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# Utilizing Nature's Capacity in Reducing the Pollution Load of Industrial Wastewater (Case Study: WWTP in Khayyam Industrial Town, Iran)

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## ABSTRACT

The wastewater produced in industrial towns, is a serious threat for the environment. Utilizing proper methods for treatment of this wastewater has always been a concern. Constructing wastewater treatment facilities is costly. Utilizing the nature's capacities for treatment of the wastewater can reduce the costs of wastewater treatment considerably while have a high efficiency. In this paper the feasibility of utilizing the nature's capacity in Neyshabur (in Iran) for treatment of the wastewater produced in Khayyam Industrial Town is investigated experimentally. The main aim of this paper is evaluation the self-purification of industrial wastewater in Khayyam Industrial Town. For this purpose the effect of natural bed material, the formation of biofilm layer and a BioCord media on TDS, EC and COD is studied. Results showed that in a 7-day period, the bed material, biofilm layer and BioCord media eliminate COD to the amount of 45.9%, 62.2%, and 51.2% respectively. Analyzing the experimental results shows that for industrial wastewater, increasing EC in during time causes increasing TDS linearly. The equation for relation between wastewater parameters, temperature and retention time is presented by using experimental data.
**KEY WORDS:** Industrial Wastewater, Nature's Capacity, Bed Material, Biofilm, BioCord media

## 1. INTRODUCTION

Various industrial activities generate divers pollutions. Raw entry of this wastewater to nature will cause irrecoverable damage to the natural environment. Raw discharge of wastewater to natural environment will reduce the available oxygen of surface waters and adds toxic matters and heavy metals to the ecosystem [1]. Toxic matters and heavy metals destroy live organisms and causes various health hazards for humans. Limited water resources on earth and uncontrolled increase in its consumption, has set off an alarm for a water crisis in the upcoming years [2]. Proper conservation and utilization of water resources is the key to overcome the hardships that are before us. For the purpose of proper utilization of the water resources, reusing the wastewater and construction of necessary facilities for collection and treatment of wastewater is a must. Employment of methods that will reduce the pollution load of the wastewater for its reusing is a priority. Settlement is a low-cost physical mechanism [3]. In this procedure the suspended material in the wastewater is removed and the pollution load is reduced. Parameters like the diameter of particles, temperature of the sample, amount of the entering load, and proportion of the existing particles in the sample contribute to the efficiency of settlement. Using cinder as an absorbent is another cost-effective method with an appropriate elimination efficiency [4]. Abundance and availability, makes using cinder possible as a cost-effective approach for pollution elimination. In their studies on urban wastewater, Chiu et al have approximated the percentage of elimination of COD utilizing cinder up to 35% [4]. Oliviera et al. utilized the wastewater containing solid particles produced in tannery industries as absorbents for removing the tint in textile industries and showed that the solid particles in tannery industries can enhance the tint removal in textile industries [5]. Zheng et al. measured the value of COD elimination using a submerged Nanofilter (membrane plate) in the sample [6]. They reported the ratio of COD elimination as 85%. Similar studies showed that reduction in the value of COD depends on the inner area of the existing pores inside the membrane [7]. Xu et al used BioCord to fill an anaerobic bioreactor in vitamin C wastewater [8]. They reported the removal rate of COD was 55% in optimum hydraulic retention time. Marjaka et al. investigated the ratio of nitrogen elimination TOC, DOC using a porous surface [9]. They showed that with the formation of a biofilm layer on these surfaces, aerobic and anaerobic reactions for elimination of the pollutants is intensify. Lewandowski reported that the formation of biofilm is one of the major factors in membrane biofouling [10]. Yun et al showed that different DO level is the main factor in difference of the natural biofilm that is formed on membrane surface [11]. Other researchers attempted nutrient removal using artificial wetlands and in the end evaluated the ratio of their removal by examining the outflow of wastewater [12]. His Results showed that utilization of wetlands is effective for nutrient removal. Wu et al. studied

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the effect of temperature on activity of the micro-organisms' metabolism and showed that in a certain temperature span these activities increase while the temperature goes up [13]. In their research, they showed that the best temperature span for aerobic activity of micro-organisms is a temperature between 10-35 degrees centigrade. Hattor et al used external Magnetic field for the enlargement of floc and sedimentation improvement [14]. Results showed, addition of $Fecl_3$ enhances the effect of the external magnetic field. Furthermore, PH is also contributing to the activity of micro-organisms and removal of metalloids. Other Studies showed that the best range for the activity of micro-organisms is a neutral PH [15, 16].

