Which means, 46 g of ethanol requires 96 g of oxygen for the full oxidation to carbon dioxide and water. The theoretical COD of ethanol is therefore 96/46 = 2.09.

The World Engine for Simulation and Training (WEST) package has inbuilt ASMs and provides a modelling and simulation environment for wastewater treatment plants (WWTPs) to develop plant specific models. The models developed are used to assist in setting conditions for the optimization and design of the wastewater treatment process [11]. The basis for the design and optimization of wastewater treatment processes is a properly prepared balance of pollutants in the raw influent and primary effluent. The effectiveness of these processes is determined by the content of biodegradable substances, which are a source of energy (substrate) or a building material for microorganisms [12].

Various methods have been proposed for COD fractionation. The original one, the flow-through activated sludge process method, proposed by [13], has proved to be efficient but is time consuming and requires a complex pilot plant. The principle is the measurement of the Oxygen Uptake Rate (OUR) in an activated sludge process operated under daily cyclic square-wave loading conditions [14]. Batch experiments have proven more useful in estimating the organic biodegradable fractions.

Determining the COD fractions allows for the assessment of the quantity of non-biodegradable pollutants which decrease the effectiveness of biological treatment. Therefore, in the design and modelling of biogenic component removal systems, it is preferable to use the total COD (TCOD) in primary effluent divided into soluble and particulate fractions [15].

The division of COD in wastewater into fractions is shown in Fig. 1

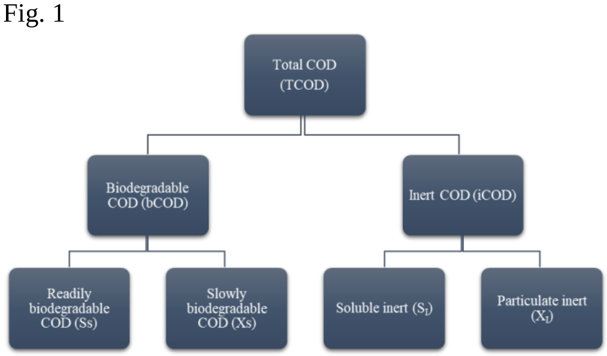

Fig. 1 Distribution of the COD fractions

The TCOD of wastewater, divided into fractions, can be calculated in a simplified way [12]:

$$TCOD = S_S + S_I + X_S + X_I \ (g\ O_2/m^3) \quad (2)$$

where:

S_S - Readily biodegradable COD substrates (soluble),
S_I - Soluble inert organic COD substrates,
X_S - Slowly biodegradable COD substrates (particulate),
X_I - Particulate inert COD substrates,

Table I Share of COD fraction in municipal raw wastewater and municipal wastewater with a significant share of industrial wastewater.

TABLE I SHARE OF COD FRACTION IN MUNICIPAL RAW WASTEWATER WITH A SIGNIFICANT SHARE OF INDUSTRIAL WASTEWATER.

COD Fractions %				
SS	SI	XS	XI	Reference
10-20	7-11	53-60	7-15	[12]
9	4	77	10	[16]
50-61.7	2.2-6	22-34.4	8-16	[12] [15]
20-25	8-10	60-65	5.7	[14]
24-32	8-11	43-43-49	11-20	[12]
36	4	40	20	[10]
Municipal wastewater with a significant share of industrial water				
Textile industry wastewater				
25	14	59	2	[17]
Dairy industry wastewater				
38.8	2.3	45.5	14.8	[12]
Baking industry wastewater				
38.8	1	44.2	15.2	[18]
Oil processing wastewater				
29.2	9.9	37.4	23.5	[19]
Paper industry wastewater				
4.2	39.5	43.1	13.2	[20]

The aim of this study is to fractionate the primary wastewater effluent COD from the primary treatment stage in one of South Africa's WWTP to provide fractions that will serve as input in the WEST for optimization and modelling. The Ss, Xs, S_I and X_I fractions were determined using the OUR batch respirometry method.

METHOD

The study focuses on a centralized WWTP which is situated in the KwaZulu-Natal Province of South Africa. The WWTP receives mixed effluents i.e. domestic wastewater and effluent from nearby industries. The industries that discharge into the WWTP are largely Oil and Dairy. The WWTP is compelled to treat wastewater that is of acceptable final effluent quality that should be devoid of excess organics - COD, ammonia (NH_3), nitrogen and P nutrients and is subject to comply with the national legislative requirements of the Department of Water and Sanitation (DWS).

TABLE II WWTP DISCHARGE LIMITS AS PER DISCHARGE LICENSE BY DWS

Determinants	Units	Value
Chemical Oxygen Demand (COD)	mg O2 /l	75
Ammonia (NH_3)	mg N/l	6
Nitrates (NO_3)	mg N/l	15
Soluble Reactive Phosphorus (SRP)	ug P/l	1000
Suspended Solids (SS)	mg SS/l	25