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Correlation between Biochemical Oxygen Demand and Chemical Oxygen Demand for Various Wastewater Treatment Plants in Egypt to Obtain the Biodegradability Indices

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Abstract

Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD) are the most commonly used parameters for the characterization of wastewaters. Both of these parameters have advantages and disadvantages, and the choice usually depends on many factors such as the time period required to determine each one of them. It is essential to obtain a correlation between BOD_5 and COD for various wastewater treatment plants, to help in the design and operation of these plants. In this paper, the biodegradability indices (B.I) for several wastewater treatment plants were obtained. The chosen WWTPs covered different regions in Egypt. The obtained correlation between BOD_5 and COD will help in evaluating the treatment processes, which in turn leading to improve the performance of these plants. The average B.I. of all investigated wastewater plants was found to be 0.67. This indicates that generally Egyptian wastewater is fairly biodegradable. El Beheira governorate was found to have the highest mean B.I. of 0.88, while the lowest mean B.I. was found to be 0.49 in Alexandria.

Keywords: Biochemical Oxygen Demand; Biodegradability Index; Chemical Oxygen Demand; Wastewater Treatment Plants.

1. Introduction

Wastewater is characterized in terms of physical, chemical, and biological composition [1]. Depending on the level of pollutants and local regulations; physical, chemical and/or biological treatment may be used [2].

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In a wastewater treatment, organic matter is converted into inert mineralized products under controlled conditions and at higher rates [3]. Organic matter or compounds refer to the general class of chemicals composed of carbon and one or more of thefollowing elements: hydrogen, nitrogen, and oxygen; and are derived from material that was once alive [4,5]. Before any wastewater can be treated, it must first be characterized, because knowing the composition of the influent wastewater is essential for successful design and operation of wastewater treatment plants [6]. The impact of an effluent or wastewater discharge on the receiving water is predicted by its oxygen demand [7]. The two most common parameters used to recognize the composition of wastewater are the biochemical oxygen demand (BOD) and the chemical oxygen demand (COD). BOD_5 is a measure of how much dissolved oxygen is consumed by aerobic bacteria in 5 days at 20^{o}C. It is the broad measure of the strength of the organic matter in a waste stream. The typical range of BOD_5 in domestic wastewater ranges from 100 to 300 mg/L. COD is chemical oxygen demand and is measured chemically by digestion with acid [8]. There exists a definite correlation between the COD and BOD under certain conditions and by determining the COD, the information about the BOD of the wastewater can be derived, but it is highly waste dependent [7,8]. These two parameters have advantages and disadvantages, and the choice usually depends on many factors such as, the reproducibility of the determinations, time period required, location of the test [9]. Although, the BOD_5 test has been in use for more than a century, and consequently remains deeply entrenched in the practice and experience of biological wastewater treatment; the test is clearly lacking in many respects compared to the COD test [10]. On the other hand, COD analysis estimates the amount of organic matter in wastewater in only three to four hours, rather than the five days required by the BOD_5 test, and can be used as an alternative. COD results are typically higher than BOD_5 values, and the ratio between them will vary depending on the characteristics of the wastewater. This ratio has been commonly used as an indicator for biodegradation capacity [1]. It is called "Biodegradability index" (B.I.). It is generally considered the cut-off point between biodegradable and non-biodegradable waste [11]. Once an average B.I. has been established for the plant wastewater stream, COD test can be used to predict BOD_5. The BOD_5-to-COD ratio is typically 0.5:1 for raw domestic wastewater, and may drop to be as low as 0.1: 1 for a well-stabilized secondary effluent. There is no official value for BOD_5 / COD biodegradability index for different types of wastewater [12]. However, reported values for biodegradability index vary from 0.4 to 0.8 , for municipal raw wastewater. The ratio can exceed 10 for industrial wastewater[13]. In this study, eight different wastewater treatment plants (WWTPs), covered all over Egypt and of different sizes, were investigated [10].

2. Materials and Methods

The main objective of the analysis was to investigate the relation between biochemical oxygen demand (BOD) and chemical oxygen demand (COD). this includes determination of ranges and mean values of biodegradability indices in an attempt to make a kind of zoning for the BOD/COD ratio (biodegradability index). Statistical representation and analysis for the collected data were performed. The Different types and treatment capacities of investigated wastewater treatment plants are shown in Table 1.