Rajasundari and Murugesan verified that bacteria, fungi, and yeast and their oxidative enzymes (peroxidase, laccase) have a great effect on Decolourization and Detoxification of industrial wastewater [17]. Azarpeykan et al., claim that utilizing reverse osmosis in Water Treatent System of Jask City produced less desirable limit in terms of Ca, Mg, TDS Which increased affliction with disease in the consumers and decreasing nutritional value [18]. Yazdanbakhsh et al., employ Electro coagulation–Flotation on olive oil mill natural wastewater in the laboratorial scale bath electrochemical reactor with 1750 ml useful volume. They observed that the efficiency for turbidity, chemical oxygen demand (COD) and phenolic compounds were 99.89%, 96.14%, 89.97% respectively [19]. Slamet and Hermana investigated the effect of light exposure and water depth on COD, nitrogen and phosphate removals to treat municipal wastewater by utilizing a series of lab scale algal bioreactors. The results showed that the maximum of COD reduction occurred in bioreactor operated in 25 cm water depth and with natural lighting during six days was able to remove up to 49%. The better nutrient removal occurred on 40 cm water depth, where the reduction of phosphate concentration up to 75 %; nitrogen as ammonia 98.8 % and nitrogen as nitrate up to 80.2 %. [20]. Among the numerous approaches of wastewater treatment, environmental-consistent procedures have a high importance. Utilization of natural capacities in refinement of pollutants, saves money and reduces the consumption of water resources. Nowadays employing these methods is at the center of attention because of their easy employment, low cost, and high efficiency. The focus of this paper is utilization of methods based on natural capacities for treatment of Khayyam Industrial Town's wastewater in Neyshabur, Iran. Thus, the effectiveness of natural bed materials, formation of a biofilm layer, and enhancement of the effective surface using a BioCord media on wastewater treatment is studied by developing a pilot.

## 2. MATERIALS AND METHODS

In this study, the effect of bed materials, formation of a biofilm layer, and BioCord media on treatment ratio of wastewater is investigated using experimental data. Examined wastewater samples are provided from the wastewater treatment plant in Khayyam Industrial Town. The majority of active industries in Khayyam Industrial Town are dairy, edible oil and fat, and paper industries. The value of the outflow COD from industrial town was varying between 3000-8000 mg/l in the duration of this study. The wastewater outflow of the industrial town, entered the designed pilot.

### 2.1. Characteristics of the Test Basin:

To conduct the experiments and studying the effect of each of the above mentioned parameters, a basin with dimensions of 2.0m×2.0m and a height of 0.6m was constructed in the Industrial Town. To prevent wastewater seepage through the ground, the basin perimeter was insulated using proper material. Figure 1 shows a view of the constructed basin. The wastewater remained in the basin for 7 days after entering the basin and filling it. The initial sampling was done when the wastewater entered the basin and the rest of the samples were taken on days 1, 4, and 7. The wastewater quality parameters including TDS, EC, COD, SAL and PH were examined. For the purpose of uniformity the wastewater sampling was done at 11 o'clock of the proper days. For the duration of the test the temperature of the environment and also the temperature of the wastewater was measured.

Fig 1**.** View of the constructed test basin in Khayyam Industrial Town

**2.2. Investigation of the effect of natural bed materials**

For the purpose of investigating the effect of natural materials of the bed and its contribution to the pace of wastewater treatment, the tests were conducted in two stages. In the first stage, the basin's bed material was selected from available soils in the basin location and 10 centimeters of these materials were used in the basin. In this stage the suspended particles in the wastewater got trapped in the pores that existed in the bed materials. Larger particles settled faster and as the time passed smaller particles settled on the bed materials.

In the second stage of the study, the effect of formation of a biofilm layer on the region's natural bed materials on reducing the pollution load is investigated. In this case the live cells of the micro-organisms attached to the bed materials form the biofilm layer. Micro-organisms use the available organic and inorganic materials in the wastewater as their food source. In doing this, the thickness of the biofilm layer increases by entrapment of other micro-organisms. It can be expected that when the thickness of this layer increases, the capability of elimination of organic and inorganic materials in the wastewater is also enhanced [21].

