

COMPARISON AND EVALUATION OF CURRENT AND INNOVATIVE TECHNOLOGIES FOR INDUSTRIAL WASTEWATER TREATMENT

E. A.TZANOU¹, E. K. OIKONOMOU¹ and A. G. GUITONAS¹

¹ Aristotle University of Thessaloniki, School of Technology, Faculty of Rural & Surveying Engineering, Dept. of Transportation and Hydraulic Engineering.
54124, Thessaloniki, Greece. Tel/fax: +302310996104,
E-mail: etzanou@topo.auth.gr

EXTENDED ABSTRACT

Industrial wastewater discharges and their treatment processes are of great interest for environmental pollution control and management. During the last decade innovative technologies and techniques have been assessed and applied due to the enforcement of discharge regulations. The increasing pressure to comply with the wastewater discharge permits has led to the construction of new and upgrading treatment works and to cost-effective and application-specific treatment processes.

Existing biotreatment processes have proven in many cases inappropriate for degrading and removing organic matter in high concentrations. The main difficulties that usually appear in conventional processing can be overcome by changes in the microbial community during treatment. One of the most problematic areas in biotreatment processes is the biodegradation of fats, oils and grease. These components in wastewater streams require specific technology in order to produce a low-organic loading effluent.

The problem increases because of the fact that industrial units and operators are reluctant of altering the already installed processes. Industries are more likely to construct typical treatment works despite the fact that they might have essential differences in their production procedures and consequently in their discharges.

In the Prefecture of Thessaloniki, a research took place concerning the industrial units which operate during the last five years, according to official data provided by local authorities. This data was processed, analyzed and categorized in order to get information on treatment works operated, their influents and effluents, organic loadings, specialized wastewaters, discharge limits, effluent receivers, e.t.c. The results and conclusions are of great importance because they provide analytical information on environmental pollution, indicate the areas that industrial operations increase, group these industries according to their installations and wastewaters.

Food processing industry showed the greater increase in terms of operating units in comparison to other industrial applications. By taking into account the fact that food industries produce high-strength industrial wastewater because of their concentration in fats and oils, the study was focused on the area of biotreatment which involves the use of specific microorganisms and bacteria. Samples were collected from specific industries and laboratory and pilot work took place. The study showed that improvement in conventional biotreatment processes may be accomplished by the use of bioadditives such as enzymes and specific microorganisms.

Key words: wastewater, biodegradation, fats, oils, microorganisms, enzymes, industrial effluents.

1. INTRODUCTION

The importance of industrial wastewater treatment is well-known for more than 30 years. Treatment processes are of great interest and importance for environmental pollution control and management. Disposal of treated wastewater could be considered as the first step in a very indirect and long-term reuse [2]. The most commonly implemented disposal of treated wastewater is by discharge and dilution into ambient waters. It is of high priority to ensure that effluent discharges to ambient waters or to any kind of receivers, are within the acceptable limits and would not alter or downgrade the characteristics of the environment. Environmental systems and environmental sustainability play an important role in water quality assessment. As far as wastewater is concerned treatment, disposal, control and reuse may be considered as an integrated management system.

Discharges of treated wastewater and runoff from urban and agricultural areas reach in natural water bodies which operate in this case as receivers and their characteristics are often affected and significantly altered due to human activity and industrial activity [1]. Many of these water bodies would be ephemeral in the absence of these discharges. Since policies, legislation and criteria have been set to secure environmental impacts, ways and methods of treatment, control and inspection of dischargers and their effluents are set. The increasing pressure to comply with the wastewater discharge permits has led to the construction of new and upgrading treatment works and to cost-effective and application-specific treatment processes.

Determination of the effluents' characteristics is one main factor in regard to the assimilative capacity of receiving waters and their quality parameters. This is followed the overall approach of considering the receivers as environmental management systems.

Existing biotreatment processes have proven in many cases inappropriate for degrading and removing organic matter in high concentrations. This comes as a result of the fact that treatment works set in industrial units follow conventional techniques without taking into account special influent characteristics and particular treatment requirements. The already installed processes are many times unsuitable and inefficient. Operators are reluctant of altering and improving typical processing because of the cost. This contributes to the fact that inspection and monitoring by the national and local authorities are bare minimum. As a result industries are more likely to construct typical treatment works despite the fact that they might have essential differences in their production procedures and consequently in their discharges.

To assess and to focus on the above, a study took place concerning the industrial units which operate during the last eight years in the Prefecture Thessaloniki. The research constitutes in three parts. The first includes collection and analysis of detailed information on industrial water pollution and industrial effluents. The second focuses on the categorization according to organic loading and biological characteristics of industrial wastewater and the final part is a particularization on effluents and their treatment from food industries.

2. DATA COLLECTION AND ANALYSIS

The data collected concern wastewater from industry and manufacture operating in the Prefecture of Thessaloniki from October 1997 until October 2004. Data were provided by the Environmental Protection Office, department of Pollution Control and Sanitary Protection of the Environment and it regarded installation active during the aforementioned period.

The data were recorded in a database of 32 different fields containing, among other, information of name of industry, type, category, class, area, location, date of establishment, operation permission given by the Environmental Office, existence of wastewater treatment unit, wastewater flow, influent characteristics (BOD, COD, etc.), effluent characteristics (BOD, COD, etc.) way of discharge, receiver and its discharge limits. More than 320 industrial operations were established during the research time period while a similar number of industries applied for permanent permission of operation by submitting an Environmental Impact Assessment (EIA) or by undergoing Environmental Auditing at the same time. Until the year 1997 (from the first submission of EIA in 1973), 1271 industries and manufactures record existence and operation of their treatment units. These figures (figure 1,2 and 3) give an idea of the situation and industrial activity in Thessaloniki, although it is not representative because there were many small-scale industrial applications that were not registered and were illegally operating.

