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DETERMINATION OF INERT CHEMICAL OXYGEN DEMAND (COD) FRACTIONS OF CUMHURIYET UNIVERSITY WASTEWATER

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ABSTRACT

Some amounts of inert products are given into environment due to biological degradation of substrate in activated sludge system. The effluent of biological wastewater treatment consists of inert substrate in influent flow, soluble microbial products and non degradable or slowly degradable organic products.

Soluble inert COD (S_I) must be determined for discharge standards since it did not give any reaction in activated sludge system and was given with wastewater discharge. However particular inert COD (X_I) accumulated in system depending on sludge retention time due to it is only wasted from system by wasted sludge.

This study focused on inert fractions of Cumhuriyet University campus wastewater which consists of domestic, hospital and laboratory wastewaters. Experimental method was used suggested by Orhon *et al*. and modified by Germirli *et al.* in order to determine directly influent particulate and soluble inert fractions. According to the experimental procedure three aerobic batch reactors, two with the wastewater and the third with glucose were run parallel. In the reactors, the change in the soluble COD profiles is observed for a period during which all degradable COD is entirely depleted, in other words, the COD profiles reach a plateau and remain unchanged.

Wastewater samples were taken equalization tank in wastewater treatment plant. The conventional parameters of campus wastewater characterization were as follows: Total COD (C_{T0}) = 372 mg l^{-1}, total soluble COD (S_{TO}) = 124 mg l^{-1}, total suspended solids (TSS) =177 mg l^{-1}, ammonia (NH_3) = 31.2 mg l^{-1}, ortho-phosphate (PO_4-P) = 11.3 mg l^{-1} and pH=7,4 .

In this study, in order to determine inert COD fractions in Cumhuriyet University campus wastewater, three aerobic batch reactor systems were used. At the end of approximately 381 h operation, COD composition of campus wastewater were found to be C_{T0}=372 mg l^{-1}, X_{S0}=56 mg l^{-1}, S_{S0}=104 mg l^{-1}, C_{S0}=149 mg l^{-1}, S_I=12 mg l^{-1}, X_I=211 mg l^{-1}, respectively.

KEYWORDS: Activated sludge, glucose, inert COD components, residual metabolic products, campus wastewater, Sivas.

1. INTRODUCTION

One of the biological wastewater systems, activated sludge process, is widely used. The modelling and design of these systems are essential aspect of Environmental Engineering [1]. Conventional activated sludge models composed of single substrate and biomass components are useless in last days. Multicomponent models are chosen for both characterization of raw wastewater and explanation and understanding of activated sludge process [2]. Up to now, activated sludge models used assumed that effluent substrate concentration was independent of influent substrate concentration and substrate characterization of effluent and influent remained unchanged. A lot of research indicated that most of the residual substrate were produced by biomass and effluent substrate concentration related with influent of it. Both influent and effluent substrate components and components of biomass can be determined by using multicomponent activated sludge models recently [2,3].

The important point on multicomponent models of activated sludge systems is determination of wastewater characterization. This depends on organic matter and characterization of wastewater. COD parameter used for substrate determination can not give degradation of organic matter biologically. Therefore, biological degradation parts and inert fraction of COD must be determined since all modelling and calculations of design need to do with biodegradable COD. The determination of particulate and inert fractions of wastewaters are also important in order to regulate the discharge standards and operating conditions [1].

Inert COD parameters considered in modelling and design of activated sludge systems are only not inert COD components in wastewater. It must be also determined the soluble (S_P) and particulate microbial (X_P) products occured with biological growth processes[1]. Inert soluble COD(S_I) and inert particulate COD(X_I) leave the treatment system unchanged, however, X_I is entrapped in the sludge line[4]. Both S_I and X_I inert COD components in wastewaters and also soluble and particulate inert metabolic products occurred in system must be determined in order to assess suitable operation conditions with providing correct modelling and design [1].

In this study, soluble and particulate inert COD fractions in wastewater of Cumhuriyet University and residual soluble inert metabolic products come from biological growth processes were experimentally investigated. Three aerobic batch reactors were used in order to determine inert COD fractions in wastewater composed of hospital, laboratory and domestic wastewaters. Inert COD parameters were observed from batch reactors acclimated with wastewater and glucose and fed with raw, filtrated wastewater and glucose throughout 381 hours.

