__Original Research Article__

Sewer water effect on the corrosion of caste iron before and after treatment

Abstract

Chemical and biological corrosion of sewers and sewage treatment plants constitutes a serious problem and its effects result in the loss of billions of dollars a year. It is generally acknowledged that corrosion of cast iron caused by microorganisms is associated with their production of sulphuric acid as the main metabolic product and also due to the presence of other chemical constituents. And so, this study aimed to compare and evaluate the effects of sewer water treated by bio-filter reactors using agriculture waste and that untreated on the corrosion of cast iron pipes. The corrosion rate was tested chemically by using the weight loss technique.

Key words: Sewer water, Treatment, Corrosion test

Introduction

Sewer / Wastewater are essentially the water supply of the community after it has been fouled by a variety of uses [1]. From the standpoint of sources of generation, waste water may be defined as a combination of the liquid (or water) carrying wastes removed from residences, institutions, commercial and industrial establishments, together with such groundwater, surface water and storm water as may be present [2]. Generally, the wastewater discharged from domestic premises like residences, institutions, and commercial establishments is termed as "Sewage/Community wastewater". It comprises of 99.9% water and 0.1% solids and is organic because it consists of carbon compounds like human waste, paper, vegetable matter etc. Besides community wastewater/sewage, there is industrial wastewater in the region. Many industrial wastes are also organic in composition and can be treated physico-chemically and/or by micro-organisms in the same way as sewage [3]. Biological treatment is used for reduce the organic content and the nutrients by activates the existing microorganisms in wastewater [4]. In biological treatment there are two actions may occur, aerobic action which acts in the presence of oxygen, and anaerobic action which acts in the absence of oxygen. In this work biological type of filters was used and considered as one of the most kinds which are used for secondary treatment of municipal wastewater. It consists of a highly permeable media to attach microorganisms on it and percolate wastewater through it. The theory of work of this kind is depended on the interaction between organisms and organic material in the wastewater, which include carbonaceous, nitrogenous and phosphorus compounds.

Biological filter can be classified according to the hydraulic load, with taking the media type, flow direction and operation procedure into consideration, to five main types [5]:

1. Trickling filter (TF).

2. Bio-tower.

3. up flow filter.

4. Fluidized bed reactor (FBR).

5. Biological aerated filter (BAF).

The advantage of trickling filters compared to other wastewater treatment systems is that its operating costs are low.

Cast iron and steel corrode; however, because of the free graphite content of cast iron (3% - 4% by weight or about 10% by volume), an insoluble graphitic layer of corrosion products is left behind in the process of corrosion. These corrosion products are very dense, adherent, have considerable strength, and form a barrier against further corrosion. Because of the absence of free graphite in steel, the corrosion products have little or no strength or adherence and flake off as they are formed, thus presenting fresh surfaces for further corrosion. In tests of severely corroded cast iron pipe, the graphitic corrosion products have withstood pressures of several hundred pounds per square inch although corrosion had actually penetrated the pipe wall [6].

Corrosive behavior of metals in aqueous solutions is mainly determined by dissolved salts and oxygen [7]. In order to minimize corrosion problem in water supply system, it's important to identify the mechanism of corrosion rate of ions with cast iron, the extent to which they contribute to corrosion in waste water as well as threshold limiting values to which the corrosion rate should be minimize in order to provide excellent corrosion resistance [7].

This work examines the corrosion behavior of cast iron when exposed to sewage water before and after treatment by bio-filter reactor. The corrosion rates in these media are also calculated to study their stability when similar industrial environments are encountered.

2. Experimental

2.1 Sewage water treatment processing.

Wastewater (sewage water) treatment was done using a pilot consisted from two parallel lines, one worked as standard rate (S.R) bio filter and the second as high rate (H.R) bio filter with recirculation water. The pilot consisted of the following components:

1- Two columns reactors, each consists of a pipe with 50 cm diameter & 2.00m height as shown in Figs. (1 and 2).

2- A 10 cm depth of gravel put at the reactor bottom used as a media support layer, it used for preventing the escape of applied media particles and the effluent clogging.

3- The bio-filter was a double layer of both grape stalks and rice husk of 30 cm depth of each in which layer of grape stalks overlaid at rise husk layer. Both types of these agriculture wastes were used without any treatment except cut to pieces of two cm length.

4- The wastewater was sprinkled at the top of the pipe by using perforated spiral hose.

