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REMOVAL OF ORGANIC MATTER FROM SOME WASTEWATERS BY USING AEROBIC TREATMENT

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ABSTRACT

The main objective of this work was to apply a simple method to treat wastewaters, by using only oxygen supply. The studied wastewaters contained high quantities of organic matter expressed as COD or BOD. However, the slaughterhouses wastewater contained the highest amount of organic matter followed by the industrial wastewater obtained from a local sugar factories. The domestic wastewater came at the third place in its organic matter content and the less amount of organic matter was found in agricultural wastewaters. From no agitation to higher agitation rate, the removal percentage of COD was increased. Removal of COD from the studied wastewaters ranged from 88% in Domestic wastewater to 93% in Agricultural wastewater at agitation speed of 200 rpm after 96 hours only.

INTRODUCTION

Biological wastewater treatment, in its simplest form, is the conversion of biodegradable waste products from municipal or industrial sources by biological methods. The practice using of a controlled biological population to degrade of waste had been used for centuries, but while early wastewater treatment processes were quite simple, they have become more and more complex over time. Today, treatment of biodegradable wastes prior to discharge has become an essential part of municipal and industrial operations. Biological oxygen demand (BOD) and chemical oxygen demand (COD) are two different ways to measure how much oxygen the water will consume when enters the recipient. In both cases the oxygen-consuming substances are mainly of organic origin. These substances should be reduced to a minimum in the wastewater treatment plant. Industries normally focus more on COD and municipalities more on BOD removal. The wastewaters are characterized by high pH, total suspended solids (TSS), organic matter expressed as chemical oxygen demand (COD), color, and alkalinity. In some cases the effluent is not considered suitable for direct biological treatment processes due to the presence of recalcitrant compounds. In a recent review article, several physicochemical methods, such as coagulation−flocculation, ion exchange, adsorption, membrane technology, irradiation and chemical oxidation and also biological processes have been suggested for the removal of COD from industrial wastewaters (Singh and Arora, 2011). When free dissolved oxygen is present, the ecosystem is considered to be aerobic. If excess raw sewage is discharged to receive water, the available food supply may result in a large microbial populations that fully depletes all of the dissolved oxygen. This result in the system becoming anoxic or anaerobic.

The above mentioned information indicate that supplying the wastewater with dissolved oxygen is essential for microbial viability and may be efficient method for organic matter removal. Generally, physicochemical treatment processes alone are not preferred, despite their effectiveness, due to the high costs involved. Hence, the application of suitable physicochemical methods in conjunction with a biological process may offer a cost-effective and acceptable solution. In the past, several researchers had studied the coagulation of synthetic and real textile wastewater using various inorganic chemicals (e.g., $FeCl_3$, $FeSO_4$, alum, lime, and $MgCl_2$) as well as components of biological origin, such as chitosan and HOC-100A (Hassan *et al*.,2009 and Szygula *et al*., 2009).

A significant increase in COD removal has been reported by use of adsorption as a post-treatment step (Harrelkas *et al*., 2009). Kurniawan and Lo (2009) reported that combined treatment by Fenton's oxidation and granular activated carbon (GAC) adsorption could reduce the overall COD and NH_3−N by 82% and 59%, respectively. Juteau *et al*., (2004) reported that livestock wastewater contains high-strength of COD, BOD, color, nitrogen, phosphorus and suspended solids. Large volumes of livestock wastewater are produced, and the wastewater is a primary pollution source of surface and ground waters. Much attention is paid to these problems in many countries as treatment of livestock wastewater poses a difficult problem. Issues include the intense odor, the possibility of pathogen dissemination and the content of structured polymers toxic to microorganisms. According to the report on the 30 years history in livestock industry's environmental improvement (2006), the law concerning the appropriate treatment and promotion of utilization of livestock manure has been put into effect in Japan, the advanced biological treatment methods of livestock wastes have been intensively pursued, including efficient composting, wastewater treatment using protozoa or sulfur oxidizing denitrifiers and methane fermentation incorporated with membrane. However, application of chemical treatments to livestock wastes is relatively small in number.

