Biodegradability and Characterization of Industrial Wastewater in Hungary

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Abstract

Industrial wastewater is a growing environmental challenge which often requires onsite solutions. Yet, as food industrial wastewater usually contains high concentrated organic matters; its biological degradability is usually limited. While food industry is expanding in Hungary, only a handful of studies have discussed the industrial wastewater characterization, which was the focus of this study. Wastewater samples were collected from different industrial sites and characterized in order to determine the initial properties and potential digestibility. pH and electrical conductivity (EC) were measured, liquid and solids were analyzed for a range of physicochemical parameters. Experiments followed established protocols. It was summarized that; the salinity of wastewater estimated by EC was low, pH values were in the acceptable range (>5) and COD, BOD measurements revealed an average -COD/BOD- ratio of (1.2) and a range between (1.0) and (1.6). Furthermore, the sodium absorption ratio (SAR) was calculated. It was concluded that raw industrial wastewater could cause severe problems if dumped into soil (used as a fertilizer) without further treatment considering its high value of SAR (15). Moreover; the preliminary results showed the need of more advanced, efficient and clean treatment techniques for removal of COD and BOD.

keywords: Biochemical Oxygen Demand (BOD); biodegradability; Chemical Oxygen Demand (COD); Sodium absorption ratio (SAR).

Introduction

Increasing amount of industrial wastewater is discharged every year as a result of the significant industrial growth around the globe. Since the 1980s, there are an approximate of 10,000 new chemical compounds are introduced to the industrial activities every year (Tchobanoglous et al.,1991). As a result of the changes in manufacturing technology; changes also occur in the characteristics of the processing wastewater. Moreover, research into the characteristics of industrial processing wastewater has become more extensive lately and the understanding of their potential health and environmental hazards has become more comprehensive. Wastewater can be characterized in terms of physical, chemical, and biological composition (Abdalla & Hammam, 2014).

Industrial effluent varies in composition depending on the type of industry and materials processed in that industrial site (Tchobanoglous et al.,1991). The composition of industrial effluent includes a range of constituents, such as biodegradable and non-biodegradable organic matter, inorganic matter, and potentially inhibitory substances. Industrial effluents may also be severely nutrient deficient and contain high concentrations of heavy metals (Mhlanga & Brouckaert, 2013). However, the flow pattern of industrial effluent streams is mainly influenced by the nature of the operations within a factory, such as shifts, whether a batch or continuous process is used, and more other factors.

Before treatment of wastewater, it needs to be characterized, because knowing the composition of the influent wastewater is essential for successful design and operation of wastewater treatment plants (Sincero & Sincero, 2003). The impact of wastewater discharged on the receiving water can be predicted by its oxygen demand. However, if used in irrigation or dumped into soil; salinity and sodium adsorption ratio (SAR) must be measured to predict its impact on the soil, roots and living microorganisms (Mau et al., 2016).

The two most common parameters are used to study the composition of wastewater are the biochemical oxygen demand (BOD) and the chemical oxygen demand (COD) (Abdalla & Hammam, 2014). BOD_5 is a measure of the amount of dissolved oxygen is consumed by bacteria in 5 days at 20^o C. Despite the fact that regulations for BOD are different depending on the country and region, the typical acceptable range of BOD to be discharged to the sewer systems is no more than 300 mg/L (Abdalla & Hammam, 2014). COD is the chemical oxygen demand and its measured chemically by digestion with acid and it used to determine the amount of total organic matter (including non-biodegradable organic matter) in wastewater (Russell, 2006). COD values are typically higher than BOD_5, and the ratio between them will vary depending on the characteristics of the wastewater. BOD_5/COD ratio has been commonly used as an indicator for biodegradation capacity. COD/BOD_5 ratio is usually under 2.5 for domestic wastewater and it could reach up to 10 for industrial wastewater (Markantonatos, 1990; Papadopoulos et al., 2001). Many wastewater treatment technologies were designed and developed in the past to provide an efficint COD, BOD removal for environmental protection, in addition of clean energy source.

In Hungary, and since the EU accession in the late 90s, a remarkable technological development in the field of wastewater treatment took place to meet high international quality standards (source: Hungarian Central Statistical Office (KSH)). For example, between 2011 and 2015 an equivalent of EUR 2.4 billion (USD 3.1 billion) was spent in developing more than 500 operating wastewater treatment plants in the country, more than 50% of their capacity is used to deal with wastewater with a high organic contents produced by the Industrial section (Hungarian Central Statistical Office, 2014). Specifically, food industry produces the highest concentrated wastewater of organic contents (Galambos et al., 2004). While food industry is expanding in Hungary, only a handful of studies have discussed the characterization of the food processing wastewater which was the focus of this study.

Materials and methods

Wastewater was collected from three different sites in Hungary; two of these were taken from industrial sites: Meat processing wastewater originated from Pick Ltd, Szeged dairy wastewater collected at Örménykút Mozarella Kft. and a municipal wastewater from the wastewater treatment plant of Kiskunhalas city.

Collected wastewater samples were characterized based on the following physicochemical parameters: pH, salinity, total solids (TS), volatile solids (VS), and ash. Organic load (COD and biological oxygen demand [BOD]), were also determined. TS, VS, and ash were determined following the APHA method (APHA; 1992). Samples were stored in a freezer (-15) after sampling. pH and electrical conductivity (EC) were measured using special electrodes and pH meter (CONSORT C535).