5- One of those pipes worked as high rate biological filter (H.R.) and the other worked as standard rate biological filter (S.R.). The treated water used in this study is that obtained from H.R.

The raw wastewater samples were collected from the effluent manhole in our city. It was lifting to a rubber tank which is used as a feeding station for the pilot system by using a withdrawal pump. The pilot was working for 24 hours per day and the samples were collected after one week of the pilot operation to ensure the system stability.

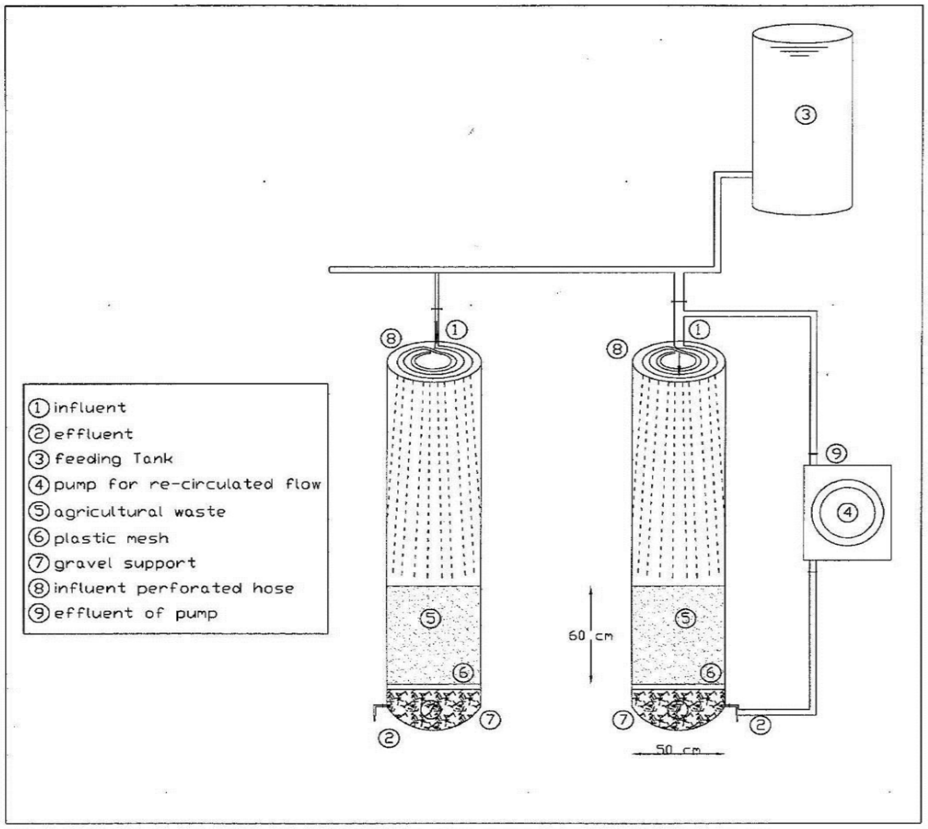

Fig. 1 Pilot Components

Fig. 2 Pilot complete System

All parameters were measured in this study followed American standard methods for water and wastewater examinations [4], for the following parameters:

1. Total dissolved solids (TDS).

2. Dissolved oxygen (DO).

3. PH. 4. Temperature, (T).

5. Chemical oxygen demand, (COD).

6. Biochemical oxygen demand (BOD).

7. Turbidity.

The total suspended solids (TDS), Dissolved oxygen (DO), the pH value, and temperature of the samples were measured electrochemically by using multi parameters & photometer instrument manufactured by (YSI) company.

The chemical and the biological oxygen demand for each sample were measured according to the Standard American Method for the examination of water and wastewater [4].

2.2 Corrosion tests

2.2.1 Weight loss measurement

The experiments were performed with cast iron having a composition (wt. %): C ≥ 4.5 ; Mn = 0.29 6, P = 0.158, S ≥ 0.150, Mg = 0.0016, Si = 2.63 and Fe to balance. The cast iron sheets of 3.0 x 3.0 x 0.8 cm^3 were abraded with a series of emery papers (grades 320, 600, 800 and 1200) and then washed with distilled water and acetone. After weighting accurately (using A&D HR-120 0.1 mg Analytical Balance), the specimens were immersed in a 250 mL beaker containing 250 mL of the test water (sewage water before and after treatment). After immersion time of 5, 10, 15, 20, 25 and 30 days, the specimens were washed, dried, and weighted accurately.

