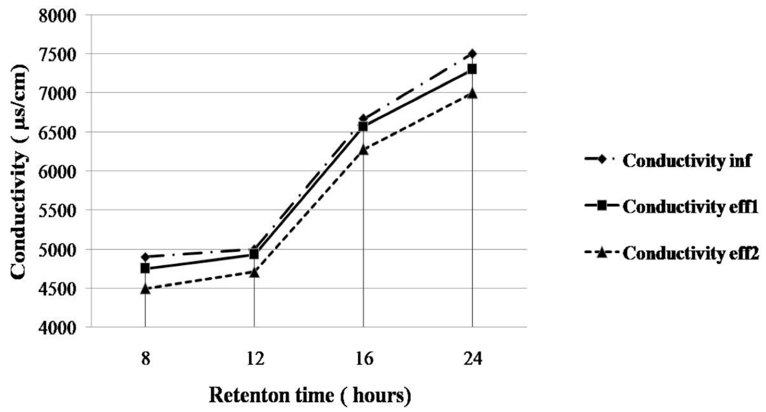

Fig (2) : Relation between Retention time and conductivity

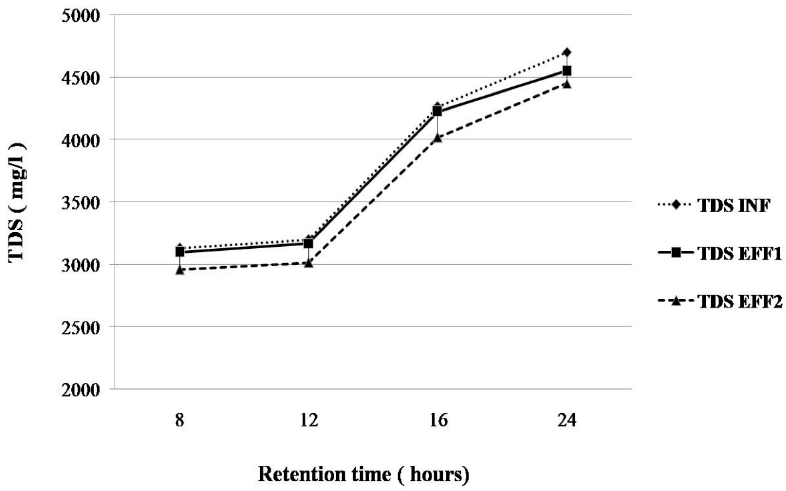

Fig (3) : Relation between Retention time and TDS

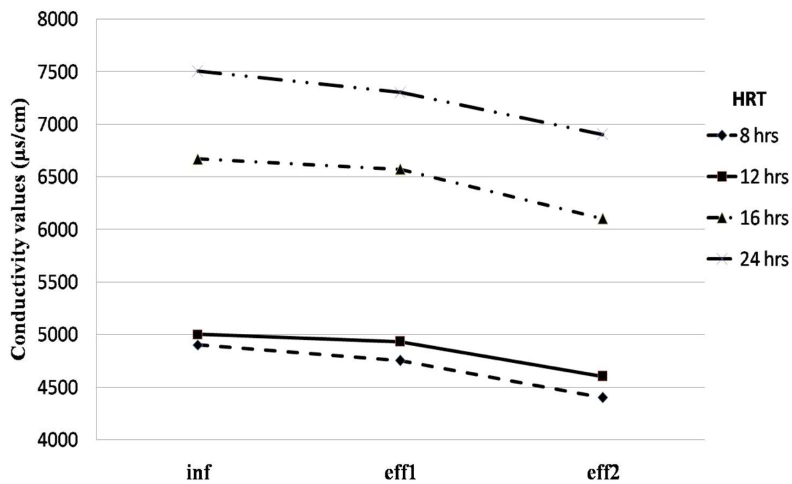

Fig (4) : Effect of staging on conductivity with varying HRT

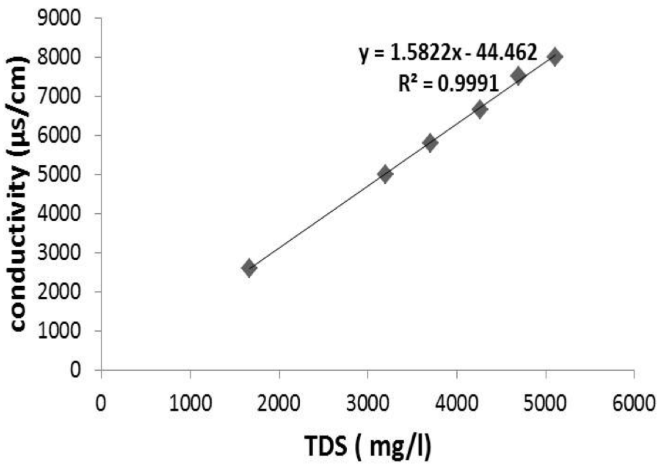

Fig (5a) : The correlation between conductivity and TDS for influent

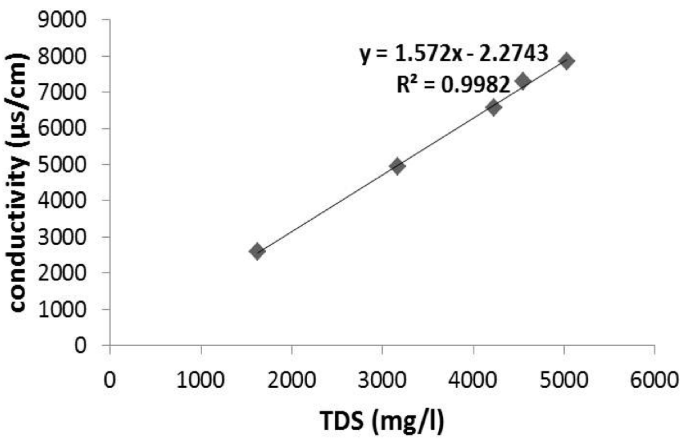

Fig (5b) : The correlation between conductivity and TDS for effluent1

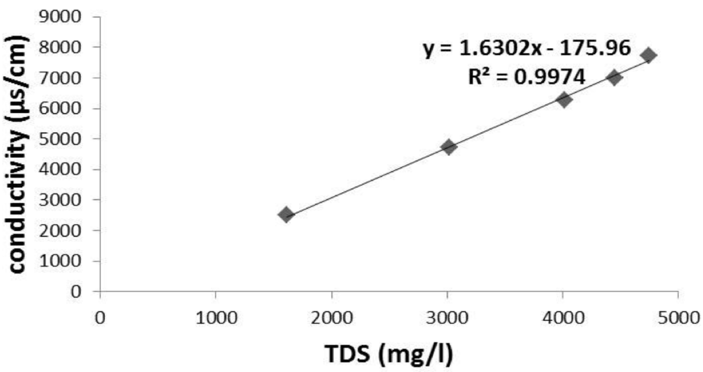

Fig (5c) : The correlation between conductivity and TDS for effluent 2

Effect of Hydraulic Retention Time on pH:

The pH variation for influent, effluent 1 and effluent 2 were recorded and shown in Fig. 6. pH value of effluent decreased with the production of organic acids by the acidogenic bacteria in the initial stage of fermentation. Then pH gradually increased but the variation of the pH value, perhaps was controlled by the bicarbonate buffering action and retreating in three day intervals. During the study period, pH value varied around 5.5 which confirmed that the reactor operated in the acidogenic phase, since the pH range from 7 and 8 is favorable for the methonogenic bacteria (Benson *et al.,* 2007). According to Shefali, (2002) the optimum pH value for anaerobic digestion ranged from 5.5 to 8.5.

Anaerobic bacteria, specially the methanogens, are sensitive to the acid concentration within the reactor and their growth can be inhibited by acidic conditions. It has been determined that an optimum pH value for anaerobic treatment lies between 5.5 and 8.5. During digestion, the two processes of acidification and methanogenesis require different pH levels for optimal process control. The retention time of digestive affects the pH value and in a batch reactor acetogenesis occurs at a rapid rate. Acetogenesis can lead to accumulation of large amounts of organic acids resulting in pH below 5. Excessive generation of acid can inhibit methanogens, due to their sensitivity to acid conditions. Reduction in pH can be controlled by the addition of lime or recycled filtrate obtained during residue treatment. As digestion reaches the methanogenesis stage, the concentration of ammonia increases and the pH value can increase to above 8. Once methane production is stabilized, the pH level ranged from 7.2 to 8.2.

