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Advanced oxidation process and biotreatment: Their roles in combined industrial wastewater treatment

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ABSTRACT

The use of Fenton's reagents in destruction of waste material present in Tambla Tributory (Durgapur,India) industrial wastewater has been investigated. Significant drop in COD removal has been observed. Optimisation of process parameters like pH, temperature, H_2O_2 and $FeSO_4$ has been done. Temperature and pH played a key role in this treatment process, in addition the process initially liberated heat due to reaction between $FeSO_4$ and H_2O_2. From the experimental results it has been observed that with increasing $FeSO_4$ and H_2O_2 concentration the degradation of waste increases. At an optimum concentration of $FeSO_4$ (6 gm/l) and H_2O_2 44.40 gm/l reduced 60% COD, whereas 220gm/l H_2O_2 was required for 95% COD removal. To reduce cost and the H_2O_2 concentration for maximum waste degradation, Fenton's oxidation process followed by biochemical treatment was tried at same experimental condition. The treatment enhanced the overall removal efficiency of COD, BOD, salinity and colour significantly. The microbial treatment by *Thiobacillus ferrooxidans*, following Fenton's reagents treatment, showed that the COD reduction has reached to about 97% compared to 60% with Fenton's reagents and 17% with *T. ferrooxidans* alone in 24 h, showing the synergistic effect. Thus the combined treatment results indicate the possibility to minimize the Fenton's reagents without compromising the efficiency of the process but ultimately reducing the overall treatment cost. This study seems to be very much important and economical by reducing the required H_2O_2 amount to about five times using a suitable micro-organism. This hybrid treatment system showed 97% COD reduction can be achieved within two days.

1. Introduction

The effluents having contaminants such as synthetic chemicals, dyes, organic matters, refractory organic waste, heavy metals etc are discharged to the nearest water bodies with or without any preliminary treatments. This causes serious damage to the DO level and ecological balance of the ecosystem of the nearby receiving water bodies [1,2]. Thus numerous studies are going on for finding a suitable technology to the wastewater treatment. Within that advanced oxidation processes (AOPs) have led the way in the treatment of aqueous waste. It is rapidly becoming the chosen technology for its many applications such as organic pollutant destruction in the form of toxicity reduction, Bio-degradability improvement BOD/COD removal as well as odour and colour removal. Literature reveals that a lot of effluents like carpet dyeing wastewater [3], trihalomethanes [4], cork cooking wastewater [5], synthetic dye Orange II [6], Acid dyebath effluent [7], textile secondary effluents [8], dye wastewater [9] are effectively being treated by Fenton's reagents. Fenton's treatment also improves the biodegradability of the wastewater [10]. The major drawback of Fenton's treatment appears to be the requirement of large concentrations of H_2O_2 and $FeSO_4$ in the treatment process. It is also supported by several studies that the H_2O_2/Fe^{2+} ratio are the key to improve the efficiency of the Fenton's treatment. Tang and Tassos, Kochany and Lugowski [4,11] have pointed out that optimal H_2O_2/Fe^{2+} ratio has to be maintained to achieve the maximal degradation efficiency. The optimum reaction conditions like temperature, pH, H_2O_2 and $FeSO_4$ have to be optimized to achieve maximum waste degradation by Fenton's reagents. Though most of the literature reported [6–8] that 30 °C is the optimum temperature for Fenton's oxidation, there are studies, suggesting that this may vary with the type of effluents [6,7]. Nowadays bioremediation/biotreatment has also proved to be a new technology for wastewater treatment and people are finding the significant role of micro-organisms in reducing the COD level of different types of waste in industrial effluents [12–15]. Among the various micro-organisms studied for wastewater treatment process, chemolithotropic bacteria

Abbreviations: SAIL, Steel authority of India; DPL, Durgapur projects Limited; DCL, Durgapur Chemicals Limited.

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Table 1
The effluent (wastewater) characteristics in Tamla nalah: in general.

Temp. (°C)	30–40
pH	6.5–11.5
Colour	Slight Brownish–dark Brownish
TDS (mg/L) at 105 °C	200–440
TSS (mg/L) at 105 °C	320–450
BOD (mg/L)	900–1100
COD (mg/L)	2700–4000
Phenol (mg/L)	4–12
Cyanide (mg/L)	0.4–2.5
Free Ammonia (mg/L)	45–65
Fixed Ammonia (mg/L)	1100–1800
Oil & Grease (mg/L)	20–40
Sulphide (mg/L)	10–12