The corrosion rates were calculated in miles per year using the recommended relation by American Society for Testing and Materials (ASTM) 1985 [8] that has been used successfully applied by Sanusi [9] and Orubite [10]. Generally, the miles penetration per year (MPY), the unit used as the corrosion rate, is calculated by Equation (1):

$$MPY = \frac{534W}{DAT} \qquad (1)$$

Here, W is weight loss (mg), D is density (g/cm^3), A is area, and T is hour (h).

While MPY is most advisible in terms of realistic consideration, milligram per square decimeter per day (mg / dm^2 / day, mdd), the weight loss by unit hour has often been used recently.

$$1\,MPY = \frac{1.44\,mdd}{D} \qquad (2)$$

3. Result and discussion

3.1. Characteristics of the tested water

Table 1 shows the quality data of the tested water before and after treatment.

Table 1: the quality data of the tested water in one week operation of the represented pilot system with high rate bio-reactor (HR).

Sample No.	Sample	COD	BOD	DO	Temp.	Conduc.	TDS	pH	Tur.
No samples in first week									
1	SW	979.40	715.18	2.70	18.60	680.00	495.20	7.92	89.50
	TW	166.13	133.24	1.22	18.10	610.00	470.00	7.80	40.15
2	SW	795.50	524.30	2.33	18.30	660.00	430.50	7.84	79.60
	TW	133.17	88.24	1.15	17.10	580.00	410.20	7.76	25.00
3	SW	711.00	496.23	1.87	16.50	590.00	420.20	7.54	72.20
	TW	112.30	78.15	0.86	15.30	550.00	380.00	7.41	23.20
4	SW	610.00	461.54	1.20	16.20	530.00	395.50	7.36	65.80
	TW	91.42	67.28	0.70	15.80	490.00	370.20	7.28	21.10
5	SW	217.20	162.00	0.60	16.10	510.00	366.10	7.33	60.20
	TW	10.50	11.40	0.30	15.10	466.00	340.40	7.18	18.40
6	SW	203.15	145.23	0.45	16.30	508.00	350.00	7.24	60.00
	TW	7.08	9.80	0.25	15.10	445.00	310.80	7.11	15.90

SW: Sewage water and TW: treated water.

BOD: Biological oxygen demand

COD: chemical oxygen demand

DO: Dissolved oxygen

Tur: Turbidity

TDS: total dissolved solids

As shown in Table 1, some of the water quality parameters have been changed with time and others have no change or changed slightly like pH and temperature. The most important parameter which affect the corrosion process greatly is the dissolved oxygen (DO). The dissolved oxygen in water increases as temperature, pressure, and surface area of water increase. Since oxygen reacts as a polarized cathode in water, it promotes both pitting corrosion and uniform types of corrosion. As shown in equation (1), oxygen works as an electron acceptor that accepts the electron produced by the corrosion of metallic ions, accelerating corrosion as the electron acceptors are converted to hydroxyl ions. Without oxygen dissolved in water, corrosion does not progress [11].

$$O + 2H_2O + 4e^- \rightarrow 4OH^- \quad (1)$$

Table 2: the treatment efficiency.

Run No.	Sample No.	BOD_{in}	BOD_{out}	COD_{in}	COD_{out}	E_{act}	
						According to BOD	According to COD
	1	715.18	133.24	979.40	166.13	81.36	83.00
	2	524.30	88.24	795.50	133.17	83.16	83.25
	3	496.23	78.15	711.00	112.30	84.25	84.20
	4	461.54	67.28	610.00	91.42	85.42	85.10
	5	162.00	11.40	217.20	10.50	92.96	95.16
	6	145.23	9.80	203.15	7.08	93.25	96.51

$$E_{act} = \frac{before\ treatment - after\ treatment}{before\ treatment} * 100 \quad (2)$$

E_{act}: treatment efficiency

3.2 Corrosion rate by tested water

The weight loss results obtained from this test were analyzed to calculate the corrosion rate of the cast iron in both raw (SW) and treated water (TW). Before measuring the weight to determine the difference between the corrosion rates, few procedures were followed. The iron coupons were collected from the test media, cleaned from the corrosive by products, wiped lightly with a brush, cleaned with distilled water, dried for 2 h in an oven at 105 ^{o}C, and weighted. By calculating the weight difference between the weight of the coupons after removing all the corrosive byproducts from the coupons that were soaked for specified time and the initial weight of the coupons, the test compared the weight over time. The corrosion rate was converted to the rate in mdd.