Recently, advanced oxidation processes (AOP) have been proposed to treat relatively low-strength industrial wastewaters containing non-biodegradable substances toxic for microorganisms. Among them, the Fenton method is cost-effective, easy to apply and effective with relatively low-strength wastewater containing organic compounds and had been applied to the decolorization of textile wastewater (Meric *et al.*, 2005). More recently, Wosiack *et al.*, (2015) evaluated the performance of a continuous flow structured-bed reactor in the simultaneous removal of total nitrogen and chemical oxygen demand (COD) in the effluent from an animal food plant. The reactor had an intermittent aeration system; hydraulic retention time of one day; temperature was 30 °C; and recirculation ratio of five times the flow. An experimental central composite rotational delineation type design was used to define the aeration conditions and nitrogen load (factors) to be studied. It was observed that the aeration factor showed the greatest significance for the results and that the effluent Total Kjeldahl Nitrogen (TN) concentration did not have a significant effect, at a 95% level of confidence, on COD removal. Throughout the experiment, the COD/N ratio remained between 3.2 and 3.8. The best results for COD and TN removal, 80% and 88%, respectively, which were obtained with 158 min of aeration on a cycle of 180 min and 255 mg L^{-1} of Total Kjeldahl Nitrogen (TKN) in the substrate.

This work briefly discusses the simplest method to treat wastewaters, by using only oxygen supply. Since the modern methods in wastewaters treatments are complex and economically very expensive, the application of this simplest method fits our economic circumstances in Egypt and at the same time leads to the main purpose of treatment, which is the removal of organic matter. This method is simply harnessing microbes which naturally are present occure in the wastewater to oxidize its content of organic matter.

MATERIALS AND METHODS

1. Sampling

Composite sampling technique was used in this study to collect the samples from four different wastewaters types. This sampling technique consists of a mixture of several individual grab samples collected at regular and specified time periods, each sample was taken in proportion to the amount of flow at that time. Composite samples give a more representative sample of the characteristics of water at the plant over a longer period of time. This technique was used to collect the samples from domestic wastewater, agricultural wastewater, slaughterhouses wastewater and, wastewater of a sugar factory in AbouKorkas city, El-Minia Governorate, Egypt. The composite wastewater samples were kept in glass stoppered containers at 0.0 °C for not more than 7 days.

2. Determination of organic matter expressed as chemical oxygen demand (COD)

The chemical oxygen demand was determined according to the method described by Wolf and Nordmann (1977) in which the organic matter was oxidized in a sulphuric acid/di-potassium chromate solution. The concentration of the green Cr^{3+} ions was determined spectrophotometrically at 620 nm.

The procedure can be summarized as follows:

1- One hundred ml of the composite wastewater sample was homogenized in a blender and then placed in aglass vial.

2- The COD reactor (oven) was turned on and preheated to 150°C.

3- A clean thick wall COD glass vial contained 8 ml of sulphuric acid/di-potassium chromate solution was held at 45-degree angle and 2.00 ml of the homogenized wastewater sample was pipetted into the vial.

4- The vial cap was tightly replaced and the outside of the vial was rinsed with de-ionized water and wiped with a paper towel. It must be noted that the vial will become very hot during mixing.

5- Each vial was gently inverted several times to mix the contents while still warm, and all vials were left until cooled to room temperature (0°C).

6- After cooling to room temperature the vials were placed in the preheated COD reactor (150°C) for 2 hours.

7- After two hours the reactor was turned off and the vials were left to cool to the room temperature.

8- A lab spectrophotometer was calibrated to zero using de-ionized water and then used to measure COD at 620 nm.