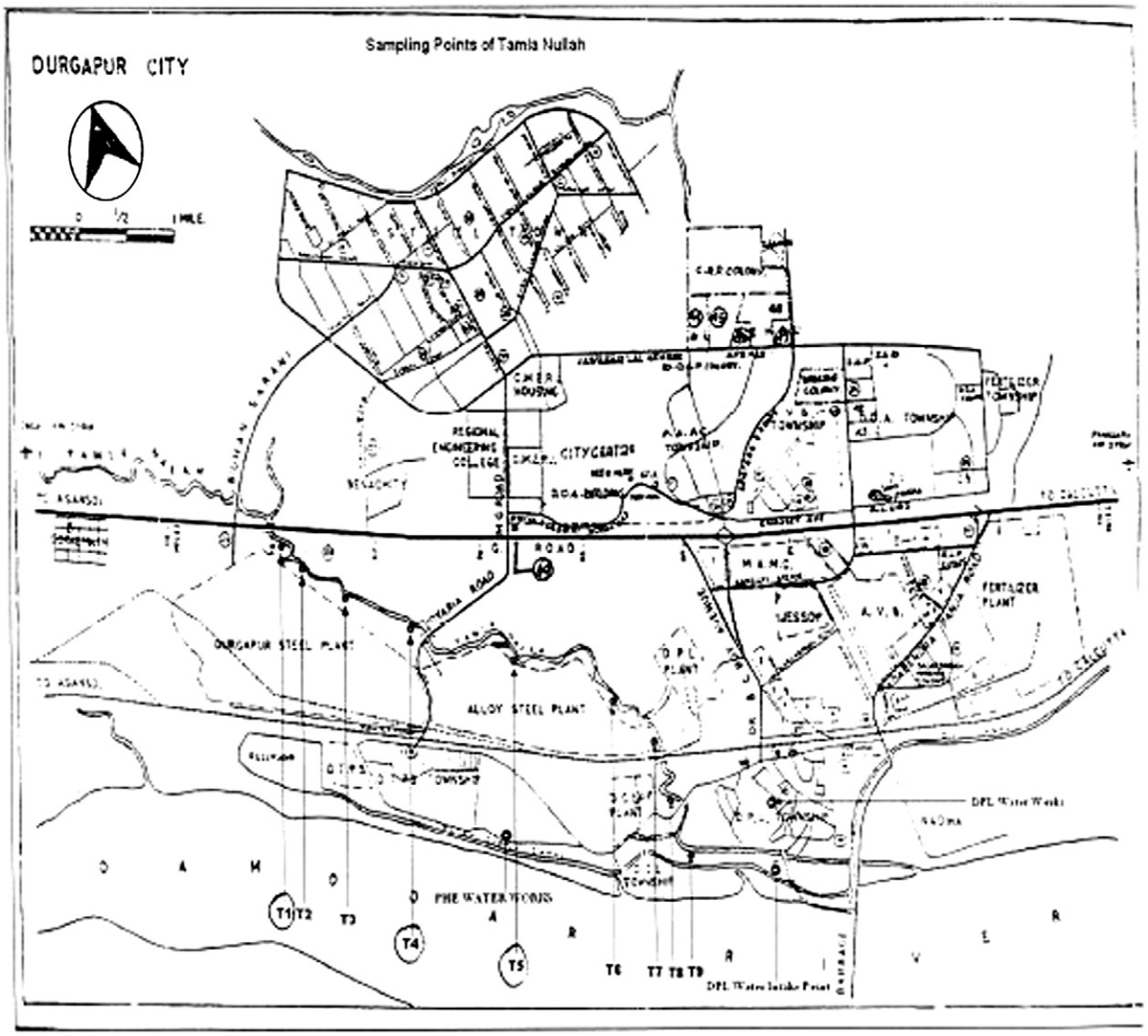
Except these some other unwanted chemicals are available in the Tambla water like Phenolic compound, cyanide as CN, Ca^2, Cr, Cu, Ni, Zn, Mg^{2+}, Fe ion etc.

have shown to have potential role in wastewater treatment under aerobic condition [16–20]. *Thiobaccilus ferrooxidans* is a member of chemolithotropic group and it grows in a $FeSO_4$ containing inorganic media (9 K) at pH 2.5–3.5. Advanced oxidation process reduces the toxicity level of the wastewater and allows the micro-organisms to grows Thus enhances the biodegradability [10]. The present study is therefore designed to see the effect of combination of Fenton's reagents and suitable micro-organisms in wastewater treatment, so that an economical, time saving tools can be designed for effective wastewater treatment system.

2. Materials and methods

2.1. Wastewater

Durgapur is called the rurh of Bengal (W.B, India). A number of giant manufacturing units like Durgapur steel plant (DSP), Alloy steel plant(ASP), Durgapur Chemicals (DCL), Durgapur projects LTD (DPL) and East India pharmaceuticals are located surrounding the city. In addition a number of power plants are there to cater the power demand of various industries and localities. The wastewater generated are normally disposed off to the nearby channel (Tamla tributary) from these industries either with minor treatment or without treatment (Table 1). This channel finally finds its way into the river Damodar, the only potable source of water. Day by day the quality of water is being degraded, which is ultimately affecting the health of human beings and the entire ecosystem of the aquatic life. Wastewater samples were collected from the different points of Tamla tributary (see Pic. 1), which is not the waste of any specific



Pic. 1. Sampling site of Tamla tributary, Durgapur, Dist: Burdwan, West Bengal (India).