Effect of Hydraulic Retention Time on COD Removal:

The COD for the influent, effluent 1 and effluent 2 COD was measured. A standard sample with a COD of 5000 mg/L was measured every 2 samples to check the accuracy of the measurement. Fig. 7 shows the organic loading for the influent, Eff1 and Eff2 under varying HRTs. An increase in influent organic loading (OL) from 20 to 50 g COD/m^3.d resulted in an slight decrease in OL in Eff2 (7 to 9 g COD/m3.d) for HRTs 12,16 and 24 hrs, but at HRT 8 hrs the influent OL of 68 g COD/m^3.d resulted in rapid decrease in the Eff2 (20gCOD /m^3.d). Fig. 8 shows the variation of COD under varying of hydraulic retention time for influent, Eff1and Eff2. The influent COD concentrations were used in the range from 5000 to 9500 mg/l under varying of HRTs 8, 12, 16 and 24 hrs. The Eff1COD decreased from 4800 mg/l at HRT of 8 hrs to 3000 mg/l at HRT of 24 hrs. Similarly, The Eff2COD decreased from 2200 mg/l at HRT of 8 hrs to 1600 mg/l at HRT of 24 hrs.

Organic matter removal at each stage of the reactor:

Upon analyzing the COD removal efficiencies at the exit of each stage for a given HRT, interesting results were observed in all cases (Fig. 9, 10 and 11). The effect of the stages on COD values that measured in each reactor is given in the above mentioned figure. It can be seen from the figure that, COD removal is realized more rapidly than others in first reactor. COD removals are determined as 80%, 77%, 74%, and 69% for 16, 12, 24, and 8hrs

(HRT) respectively. As previous explained about COD is the same about TOC as shown in Fig.10. stage that degraded most of the complex organic matter that the system was capable of assimilating was the first. For 8, 12 hrs of HRT the first stage was sufficient to achieve the final removal values of the treatment, in the rest of the stages only what was achieved in the first one was maintained. On the contrary, for HRTs of 12 and 8 h, the COD removal results were better distributed between the stages, although basically in the first three. The degradation action of the biomass in each part was less in the first stage, hence giving a combined action of all stages that was one of the principal objectives of this type of anaerobic reactor design. As can be seen in the figure, the COD removal efficiency increased from the first to the second stage from 69% at 68.4 g COD / m^3.d to 80 % at 19.6 g COD / m^3.d. As this indicator took into account only the easier material for biodegrading, this could be quickly transformed during the first stage. Even for the shortest HRT, the final effluent showed about 60–70% removal efficiency.