3. Determination of biological oxygen demand (BOD)

BOD was estimated mathematically according to the following equation:
BOD = 2/3 COD Wolf and Nordmann (1977)

4. Aerobic biological treatment of wastewaters

For each of the four type of wastewaters, an experiment with three replicates was carried out to study the effect of aeration on removal of COD, nitrate, nitrite and phosphorus. Effects of aeration on coliform group count and total count of bacteria were also studied. This experiment was carried out without inoculations depending on the microbes that are present naturally occur in wastewaters. From each wastewater type, 400 ml was placed in one liter Erlenmeyer flask with cotton stoppers. It is well known that the agitated cultures have more dissolved oxygen as compared with the static ones and that there is a positive relation between agitation speed and quantity of dissolved oxygen. Due to these conditions and due to the lack of the apparatus that measures and controls the quantity of oxygen introduced to the growth media, the agitation speeds were taken as indicators for the quantity of the dissolved oxygen. The flasks were placed on magnetic stirrers at room temperature (0C°) with the desired speed of agitation round per minute (rpm). Samples were withdrawn at intervals of 24 hours. COD, BOD, nitrate, nitrite, phosphorus, count of coliform group and total count of bacteria were determined.

RESULTS AND DISCUSSION

1. COD in studied wastewaters

The results in Table (1) show values of COD and BOD in the studied wastewaters samples collected from El-Minia Governorate before treatments. These results showed that different wastewaters contained high quantities of organic matter expressed as COD or BOD. However, the slaughterhouses wastewater contained the highest amount of organic matter followed by the industrial wastewater obtained from a local sugar factory.

Table (1): COD and BOD of domestic wastewater, agricultural wastewater, slaughterhouses wastewater and industrial wastewater

Wastewater type	COD (mg/L)	BOD (mg/L)
Domestic wastewater	3063	2021
Agricultural wastewater	2692	1777
Slaughterhouses wastewater	3976	2624
Industrial wastewater	3615	2386

The domestic wastewater came at the third place in its organic matter content and the less amount of organic matter was found in agricultural wastewater. These are expected results, since both of the slaughterhouses wastewaters and the industrial wastewater are characterized by high organic matter expressed as chemical oxygen demand (COD), color and alkalinity as reported by Singh and Arora (2011). Industries are generally water consumers. For example meat industry is one of the largest consumers of water (800–1000 m^3/ton) and consequently, It is considered one of the largest producers of wastewater among all industries (Rodrigues *et al*., 2009). This wastewater with a chemical oxygen demand (COD) concentration exceeding 1600 mg/L and a strong dark color is classified as a high strength wastewater (Kobya *et al*., 2003).

2. Effect of aeration on removal of COD from wastewaters

The results in Tables (2-5) show the effect of aeration through different agitation speeds on removal of COD from the studied wastewaters. It was obvious that from no agitation to higher agitation rate, the removal percentage increased. The results in Table (2) showed that at agitation speed of 120 rpm about 60% of the wastewaters COD content was removed after 120 hrs of the reaction. This percentage of COD removal was nearly constant in different studied wastewaters. At agitation speed of 160 rpm, the removal of COD increased with different percentages as shown in Table (3). Furthermore, removal of COD from the studied wastewaters ranged from 88% in domestic wastewater to 93% in agricultural wastewater at agitation speed of 200 rpm after only 96 hours (Table 4). The results of removal of COD at agitation speed of 240 rpm (Table 5) were nearly similar to those of agitation speed of 200 rpm for the some agitation period (96hrs).

When there was no agitation in treatment, microorganisms might not be able to gain energy, however in the presence of enough air as a result of agitation; the microorganisms had the ability to oxidize most of the present organic matter. The results showed that organic substrates were oxidized and provide energy for microorganisms to produce biomass. Also these results indicated that the organic substances in the studied wastewaters were readily and easy to be degraded to simple organics by microorganisms in the treatment. However, it must be considered that wastewater characteristics are depending on wastewater source and other wastewaters may contain toxic substances and may need additional processes beside aeration for right treatment. These results are in agreement with those obtained by Florante and Joseph (2009); Primasari *et al*., (2011) and Wosiack *et al*., (2015).

Table (2): COD concentration in domestic wastewater, agricultural wastewater, slaughterhouses wastewater and industrial wastewater after treatment at agitation speed of 120 rpm.