**2.3. Investigation of the effect of BioCord media**

BioCord media have a wide contact surface and a low volume. Particles with different diameters get trapped in the BioCord's pores. As these pores get smaller, more particles get trapped and elimination efficiency goes higher. For the purpose of investigating the extent to which increasing the settlement surface effects the wastewater treatment pace, the flexible, high surface area BioCord media, supported in structural frames with the dimensions of 1.5m×1.5m is used in the basin. This frame is placed at 0.3 meters from the basin's bed. Figure 2 shows a view of the used BioCord media.

Fig. 2 the BioCord media used in basin

## 3. RESULT AND DISCUSSION

Examination of the taken samples show that variation in their PH was between 6 and 7 in all tests. The effect of natural bed materials, biofilm layer and BioCord media is investigated in above section separately.

**3.1. Natural bed materials**

**3.1.1. First stage**

In the first stage pure natural bed materials are used. The reduction in COD as the time passed are showed in Figure 2. In the initial sampling the value of COD was 3250 mg/l and this value in the 7th day was 1758 mg/l(45.9% removed COD). It is seen that as the time passed, elimination of COD increased but the reduction gradient in the first day is a lot steeper than the days coming afterwards. The reason for this behavior is that larger particles need less time to settle. These particles got into the bed materials' pores in the initial days and thus are removed. The larger particles collided with the smaller ones as they moved and contributed to their adhering together. This way a larger mass are formed and settled. Furthermore as the time passed the micro-organisms covered the bed materials and by trapping other micro-organisms and suspended particles, eliminated the COD.

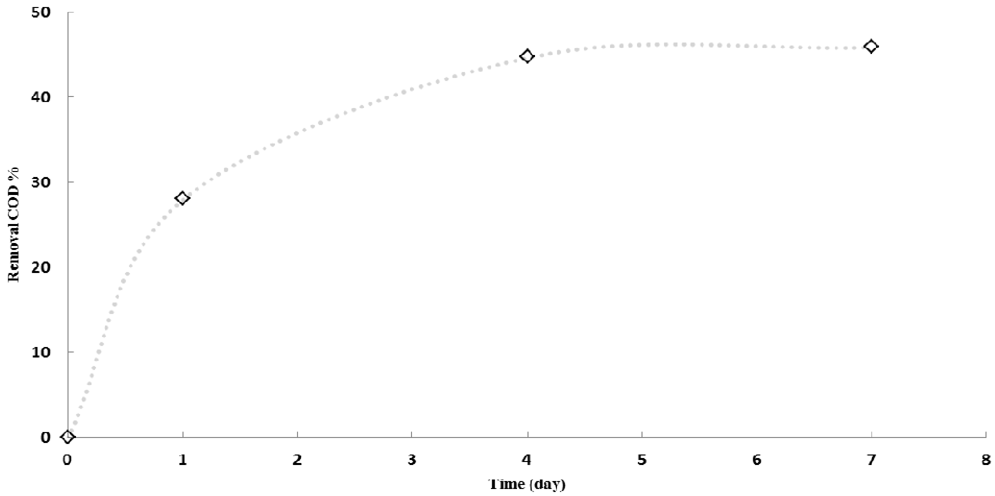


Fig. 3. Reduction in COD by time, using bed materials

When the solved salt in the wastewater crystalizes, it remains in the mix as positive and negative ions. By placing an electrode in the wastewater, the positive and negative ions move to the anode and the cathode respectively. This movement of the ions causes electrical conductivity. Electrical conductivity depends on the temperature. The relationship between EC and TDS for water has a factor of 0.55 to 0.9 and is usually selected to be 0.7 [22]. Grattan et al. gave the relationship for waters used in agriculture as follows [23]:

$EC \leq 5000$: TDS (mg/l) $=0.64 \times EC$ ($\mu$s/cm) (1)

$EC > 5000$: TDS (mg/l) $= 0.8 \times EC$ ($\mu$s/cm) (2)

Variation in TDS with EC is shown in figure 3 using experimental data and a linear equation is fitted to the data. In this diagram, the obtained data from the given relationship by Grattan et al. for agricultural water and also the relationship for drinking water is shown. It is observed that as EC increases, TDS is also increasing almost linearly. This trend is seen in agricultural and drinking waters alike. As the level of impurity in the water increases, it has a negative effect on the movement of ions and causes a decrease in EC. It can be seen that with a unit value of EC, the evaluated TDS in drinking water and agricultural water is always more than industrial wastewater. It is also observed that variation gradient of the relationship between TDS and EC in industrial wastewater is also less than drinking and agricultural water. According this figure, EC and TDS are increased during seven retention time.