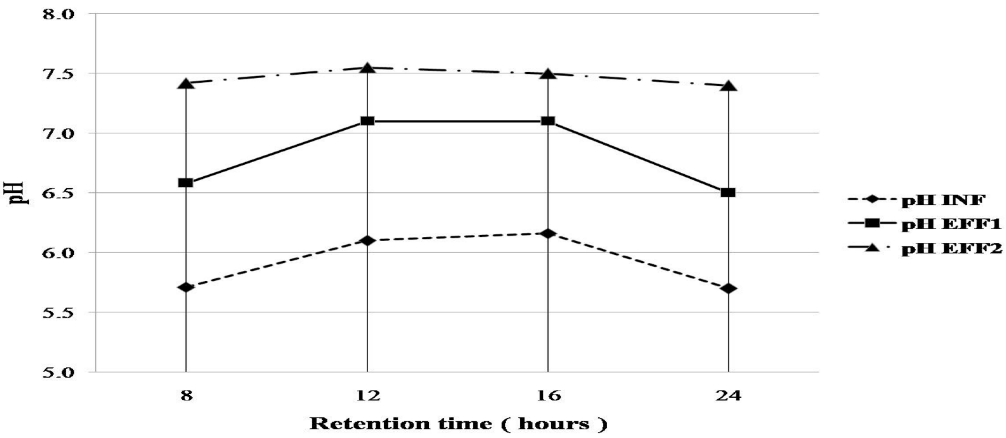

Fig (6) : Relation between retention time and pH values

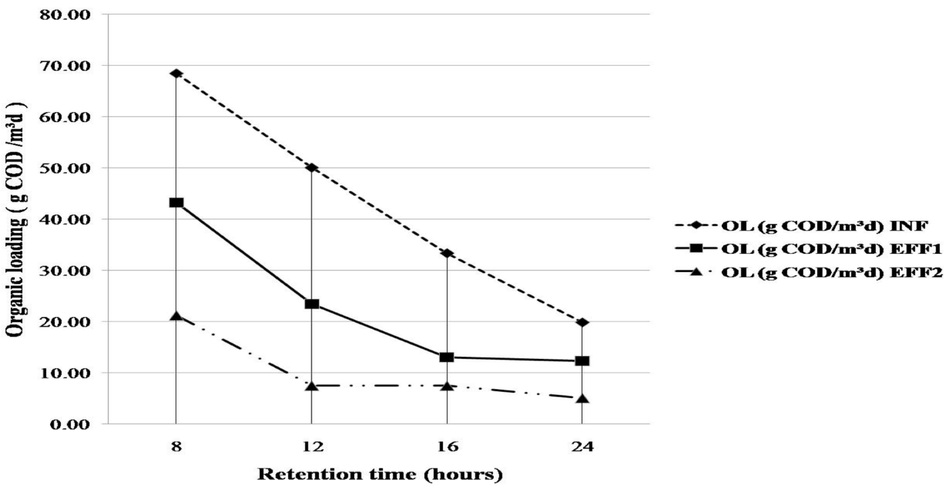

Fig (7) : Relation between retention time and organic loading

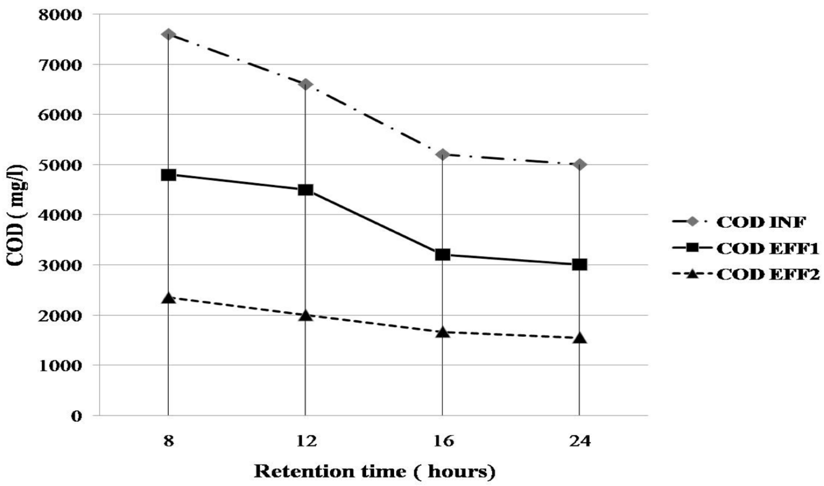

Fig (8) : Relation between retention time and COD

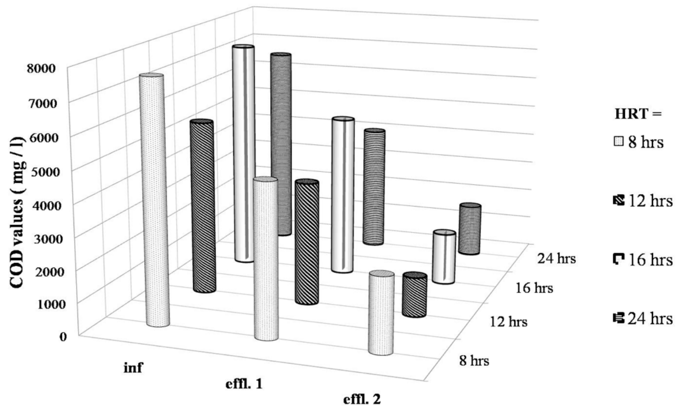

Fig (9) : Effect of stages on COD values with retention time under varying HRT

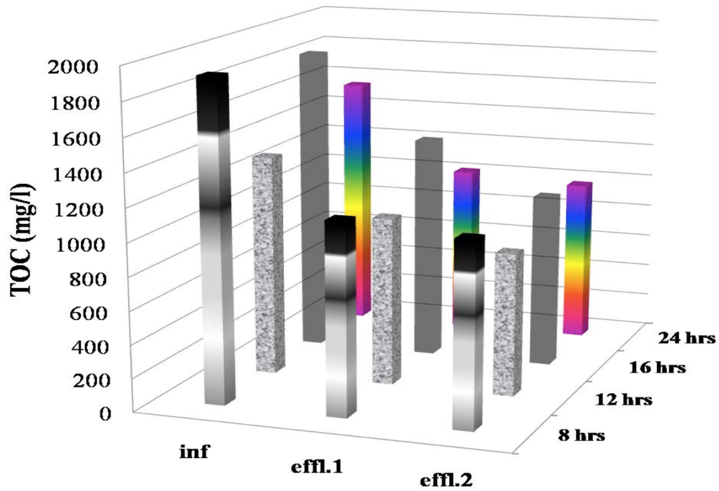

Fig (10) : Effect of stages on TOC values with retention time

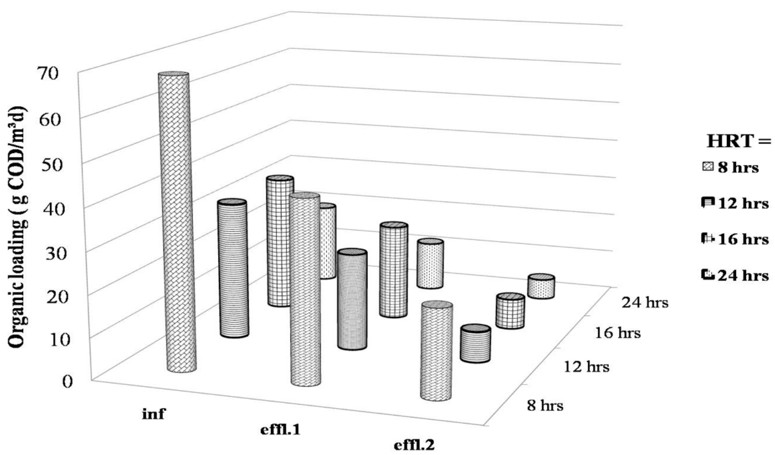

Fig (11) : Effect of stages on organic loading values under varying HRT

CONCLUSIONS

Based on the above study, the following conclusions can be drawn:

1. In the present study, it was observed that high concentration of EC, TDS, COD and TOC were present in the raw sewage however better water quality was found after treatment in final treated water.

2. The Conductivity measurements can be used to monitor the processes in wastewater treatment.

3. The EC of influent is more than the EC of effluent and it was found high correlation between TDS and EC.

4. High concentration of COD in raw sewage and low concentration in the final treated waste water due to various stages of wastewater treatment reactors.

5. The anaerobic reactors successfully treated synthetic wastewater of concentrations 5500 to 9500 mg/l. The percentage removal achieved by the unit varied from 69% at 68.4 g COD /m^3.d to 80 % at 19.6 g COD / m^3.d .

6. The two reactors seem to be better in reducing the organic load with HRT within the range of 8 – 24 hrs.

7. The Conductivity measurements increasing with decrease organic loading.