Wastewater type	COD concentration (mg/L)						
	Time (hour)						
	0.0	24	48	72	96	120	144
Domestic wastewater	3063	2656	2000	1495	1247	1236	1230
Agricultural wastewater	2692	2601	2070	1500	1217	1080	1077
Slaughterhouses wastewater	3976	3212	2800	1980	1490	1301	1296
Industrial wastewater	3615	3000	2910	2000	1771	1449	1440

Table (3): COD concentration in domestic wastewater, agricultural wastewater, slaughterhouses wastewater and industrial wastewater after treatment at agitation speed of 160 rpm .

Wastewater type	COD concentration (mg/L),						
	Time (hour)						
	0.0	24	48	72	96	120	144
Domestic wastewater	3063	2600	1800	1320	980	820	800
Agricultural wastewater	2692	2570	1420	1000	910	761	635
Slaughterhouses wastewater	3976	3002	1989	994	900	878	793
Industrial wastewater	3615	2820	2000	1100	981	813	800

Table (4): COD concentration in domestic wastewater, agricultural wastewater, slaughterhouses wastewater and industrial wastewater after treatment at agitation speed of 200 rpm .

Wastewater type	COD concentration (mg/L)						
	Time (hour)						
	0.0	24	48	72	96	120	144
Domestic wastewater	3063	2780	1867	780	360	362	358
Agricultural wastewater	2692	1877	1000	600	180	177	160
Slaughterhouses wastewater	3976	2200	1387	777	321	292	290
Industrial wastewater	3615	2320	1150	600	325	298	297

Table (5): COD concentration in domestic wastewater, agricultural wastewater, slaughterhouses wastewater and industrial wastewater after treatment at agitation speed of 240 rpm.

Wastewater type	COD concentration (mg/ml)						
	Time (hour)						
	0.0	24	48	72	96	120	144
Domestic wastewater	3063	2766	1800	782	362	360	355
Agricultural wastewater	2692	1800	997	610	177	178	162
Slaughterhouses wastewater	3976	2198	1380	770	320	288	290
Industrialwastewater	3615	2300	1150	620	326	300	298

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إزالة المواد العضوية من بعض المخلفات المائية بأستخدام المعالجة الهوائية

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إن الهدف الأساسي لهذا العمل هو تطبيق طريقة بسيطة لمعالجة المخلفات المائية بواسطة استخدام الإمداد بالأكسجين. إن الطرق الحديثة لمعالجة المخلفات المائية هي طرق معقدة ومكلفة من الناحية الاقتصادية. ولذلك فإن تطبيق هذه الطريقة البسيطة يناسب ظروفنا الاقتصادية في مصر وفي نفس الوقت ربما يؤدي إلى تحقيق الغرض الأهم والرئيسي من عملية المعالجة ألا وهو إزالة المادة العضوية.
هذه الطريقة هي ببساطة شديدة توجه الميكروبات الموجودة طبيعيا في المخلفات المائية إلى أكسدة المادة العضوية التي هي مصدر الخطر الرئيسي في المخلفات المائية. وقد أوضحت النتائج أن المخلفات المائية التي تم دراستها وهي (مياه الصرف الصحي للمنازل – مياه الصرف الزراعي – مياه الصرف الصناعي(مصنع السكر) – مياه صرف المذابح والسلخانات) تحتوي على كميات كبيرة من المادة العضوية المعبر عنها بمصطلح COD؛ إلا أن مخلفات المجازر احتوت على أعلى كمية من المواد العضوية يليها المخلفات المائية للمصانع وفي المرتبة الثالثة تأتي المخلفات المائية للمنازل (مياه المجاري) ثم أقل كمية نسبيا وجدت في مخلفات الصرف الزراعي. أوضحت النتائج أنه كانت هناك زيادة تدريجية في إزالة المادة العضوية مع زيادة كمية الهواء الذي يتم إدخاله إلى المخلف المائي. وقد أمكن إزالة 88% من المادة العضوية الموجودة في المخلفات المائية المنزلية و93% من المادة العضوية الموجودة في مخلفات الصرف الزراعي وذلك بعد 96 ساعة فقط من بداية التفاعل عند سرعة رج تساوي 200 لفة في الدقيقة.