2. CONCEPTUAL APPROACH

Effluent total soluble COD (S_T) includes non-biodegradable organics from wastewater and same in influent and effluent (S_I), some part of biological degradable amount COD (S_S+S_H) from residual biological oxidation and soluble inert COD (S_P) produced as metabolic product. As a result, effluent generally includes more soluble inert COD than wastewater, since effluent soluble inert COD includes various soluble inert products except soluble inert COD of wastewater unchanged in reactor (S_R)[5].

Experimental method was used suggested by Orhon *et al*. (1994) and modified by Germirli *et al*. (1991) in order to determine directly influent particulate and soluble inert fractions. This method involves running three batch reactors, two with the wastewater to be studied and the third with glucose. One of the wastewater reactors with the total COD (C_{TO}), and the second with the total soluble COD (S_{TO}) and, whereas the initial COD in the glucose reactor is adjusted to equal S_{TO}. The experimental studies are performed until all the biodegradable COD is depleted, where the COD profiles reach a plateau and stay unchanged. As shown in Figure 1, soluble COD in glucose reactor reaches S_{PG} value, as glucose contains no initially inert fraction, being a soluble compound. Total of S_I and S_{P1} reaches S_{R1} values beginning with S_{TO} value. Therefore, S_I value can be calculated as follows [6]:

$$S_I = S_{R1} - S_{PG} \quad (1)$$

Where, two reactor are operated with approximately the same S_{SO}. It is assumed as,

$$(S_P)_{wastewater} \approx (S_P)_{glucose}$$

Y_I coefficient can be written by using S_I and S_{TO}.

$$Y_I = \frac{S_I}{S_{S0}} \quad (2)$$

Y_{SP} stoichiometric coefficient can be formulated with following equation,

$$Y_{SP} = \frac{S_{R1} - S_I}{S_{T0} - S_I} = \frac{S_{P1}}{S_{S0}} \tag{3}$$

First reactor fed with degradable soluble and particulate fractions (C_{SO}) will give high inert soluble COD, S_{R2} because of high S_{P2}. Since S_I is known, the following equations can be written,

$$S_{P2} = S_{R2} - S_I \tag{4}$$

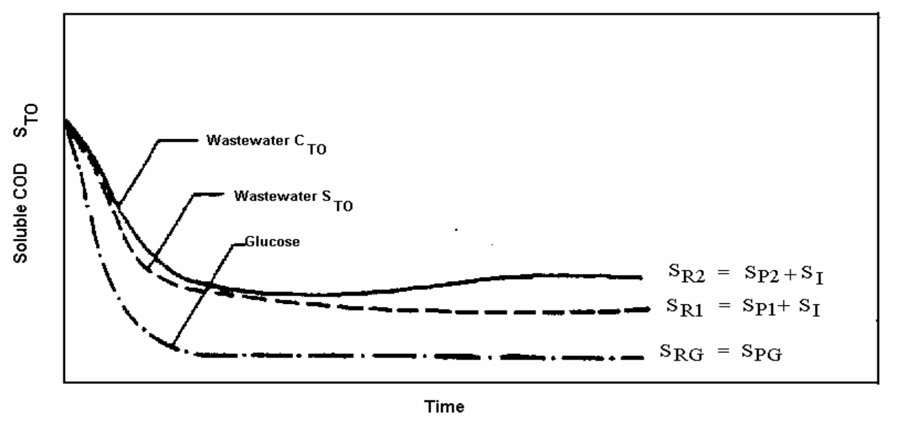

Figure 1. Experimental evaluation of X_I [6, 8]

$$C_{S0} = \frac{S_{P2}}{S_{P1}} S_{S0} \tag{5}$$

and

$$X_I = C_{T0} - C_{S0} - S_I \tag{6}$$

calculated.

3. MATERIALS AND METHODS

3.1. Characterization of the wastewater

In this study, Cumhuriyet University wastewater treatment plant mixture of domestic, comes from faculties in campus dormitory and houses, and hospital and laboratory wastewaters, toxic and harmful, were used. Generally campus wastewaters have different properties than domestic wastewaters considering amount and features of them, since population of campus have various regional differences. While population and average flowrate of campus during the education period were determined as 22435 and 21.48 l s^{-1}, that of campus during the vacation period were found to be 7240 and 14.48 l s^{-1}, respectively in 2003 by Değirmenci *et al.*(2004). As shown in Figure 2 wastewater samples were taken from effluent of equalization tank in Cumhuriyet University Wastewater Treatment Plants.