8. The effect of staging is very important especially at higher organic loading

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Received on 9 / 9 / 2013

الملخص العربى

استخدام قياسات التوصيلية الكهربية في رصد العمليات للمعالجة اللاهوائية لمياه الصرف الصحي

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**برنامج ماجستير ادارة وتكنولوجيا البيئة – كلية الهندسة – جامعة المنصورة

تقوم هذه الدراسة على إجراء قياسات للتوصيلية الكهربية أثناء عملية التحلل اللاهوائي للمخلفات العضوية وذلك بهدف دراسة إمكانية استخدام قيم التوصيلية الكهربية كمؤشر للحكم على كفاءة أداء مفاعلات التحلل اللاهوائي للمواد العضوية وإمكانية استخدام هذا المؤشر للحكم على مستوي جودة المراقبة والتحكم في نظم المعالجة اللاهوائية على النطاق الصناعي. هذا وقد تمت الدراسة باستخدام وحدة معملية تتكون من مفاعلين متصلين على التوالي حجم كل منهما ١,٥ لتر والمخلفات السائلة المعالجة بالوحدة احتوت علي مولاس قصب السكر كمصدر للكربون العضوي واعتمدت المعالجة بالوحدة على التحلل البكتيري اللاهوائي للمخلفات العضوية . وخلصت الدراسة إلى وجود علاقة عكسية بين التغير في قيم التوصيلية الكهربية وكفاءة إزالة المواد العضوية ويلاحظ أن معدل التغير في قيم التوصيلية الكهربية في المفاعل الثاني أكبر من المفاعل الأول . وفي المجمل أكدت الدراسة على إمكانية استخدام قيم التوصيلية الكهربية كمؤشر بسيط وسريع وعملي للحكم على كفاءة المفاعلات اللاهوائية كبديل للعديد من الاختبارات الأكثر تعقيدا و تكلفة .

JOESE 5

USING OF CONDUCTIVITY MEASUREMENTS IN MONITORING THE PROCESSES IN ANAEROBIC WASTEWATER TREATMENT

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Reprint

from

Journal of Environmental Sciences, 2014; Vol. 43, No. 2 : 211- 223

http://env.mans.edu.eg/journals/jes **P-ISSN 1110-192X**
e-ISSN 2090-9233