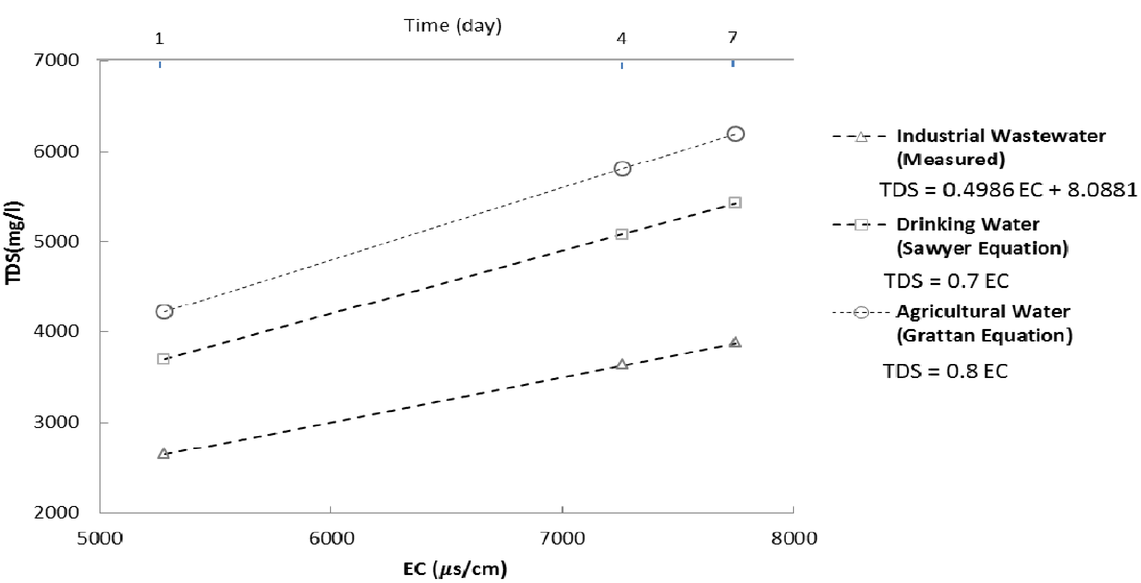


Fig. 4. Variations in TDS with EC, using natural bed materials

As the EC or TDS increases the corrosion property of the water also increases. In other words, between two water samples with the same oxygen and PH properties, the one with the higher EC has a higher tendency of corroding. Thus the increase in TDS and EC in the test basin can be due to evaporation of the wastewater, because the test basin is in the natural environment and thus as the time passes a portion of the sample in it will evaporate. This evaporation can increase the salinity and this increase can reduce the positive and negative ions in the basin, and thus the EC increases. On the other hand the collision between the particles increases as a result of the ions movement in the basin and more solid masses form and settle.

### 3.1.2. Second stage

In the second stage a thin biofilm layer is formed on basin bed. Figure 4 shows the reduction in COD with time when the biofilm layer is present. In the initial sampling the measured COD was 4840 mg/l and this number was 1838 mg/l on the seventh day (62.0% removed COD). A comparison between the obtained results with the data obtained from the test's first stage (Figure 2) shows that existence of a biofilm layer increases the elimination of pollution due to COD. The reason for this behavior is that when the biofilm layer forms, the micro-organisms (M) get trapped on this layer and are eliminated from the sample. Furthermore, these micro-organisms remove the organic and inorganic materials from the wastewater sample by feeding on them as a food (F) [24]. As the retention time increases the amount of organic materials reduces and as a result, F/M decreases. Due to this phenomenon, the micro-organisms enter the self-devouring phase for survival.