3.2. Experimental study

Three batch aerobic reactors were experimentally studied in order to determine inert COD fractions based on suggested method by Germirli *et al*. (1991) and Orhon *et al.* (1994). First, second and third reactors were fed with unfiltrated wastewater, filtrated wastewater and glucose including same COD of filtrated wastewater, respectively. All reactors were initially seeded with minimum amount of biomass concentrations (30-40 mg VSS/l) acclimated to a 50% wastewater + 50% glucose mixture. Necessary nutrients were provided by using A and B solutions. Enough air was given into reactors thorough the experiments. Aliquots were removed periodically from the mixed liquor and analyzed for soluble (filtrated) COD. Data were collected until the COD profiles reached a plateau.

Any water loss from the reactors by evaporation was replaced by adding distilled water before measuring COD. All experiments were conducted at room temperature and pH of 7,0-8,0.

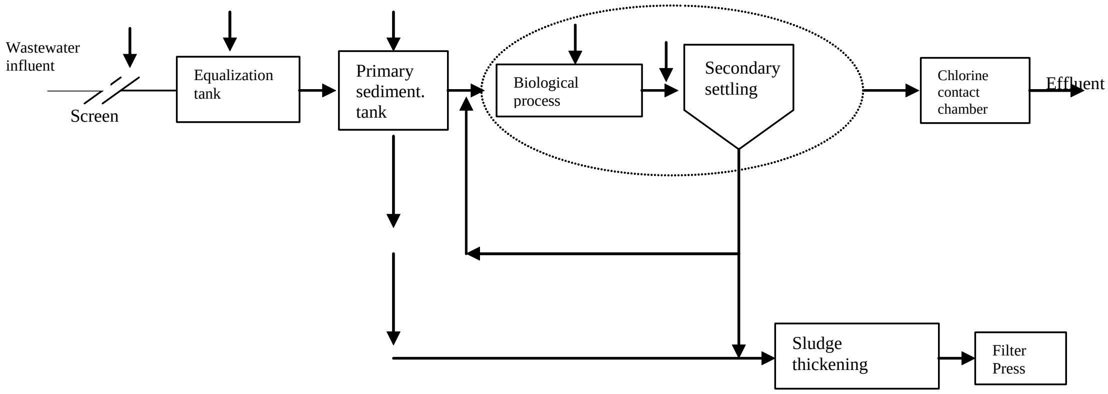

Figure 2. Illustration of Cumhuriyet University Campus Wastewater Treatment Plants

3.3. Analytical methods

All chemical analysis were performed in accordance with Standard Methods [10]. Both suspended solids (SS) and soluble COD fraction were measured using Millipore AP40 filter paper.

4. RESULTS

In this study, effluent of equalization tank in Cumhuriyet University Campus Wastewater Treatment Plants was used (Figure 2). Characterization of wastewater used in experimental study is given in Table 1.

Table 1. Properties of wastewater used in experimental study

Parameter	Concentration (mg l^{-1})
KOI_{total}	372
$KOI_{soluble}$	124
BOI_5	178
SS	177
PO_4-P	11.3
NH_3	31.2
pH*	7.4

*pH unit

Table 2 and Table 3 give results of inert COD determination experiments for three batch reactors and COD composition of wastewater, respectively. Determination of X_I for the campus wastewater is shown in Fig 3.

5. EVALUATION OF RESULTS AND CONCLUSIONS

In this study, in order to determine soluble and particulate inert fractions of wastewaters and soluble metabolic products produced in system, batch experimental study was carried out. This study is important for modelling, design and operation of activated sludge systems and determination of discharge limits.

Experimental study conducted on three parallel batch reactors operated with wastewater sample for 381 hours until it stabilized COD levels. Experimental data were first evaluated according to equation 1, yielding S_I=12 mg $l^{-1}$and S_{P1}=13 mg l^{-1} with corresponding coefficients of Y_I=0.115 and Y_{PS}=0.125. Subsequently, S_{P2} , C_{S0} and X_I were found to be 20 mg l^{-1}, 160 mg l^{-1} and 200 mg l^{-1} respectively by using equations 3,4 and 5.