Figure 3 show the weight loss of cast iron coupon over time. Initially, the weight loss was the highest in both SW and TW at 5 and 10 days of immersion but more effective in these coupons immersed in SW than that in TW as shown in Table 3. Also, it was noted that, the weight loss of caste iron became steady after 10 days, and then gradually increased on the 20th day to 30th day in case of SW, while slowly increased in case of TW.

Table 3: The weight loss and the corrosion rates of cast iron in both raw and treated water over time of 30 days.

Time (day)	Weight Loss (mg)		Rate of Corrosion mdd	
	SW	TW	SW	TW
5	0.11	0.07	0.21	0.157
10	0.23	0.12	0.151	0.136
15	0.238	0.123	0.136	0.119
20	0.246	0.158	0.124	0.105
25	0.342	0.162	0.115	0.096
30	0.356	0.168	0.109	0.0901

Figure 4 indicate the corrosion rate of caste iron in SW and TW, the corrosion rates were shown by calculating the weight loss as the unite of mdd. As shown from this figure, the initial corrosion rate of iron was the largest in both SW and TW and then decreased gradually with time. It is believed that such corrosion initially progressed quickly and gradually decreased as time passed. After 20 days it became stable and this could be due to some adsorbed compact oxide layers which suppress the corrosion rate.

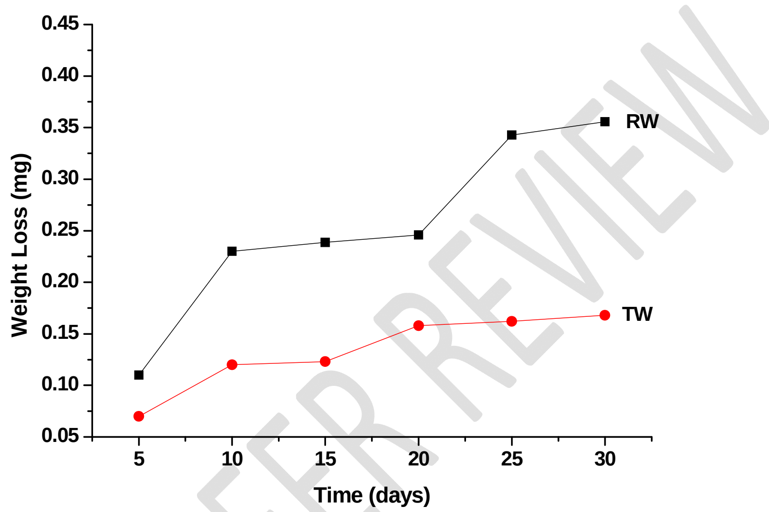

Figure 3: Weight loss of caste iron coupons with SW and TW over time.

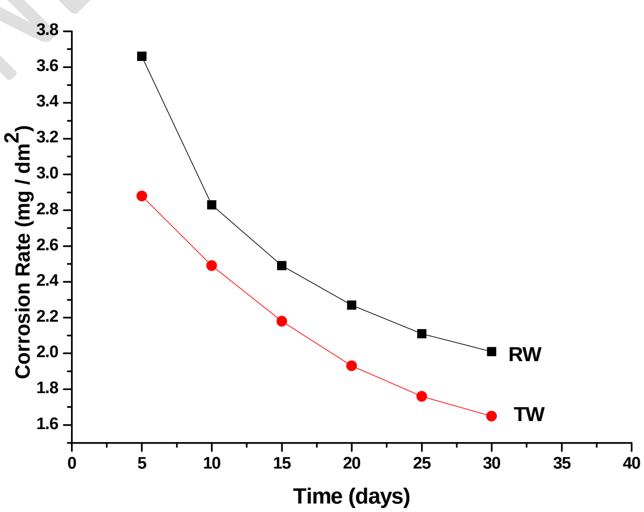

Figure 4: Corrosion rate of caste iron coupons with SW and Tw over time.

4. Conclusions

This study examined the water quality parameters before and after treatment of sewage water by bio filters also, the study observe the corrosion phenomena inside sewage water and treated sewage water and its effect on caste iron when used as tankers or pipes. It is observed that the corrosion rate of caste iron was lower in treated sewage water than that in untreated water.

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