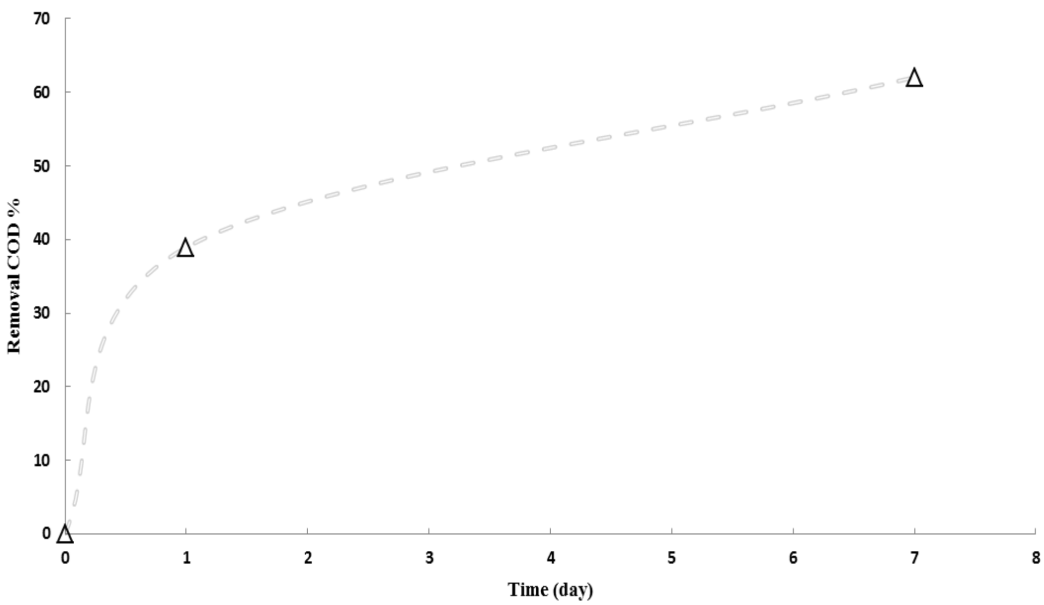


Fig. 5. Variations in COD with time, with the formation of a biofilm layer

Investigation of the relationship between TDS and EC in this stage showed similar results obtained as first stage.

### 3.2 BioCord media

Figure 6 shows the reduction in COD with time using a BioCord media and compare with natural bed materials and biofilm layer data. In the initial sampling the measured COD was 5170 mg/l and this value was 2520 mg/l on the seventh day(51.2% removed COD). It is seen that between the first and fourth days no significant changes are observed in COD elimination, afterward the elimination of COD increases. The results show that the suspended particles in the sample get entrapped in BioCord's pores and reduce the pollution due to COD, while the smaller particles remain suspended. The Brownian motion of small particles and their collision with each other form larger particles. These larger particles can get entrapped in the BioCord media. This behavior cause the pollution on the seventh day reduce. Results show that efficiency of the biofilm layer for eliminating COD is always more than the bed materials and the BioCord media. However, using the BioCord media eliminates COD with a greater pace on the seventh day. According this figure as the time passes COD elimination process will assume negligible when using natural bed material. Also on the first day, the highest COD elimination is achieved by using a biofilm layer.