3. Results and Discussion

Figure 1 shows the variability in average biodegradability index for the different governorates in Egypt. These values were obtained from the available data of BOD_5 and COD for various wastewater treatment plants in each governorate.

Table 1. Investigated WWTP Design Capacities

Plant No.	Design Capacity m^3/d	Treatment Plant	Governorate
1	620,000	Arab Abu Saed	Greater
2	150,000	6 October	Giza

Plant No.	Design Capacity m^3/d	Treatment Plant	Governorate
3	100,000	Qalioub	Greater
4	50,000	Hanoville	Alexandria
5	20,000	El Zarka	Damietta
6	20,000	El Gamalia	El Dakahlia
7	15,000	Eskan Mubarak	Alexandria
8	10,000	Bani Obeid	El Dakahlia

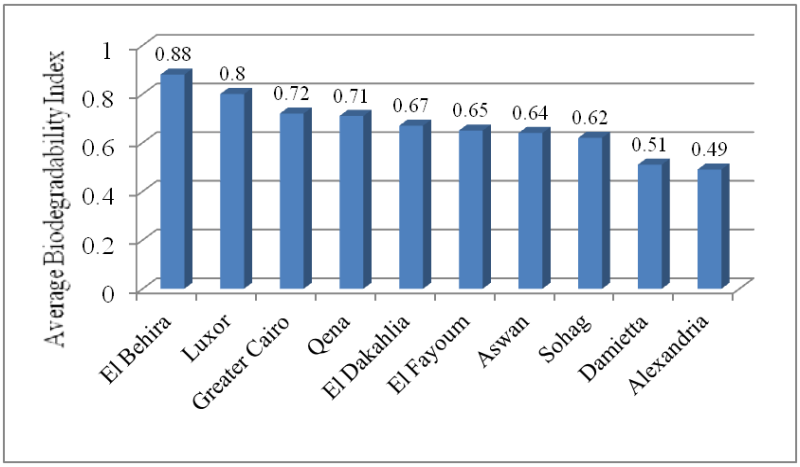

Fig 1. Average bioderadability index

Influent BOD_5 versus influent COD, of wastewater streams entering eight different wastewater treatment plants, were plotted. The data for Arab Abusaed WWTP, Qalioub WWTP, Six of October WWTP, Hanoville WWTP, El Zarka WWTP, El Gamalia WWTP, Eskan Mubarak WWTP, and Bani Obeis WWTP were shown in Figures 2, 3, 4, 5, 6,7, 8, and 9 respectively. These figures provide a clear prospect of the COD-BOD relation in different plants of variable types and treatment capacities. As shown in figures, it is clear that the correlation between BOD_5 and COD is generally linear ,except in some rare cases where the relation was polynomial and sometimes doesn't have a definite pattern (dispersed). However, this rare indefinite pattern might be due to inaccuracy in determination of the BOD_5 and COD parameters in such cases. Since the BOD and COD are correlated, the estimation of BOD_5 values using the quick COD test, and plant specific biodegradability index (which is the slope of the plotted correlation) became possible and relatively reliable. Thus, it can be used as a check parameter to evaluate performance for quick action. For existing wastewater treatment plants the BOD/COD correlation should be developed, to compromise the use of these parameters. In order to establish the BOD/COD correlation for a particular existing wastewater, one should have both COD and BOD_5 values for several representative wastewater samples. Plot the BOD_5 values versus the COD values then use the regression analysis to develop the correlation. The plotted BOD_5-COD figures indicated that there is a clear linear positive correlation for most case studies, which differ from plant to another. Assessment of biodegradability index values periodically, and comparing it to the mean B.I. for the particular wastewater treatment plant can assist in monitoring the presence of toxic and non-biodegradable substances; and hence in applying the appropriate preventive actions. Before choosing the biological wastewater treatment plant technology, it is important to know the biodegradability index of the raw influent wastewater,

as this choice would considerably affect the plant effluent quality. If BOD/ COD is > 0.6 then the waste is fairly biodegradable, and can be effectively treated biologically. If BOD/COD ratio is between 0.3 and 0.6, then seeding is required to treat it biologically, because the process will be relatively slow, as the acclimatization of the microorganisms that help in the degradation process takes time. If BOD/COD < 0.3, biodegradation will not proceed, thus it cannot be treated biologically, because the wastewater generated from these activities inhibits the metabolic activity of bacterial seed due to their toxicity or refractory properties. The relation between BOD_5 and COD for different WWTPs in Egypt are obtained from Figures 8 till 15. Thus, it can be used as a check parameter to evaluate performance of these WWTPS for quick action, and may also assist in monitoring the presence of toxic and non-biodegradable substances**.**