With the experimental assessment of X_I and S_I, the following initial composition of wastewater sample was determined:C_{T0}=372 mg l^{-1}, X_I=200 mg l^{-1}, S_I=12 mg l^{-1}, C_{S0}=160 mg l^{-1}

Table 2. Results of the inert COD determination experiments performed on raw, filtered wastewater and glucose

	Reactor I fed with unfiltered wastewater Soluble COD (mg l^{-1})	Reactor II fed with filtered wastewater Soluble COD (mg l^{-1})	Reactor III fed with glucose Soluble COD (mg l^{-1})
Start of the experiment	116 (S_{T0})	114	114
End of the experiment	32 (S_{R2})	25 (S_{R1})	13 (S_{RG})
Duration (hours)	381	381	381

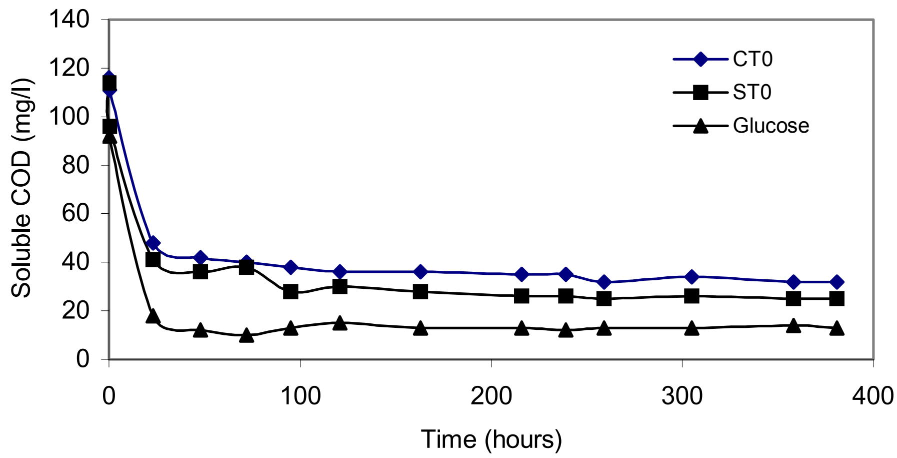

Figure 3. Determination of X_I for the campus wastewater

Table 3. COD composition of campus wastewater determined in this study

Parameter	Campus wastewater sample
Total COD, C_{T0} (mg l^{-1})	372.0
Soluble COD, S_{T0} (mg l^{-1})	116.0
S_{T0}/C_{T0} (%)	31.2
Particulate fraction, X_{T0} (mg l^{-1})	256.0
X_{T0}/C_{T0} (%)	68.8
İnert COD	212.0
Soluble fraction, S_I (mg l^{-1})	12.0
S_I/C_{T0} (%)	3.2
Particulate fraction, X_I (mg l^{-1})	200.0
X_I/C_{T0} (%)	53.8
Degradable COD, C_{S0} (mg l^{-1})	160.0
Soluble fraction, S_{S0} (mg l^{-1})	104.0
S_{S0}/C_{T0} (%)	27.9
Particulate fraction, X_{S0} (mg l^{-1})	56.0
X_{S0}/C_{T0} (%)	15.1

The comparison of this composition with similar typical values shows a very good agreement for S_I, with the 25-40 mg l^{-1} range described in the literature corresponding to S_I+S_{P2}=32 mg l^{-1} in the present study. The X_I concentration of 200 mg l^{-1} is relatively high compared with the range in the literature 25-100 mg l^{-1}. 78 % particulate COD in influent is inert. This is attributed to the fact that except domestic wastewater both hospital and laboratory wastewaters are given into wastewater treatment systems and there is no grit chamber before biological treatment unit.

Evaluation of experimental study indicated that 31.2 % and 68.8 % of total COD were soluble and particulate compounds. 27.9 %, 3.2 % and 53.8 % of total COD were soluble easy degradable organic material, soluble inert and particulate inert material, respectively.

This experimental study showed that inert COD amount of wastewaters changed depending on characterization of wastewater. Therefore, they must be experimentally determined.

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