Physics and Chemistry of the Earth 35 (2010) 828–831

Contents lists available at ScienceDirect

Physics and Chemistry of the Earth

journal homepage: www.elsevier.com/locate/pce

ED-WAVE tool design approach: Case of a textile wastewater treatment plant in Blantyre, Malawi

V. Chipofya [a,*], A. Kraslawski [b], Y. Avramenko [b]

[a] Centre for Water, Sanitation, Health and Appropriate Technology Development (WASHTED), University of Malawi, The Polytechnic, Private Bag 303, Blantyre 3, Malawi
[b] Department of Chemical Technology, Lappeenranta University of Technology, P.O. Box 20, FI-53851 Lappeenranta, Finland

ARTICLE INFO

Article history:
Received 19 March 2010
Received in revised form 12 July 2010
Accepted 18 July 2010
Available online 24 July 2010

Keywords:
Aerobic biological treatment
Case-based design
Case-based reasoning
ED-WAVE tool
Textile wastewater treatment

ABSTRACT

The ED-WAVE tool is a PC based package for imparting training on wastewater treatment technologies. The system consists of four modules viz. Reference Library, Process Builder, Case Study Manager, and Treatment Adviser. The principles of case-based design and case-based reasoning as applied in the ED-WAVE tool are utilised in this paper to evaluate the design approach of the wastewater treatment plant at Mapeto David Whitehead & Sons (MDW&S) textile and garments factory, Blantyre, Malawi. The case being compared with MDW&S in the ED-WAVE tool is Textile Case 4 in Sri Lanka (2003). Equalisation, coagulation and rotating biological contactors is the sequencing of treatment units at Textile Case 4 in Sri Lanka. Screening, oxidation ditches and sedimentation is the sequencing of treatment units at MDW&S textile and garments factory. The study suggests that aerobic biological treatment is necessary in the treatment of wastewater from a textile and garments factory. MDW&S incorporates a sedimentation process which is necessary for the removal of settleable matter before the effluent is discharged to the municipal wastewater treatment plant. The study confirmed the practical use of the ED-WAVE tool in the design of wastewater treatment systems, where after encountering a new situation; already collected decision scenarios (cases) are invoked and modified in order to arrive at a particular design alternative. What is necessary, however, is to appropriately modify the case arrived at through the Case Study Manager in order to come up with a design appropriate to the local situation taking into account technical, socio-economic and environmental aspects.

1. Introduction

1.1. Water quality degradation in sub-Sahara Africa

Malawi, like most countries in sub-Sahara Africa is experiencing industrial growth which is making environmental conservation difficult (Kadogola, 1997; Phiri et al., 2005). One of the pronounced causative factors of water quality degradation is the poor treatment of industrial waste produced by industries. The Malawi economy is predominantly agro-based, but recent years have seen considerable industrial development in and around the four major cities of Blantyre, Lilongwe, Mzuzu, and Zomba. Blantyre, on the other hand, is the country's major industrial and commercial centre since the establishment of the African Lakes Corporation in 1878 (Carl Bro International, 1995).

According to the United Nations Industrial Development Organization 2004 report (IDR, 2004), the textile sector accounted for 10.4% of industrial organic water pollution in sub-Sahara Africa in 1999. Food and beverages accounted for the bulk of industrial organic water pollution (63.2%), followed by paper and pulp (11.2%), chemicals (7.3%), primary metal (4%), wood (3%), stone, glass (0.1%) and others (0.8%).

The discharge of poor quality effluents by industries into the municipal wastewater treatment plants reduces the performance of these treatment facilities over time due to hydraulic overloading and corrosion of the sewer pipe system (Ikhu-Omoregbe et al., 2005). The proper design and operation of industrial wastewater treatment plants is important in order to minimise these negative effects.

The complex nature of the textile industry that arises from the variety of the raw materials used, processes/operations/techniques employed, chemicals applied, products obtained and in-plant measures practiced has its reflection on the quality and quantity of the effluent generated (Orhon et al., 2009).

1.2. Decision support systems for wastewater treatment schemes

An important issue in defining the appropriate treatment schemes for textile and garments effluents is to identify the possible partial pre-treatment requirements of some segregated

* Corresponding author.
E-mail addresses: vchipofya@poly.ac.mw (V. Chipofya), andrzej.kraslawski@lut.fi (A. Kraslawski), yury.avramenko@lut.fi (Y. Avramenko).

1474-7065/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.pce.2010.07.018

wastewater streams. The segregation of certain process discharges having either a toxic and/or recalcitrant nature from the general effluent and passing these discharges through a special type of partial pre-treatment can ease the treatability of the general discharge.

Screening followed by neutralisation and equalisation are the commonly applied primary treatment units prescribed for effluents generated from wet textile and garments factories (Balakrishnan et al., 2005; Orhon et al., 2009). The most commonly implemented biological treatment unit is activated sludge. Effective biological treatment lowers the total COD in the effluent below effluent discharge limitations by removing all biodegradable components. Trickling filters are rarely used biological treatment alternatives (Orhon et al., 2009).