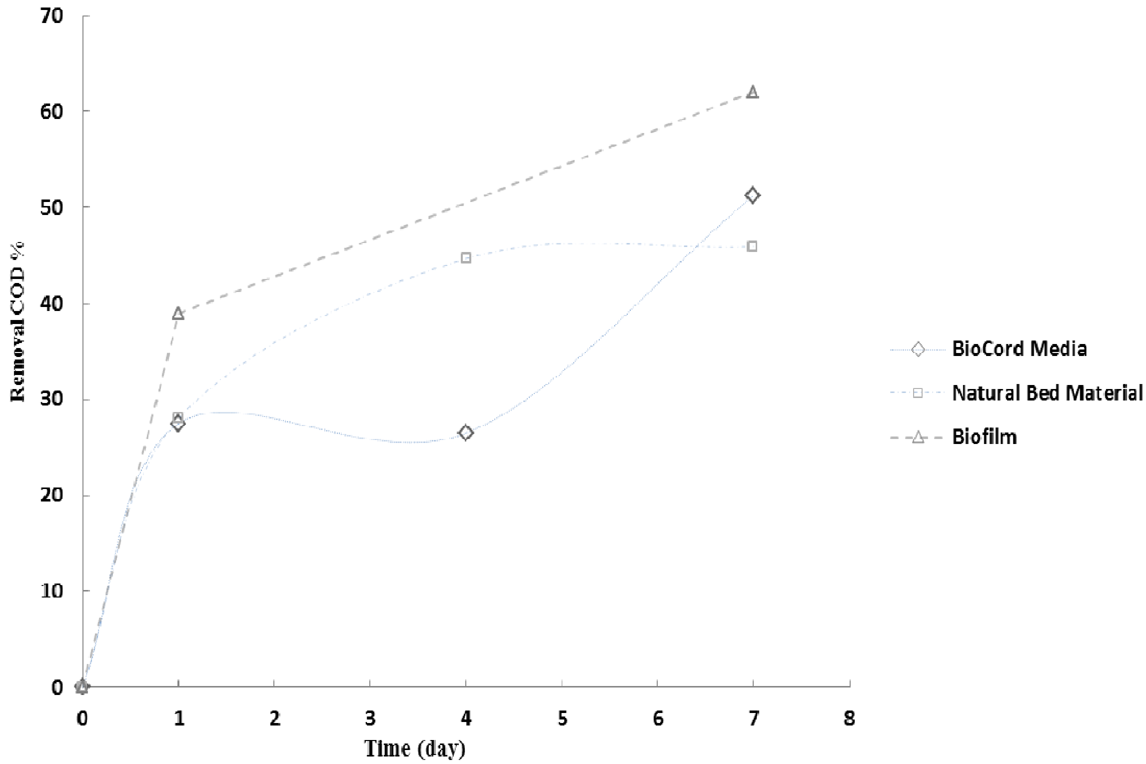


Fig. 6. COD removal with time, using a BioCord media (comparing with natural bed materials and biofilm layer)

Results obtained from this study's experiments about variations in TDS with EC and also the data about the given relationship by Grattan for agricultural and drinking water are shown in figure 7. Similar to previous case, as EC increases TDS also increases almost linearly. It is observed that the approximated value for TDS from the agricultural water is always higher than the drinking water and industrial wastewater.

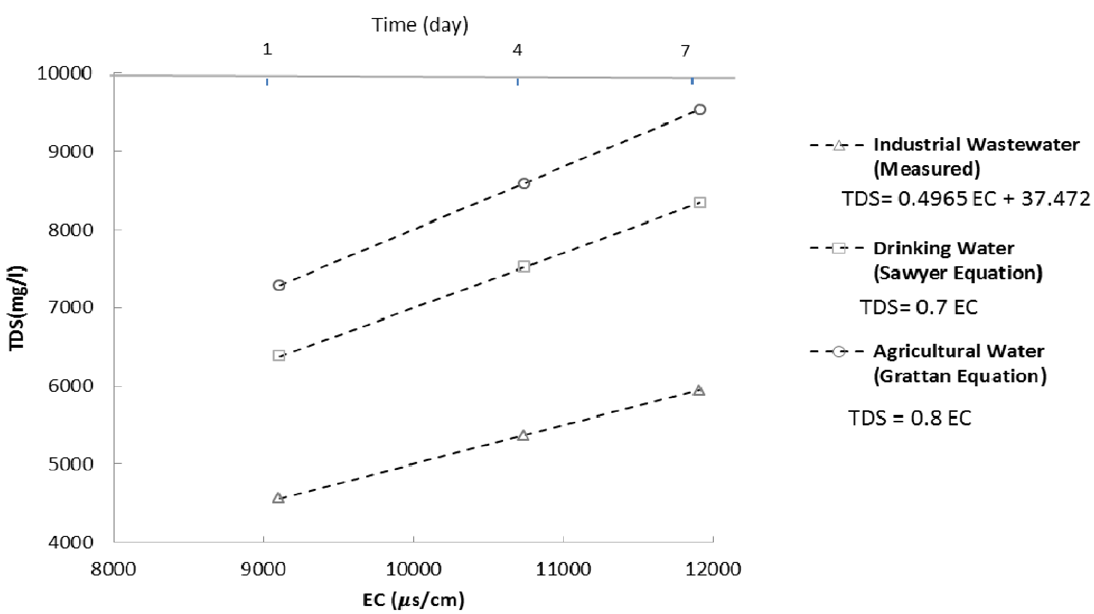


Fig. 7. Variations in TDS and EC with the presence of a BioCord media

A polynomial curve was fitted to experiment results data using MATLAB and the equation is shown here.