BOD was measured by standard methods 5210B using BOD -System OxiDirect (Lovibond);. the initial dissolved oxygen content was measured and then samples were incubated for 5 days at 20°C before BOD_5 measurements. COD was measured using the medium range tubes in accordance with EPA 410.4 and ISO 15705:2002 standards. For COD analysis dilution factor of 10 and thermodigestion at 150 °C for 2 hours was applied. Statistical analysis was performed to determine if the differences between the characteristics were significant. Data was analyzed and one-way ANOVA (single factor) was performed in Excel 2016.

Results and discussion

Wastewater characteristics were evaluated in order to determine the initial properties and potential digestibility. Table 1 shows characterization for different types of wastewater.

Table 1 Wastewater characterization for three different sites. Standard error is shown in parentheses. Statistical differences are indicated by different superscript letters.

Parameter	Örménykút Mozarella Kf	Meat processing	Municipal wastewater*
TS (g/l)	4.0^{a}	2.5^{a}	3.0^{a}
	(0.3)	(0.4)	(1.1)
VS (%) of TS	60^{a}	53^{a}	74^{b}
	(1)	(7)	(4)
TDS(mg/l)	153^{a}	788^{b}	715^{b}
	(2)	(72)	(81)
pH	5.35^{a}	6.05^{b}	7.08^{c}
	(0.1)	(0.0)	(0.0)
EC(mS/cm)	2.15^{a}	1.25^{b}	1.26^{b}
	(0.25)	(0.0)	(0.19)

* Samples were taken from the wastewater plant located in Kiskunhalas city, Hungary.

The organic fraction (volatile solids) of wastewater was around 60% except for municipal wastewater (74%) with significant difference ($P<0.05$). pH was in the acceptable range with values between 5 and 7. Total dissolved solids (TDS) averaged to 700 mg/L except for the dairy wastewater (150 mg/l).

While wastewater has low salinity (<2.5) as shown in table 1, it does have high sodium adsorption ratio (>15). SAR (sodium adsorption ratio) is a measure of the suitability of water for use in agricultural irrigation, as determined by the concentrations of Na^{+}, relative to Ca^{+2} and Mg^{+2}. Sodicity, high sodium concentrations, can cause swelling and dispersion of soil clays, surface crusting and pore plugging, leading to reduced infiltration and increased runoff (Oster, 1994). The presence of divalent ions, namely Ca^{+2} and Mg^{+2} can mitigate the impact of sodicity. Therefore, suitability of irrigation water, in terms of sodicity, can be determined by the relative concentration of these ions. Table 2 shows the concentrations of Na^{+}, Ca^{+2} and Mg^{+2} according to the monthly monitoring report in Feb./2018.

Table 2. concentrations of key elements in dairy waste water (Örménykút Mozarella Kf).

Element	Sodium(Na)	Calcium (Ca)	Magnesium(Mg)
Concentration (ppm)	457	58.1	7.45

Processing wastewater has exceeded the allowable discharge level of COD (300 mg/L), and BOD (50 mg/L) (Table 3). Interestingly, the meat processing wastewater has a significant high concentration of BOD_5 compared to others as shown in table 3 ($P<0.05$). While BOD and COD concentrations of meat processing wastewater coincide with the findings of Johns (1995); the concentrations of municipal wastewater were relatively higher than expected (Henze et al., 2001; Abdalla & Hammam, 2014). This could be attributed to the fact that industrial wastewater with high concentrations of BOD and COD is mixed with the domestic wastewater in the sewage system before reaching the wastewater treatment plant.

Table 3. COD and BOD values of different types of wastewater in Hungary. Standard error is shown in parentheses. Statistical differences are indicated by different superscript letters.

Parameter	BOD_5 (g/L)	COD (g/L O_2)	COD/BOD_5 ratio
Municipal wastewater*	1.9^{a} (0.2)	2.0^{a} (0.2)	1.1
Örménykút Mozarella Kf (Dairy)	2.2^{a} (0.0)	3.5^{a} (0.8)	1.6
Meat processing wastewater	3.0^{b} (0.0)	2.9^{a} (0.4)	1.0

* Samples were taken from the wastewater plant located in Kiskunhalas city, Hungary.

The dairy processing wastewater used in this study is considered as medium strength wastewater, i.e. ranging from 1 to 10 g/L, based on COD values. High COD values in dairy wastewater sample might be obtained considering the high amount of fats being discharged with the processing wastewater. However, low COD/BOD ratio (<10) suggests a degradable effluent with high organic matter. Thus, it can be utilized for anaerobic digestion (Myra et al, 2015). In general, Levels of COD, BOD, pH, TS, and major elements in the untreated wastewater were all beyond the allowable discharge limits, therefore, further treatment before discharge into the drainage canal is needed and required.

Conclusion

Different types of industrial wastewater in Hungary was characterized and proven to be degradable based on low COD/BOD ratio. However, extensive observations of COD and BOD measurements revealed changes due to probable seasonal variations in climatic conditions, social customs, water supply characteristics, water availability, population size, or the presence of industrial wastes. Therefore, the correlation should be periodically rechecked. Moreover, it was concluded that Industrial wastewater has high sodium absorption ratio (SAR). Therefore, Industrial wastewater could cause severe problems if dumped into soil without further treatment.

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