1.3. Case-based design

Case-based design (CBD) is one of the commonly used mechanisms of approximate reasoning in intelligent systems and decision support systems. These mechanisms offer a powerful and general environment in which is generalized a basis of already accumulated experience being represented in the form of a finite and relatively small collection of cases. Those cases constitute the essence of the existing domain knowledge. When encountering a new situation, already collected decision scenarios (cases) are invoked and eventually modified to arrive at a particular design alternative. Case storage is an important aspect in designing efficient CBD systems in that it should reflect the conceptual view of what is represented in the case and take into account the indices that characterise the case. The case-base should be organized into a manageable structure that supports the efficient search and retrieval methods. This is accomplished in the ED-WAVE tool (Fig. 1) (Avramenko and Kraslawski, 2008; Chipofya et al., 2010).

1.4. Case-based reasoning

Case-based problem solving is based on the premise that a design problem solver makes use of experiences (cases) in solving new problems instead of solving every new problem from scratch (Kolonder, 1993). Coyne et al. (1990) classify the case based approach into three activities: creation, modification, and adaptation. Creation is concerned with incorporating requirements to create a new prototype. Modification is concerned with developing a working design from a particular category of cases. Adaptation is concerned with extending the boundaries of the class of the cases.

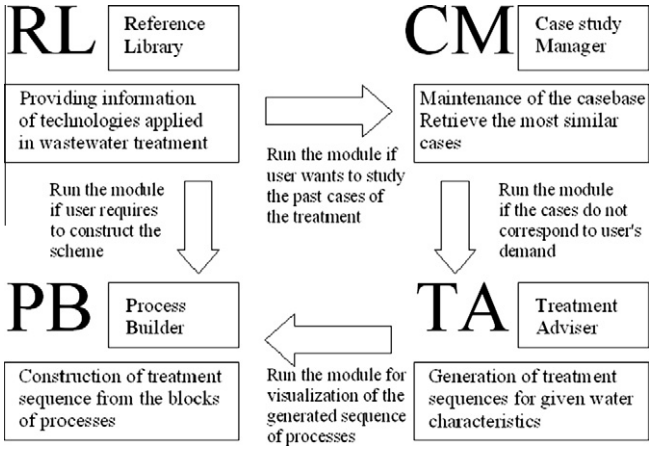

Fig. 1. Schematic diagram of the ED-WAVE software structure. *Source*: Parakeva et al., 2007.

Case-based reasoning (CBR) solves new problems by adapting previously successful solutions to similar problems.

A CBR approach can handle incomplete data: it is robust with respect to unknown values because it does not generalize the data. Instead, the approach supports decision making relying on particular experience (Avramenko and Kraslawski, 2008).

1.5. Technology selection

The technology selection process for a textile and garments wastewater treatment system for MDW&S textile and garments factory is based on the Education tool on technologies for efficient water use using virtual application sites: the ED-WAVE tool in which the principles of case-based design and case-based reasoning are applied (Avramenko, 2005; Balakrishnan et al., 2005).

1.6. Objective of study

This paper evaluates a design approach of the wastewater treatment plant at MDW&S textile and garments factory in Blantyre, Malawi, using the principles of case-based design and case-based reasoning as applied in the ED-WAVE tool.

2. Methodology

2.1. Study area

The study focused on MDW&S, a textile and garments factory in the city of Blantyre, Malawi. The city of Blantyre lies within the Shire Highlands, with a topography ranging from 800 m to 1600 m, in the southern part of Malawi. Malawi lies between latitudes 9° and 17° South and between longitudes 33° and 36° East (Malawi Government, 2007). Climatically, Blantyre like most of the districts in Malawi has two main seasons during the year, the dry and the wet. The wet season lasts from December to May and the remainder of the year is dry, with temperature increasing until the onset of the next rains. The factory at MDW&S has a wastewater treatment plant with a flow rate of 30 m^3/day. The typical wastewater parameters are BOD_5 and COD. The treatment target is to reduce BOD_5 and COD. Chlorides, nitrates, trace and heavy metal contaminants were included in this study in order to facilitate the inclusion of data from Malawi, sub-Sahara Africa, in the ED-WAVE tool.

The effluent from the plant is discharged by sewer to Blantyre wastewater treatment works. This is the largest wastewater treatment plant in the city of Blantyre.

2.2. Data collection and analysis

Data was collected through a desk study which was based on the work by Kuyeli (2007). Sampling was done between the months of October–November, 2005 for the dry season, and February, 2006 for the wet season using the grab sampling method. Samples were collected using 1-l plastic bottles that had been cleaned by soaking in 10% nitric acid and rinsed several times with distilled water. Three 1-l samples were collected at each point.

Chlorides were determined using an argentiometric method where 100 ml or a suitable portion was diluted to 100 ml and the samples were neutralised (pH 7–10) by either sulphuric acid or sodium hydroxide as described in APHA (1985). BOD_5 was determined by the Winkler method of oxygen measurement in the samples before and after incubating for 5 days at 20 °C (APHA, 1985). TSS was determined by filtering the samples through preweighed glass fibre filters as described in APHA (1985). Nitrates were determined using the salicylate calorimetric method as