$$C = -55.0491\times S + 14.4636\times Te + 5.0325\times S^{2} - 0.2774\times Te^{2} \quad (3)$$

In this equation C, S and Te are removal COD(%), salinity(%) and wastewater temperature(°C) respectively. Salinity is given by

$$S = 0.0011\times TDS + 0.0003\times T \quad (4)$$

Where T is Retention Time (Hour) and TDS define by the equation 5:

$$TDS = 0.5\times EC \quad (5)$$

Experimental results data compared with the polynomial fitted curve (obtaining from equation 3) in figure 8. Two new test data are used for fitted curve validation and also showed in this figure. Validating the equation with the new data indicates an admissible error in prediction of Removal COD.

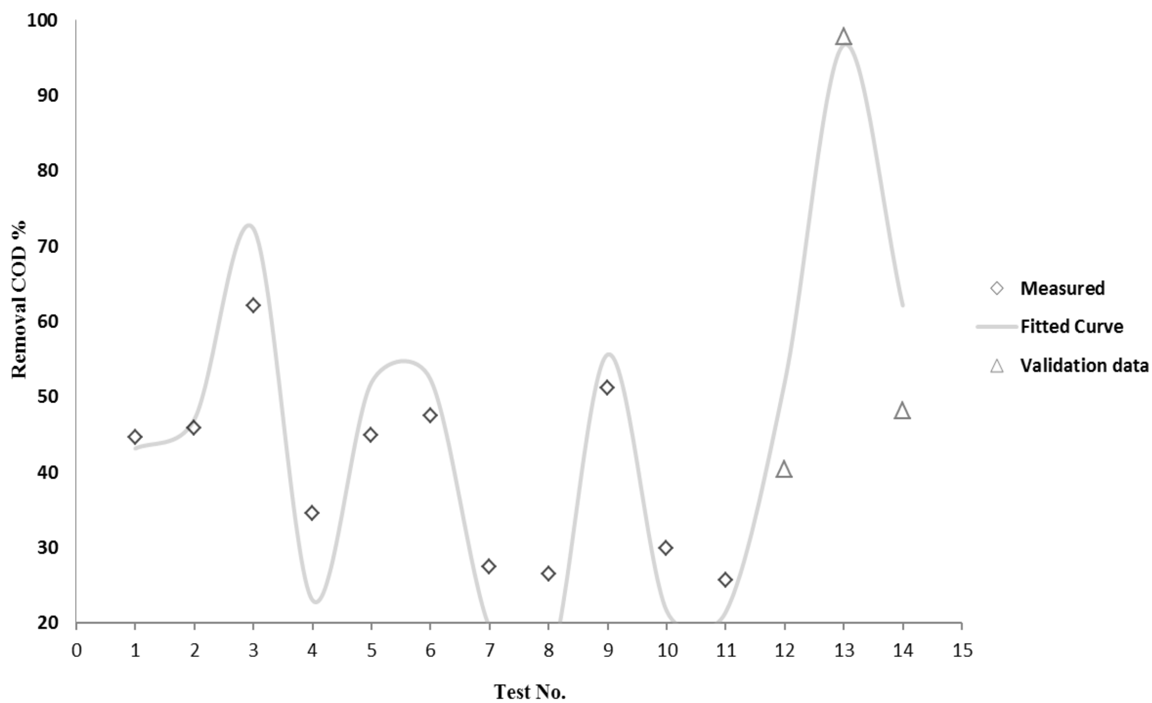


Fig. 8. Difference between the experimental data and the fitted curve in COD variation

## 4. Conclusions

In this study, effect of bed materials, formation of a biofilm layer, and using a BioCord media on treatment ratio of the wastewater in Khayyam Industrial Town was studied using experimental data. Results showed that the region's natural environment and wastewater's vicinity to the biofilm layer eliminate COD to the amount of 62.0% on the seventh day. This number is 45.9% and 51.2% for natural bed materials and BioCord media respectively. Passage of time, increases the variation gradient of COD elimination for the case of using a BioCord media, while the variation gradient of COD elimination decreases with time for the case of presence of natural bed materials. Investigation of EC and TDS showed that a linear relationship with them. A polynomial curve was presented for estimating removal COD in industrial wastewater.

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