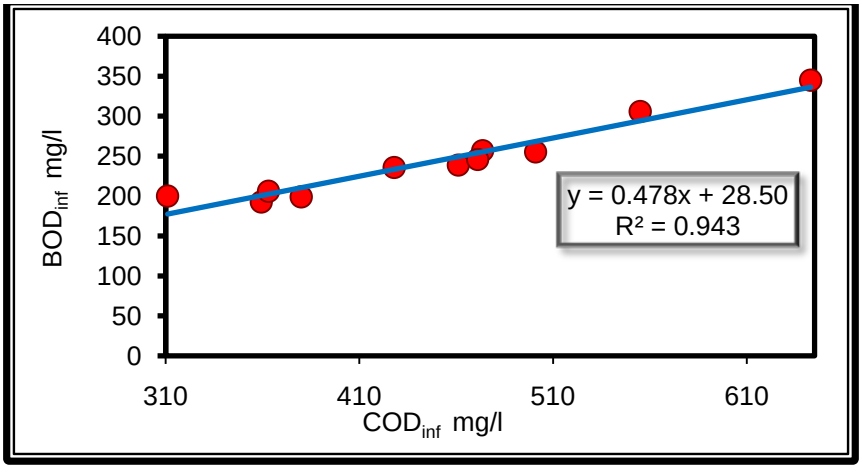

Fig. 2. Arab Abu Saed WWTP, Helwan

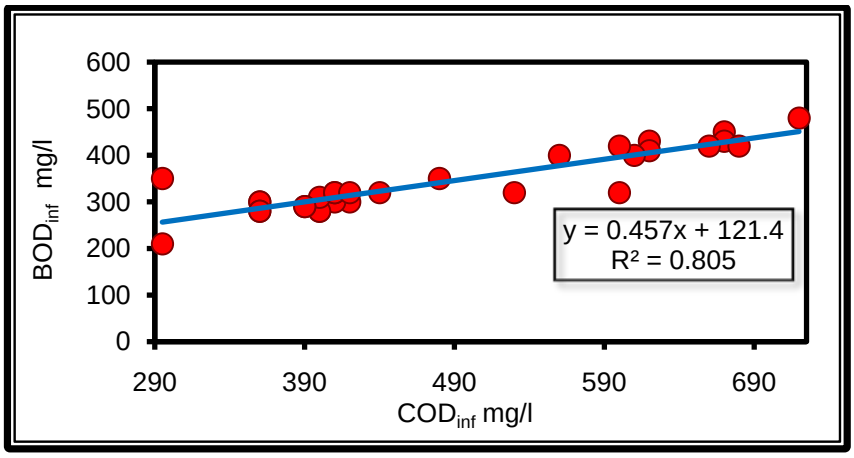

Fig. 3. Qalioub WWTP, Qalioubiya

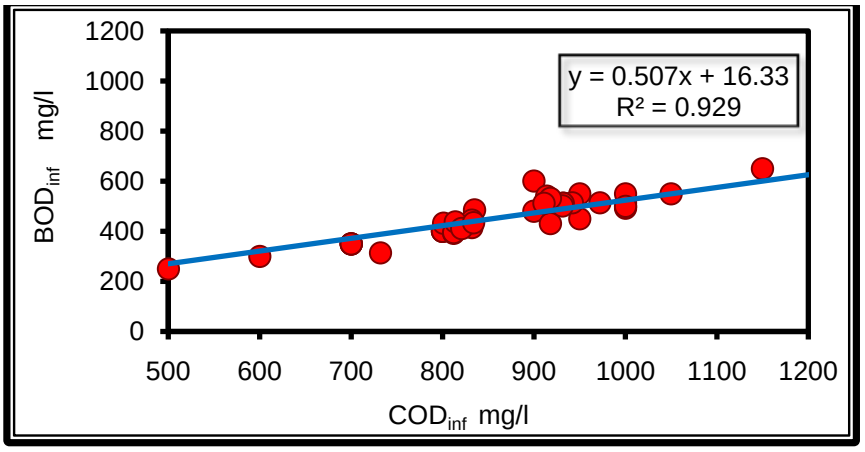

Fig. 4. Six of October WWPT, Giza

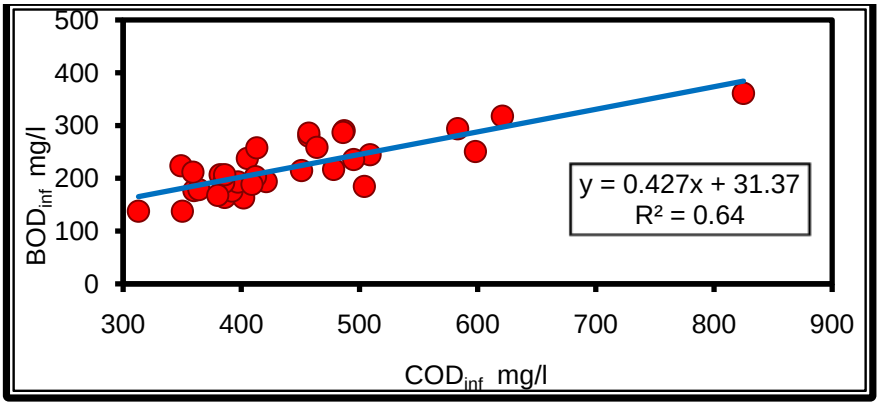

Fig. 5. Hanoville WWTP, Alexandria

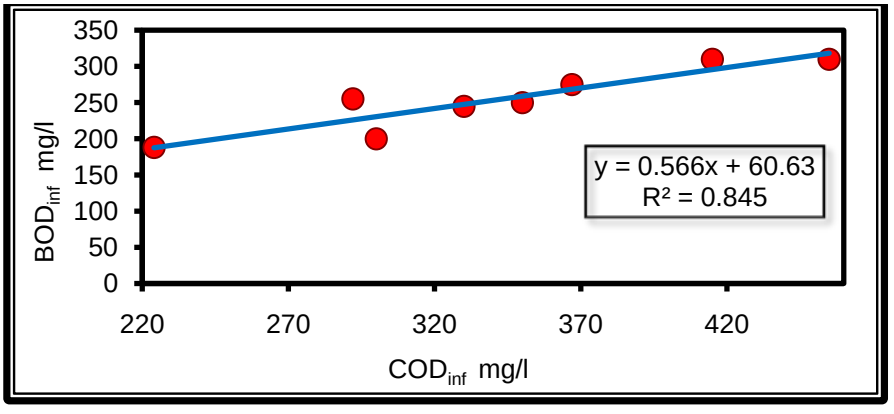

Fig. 6. El Zarka WWTP, Domietta

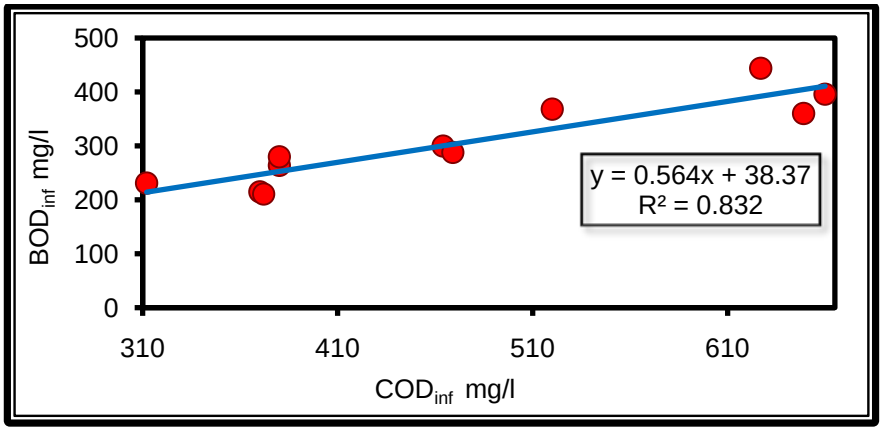

Fig. 7. El Gamalia WWTP, El Dakahlia

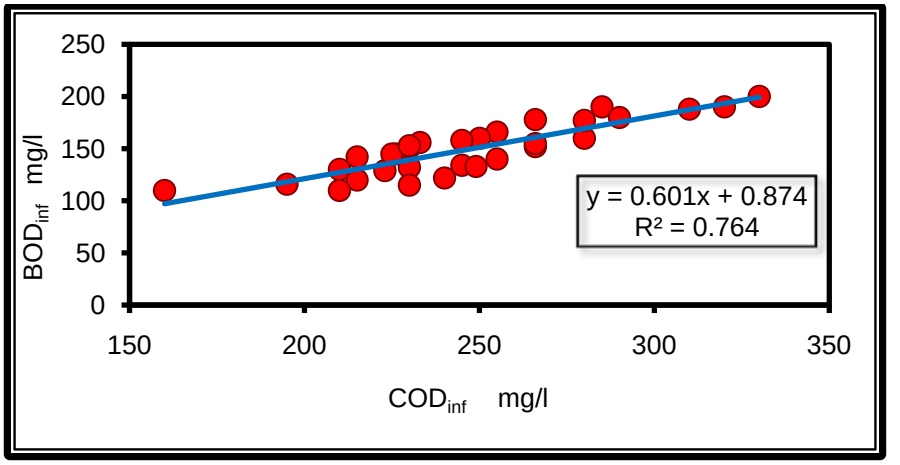

Fig. 8. Eskan Mubarak WWTP, Alexandria

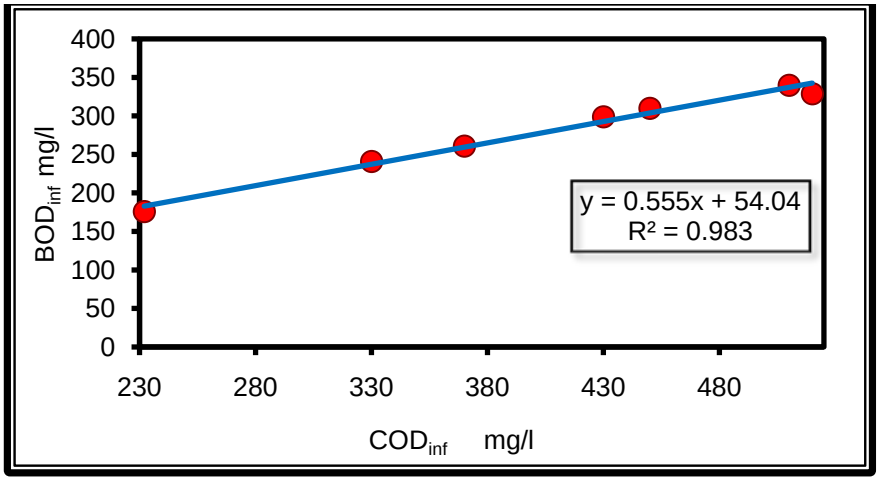

Fig. 9. Bani Obeid WWTP, El Dakahlia

4. Conclusions

The conclusions obtained from this study are as follows;

1. Biodegradability Index (B.I.) for the investigated WWTPs varied from 0.3 up to 0.96, which indicate the variability in the value of B.I.. Thus, a constant ratio for B.I. cannot be assumed unless under identical environmental conditions.
2. Raw wastewater BOD_5 & COD are obviously correlated, and the correlation is a linear positive.
3. The average B.I. of all investigated influent wastewater to wastewater treatment plants was 0.67. which indicates that generally Egyptian waste is fairly biodegradable. El Beheira governorate was found to has the highest mean B.I. of 0.88, while the lowest mean B.I. was 0.49 in Alexandria.
4. Extensive observation of the COD and BOD levels in the same wastewater has shown that the COD to BOD ratio of a particular wastewater will remain constant over time. However, the correlation should be periodically rechecked due to probable seasonal variations in climatic conditions, social customs, water supply characteristics, water availability, population size, or the presence of industrial wastes.

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