During the categorisation of data two aspects were examined. The first dealt with spatial information and distribution of industrial applications which provided information of application density in specific areas. The whole area of study was separated in ten distinct regions according to location and watershed for discharge. Also some sub-categories were introduced in order to group industrial applications by type of effluent discharge (surface discharge or not).

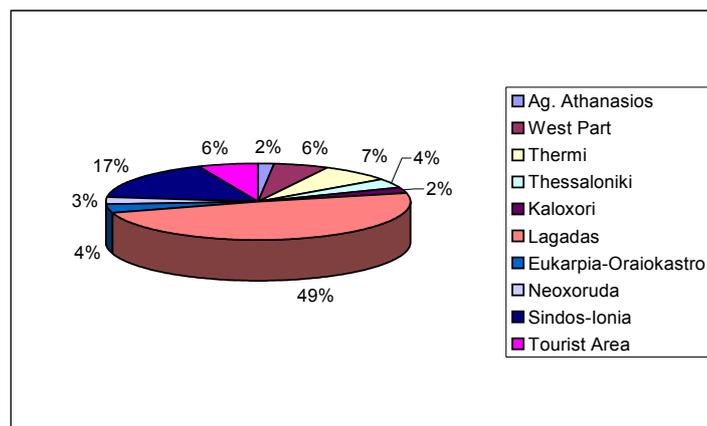


Figure 1. Distribution of Industrial Applications during Study Period

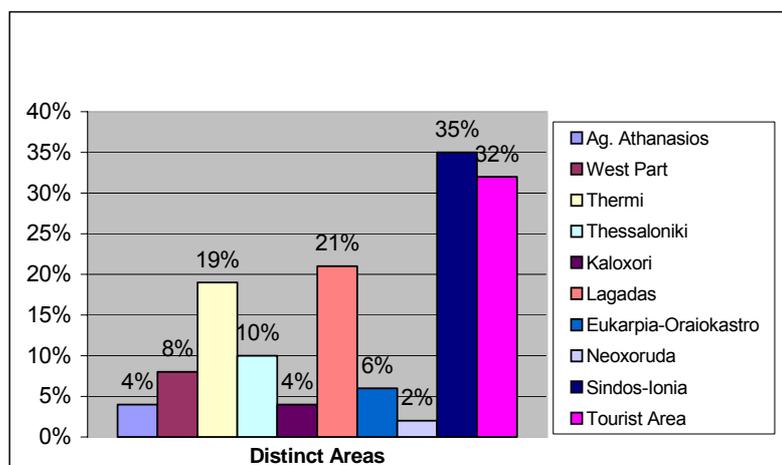


Figure 2. Increase percentage of Industrial Applications during Study Period

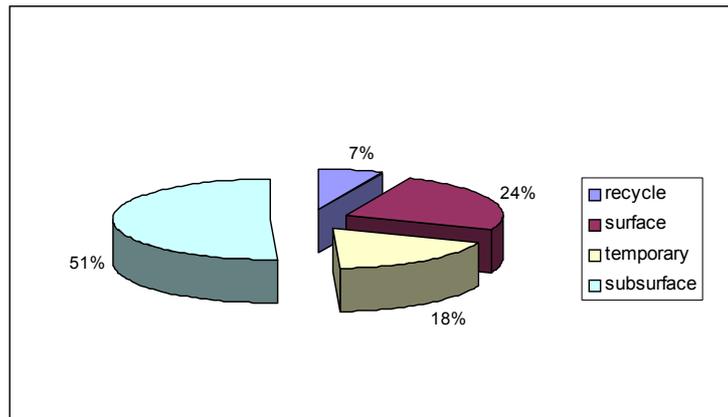


Figure 3. Estimation of Discharge Type for 2005

3. VARIATION OF CHARACTERISTICS OF INDUSTRIAL WASTEWATER

In order to group industries by production processes that consequently lead to similar types of wastewater 14 classes were introduced. These include paper industries, metal industries, chemical industries, food industries, pesticide industries, pharmaceutical industries, textiles, slaughterhouses etc. It should be mentioned that domestic liquid wastes, hospitals and clinics constitute a separate category.[4] One important parameter for this classification was the wastewater treatment process installed in each case. Industrial applications showed a respectable growth, with food processing industries taking the first place. Food processing presented an overall increase of 39% in comparison to the number of installations in 1997.

In most cases wastewater treatment units are constructed and operating by conventional methods, including the typical form of pre- and primary treatment, biological treatment processes and sludge handling and disposal. After spot tests that took place in selected sites one could come to the conclusion that neither the nature of the industry nor the projected uses of the effluents in the receiving streams were highly taken into consideration in order to adjust treatment processes so as to effectively remove waste constituents before discharge. The fact that very few industries are identical in terms of waste loadings and their variations leads to the necessity of assessing each one as a unique case. According to researchers [3], the main constituents of industrial wastewaters to be removed are: soluble organics, suspended solids, priority pollutants such as lipids, phenols, carcinogenic substances, heavy metals, toxic organics, color, nitrogen and phosphorus. It is obvious that for industrial waste minimization and treatment one could not stand in conventional series, methods and co-processing. The selection of process should depend on characteristics as biodegradability, toxicity, effluent quality and cost-effectiveness.

4. CASE STUDY. FOOD PROCESSING WASTEWATERS

For wastewaters containing nontoxic compounds, process designed criteria are able to be obtained either from the available data or from laboratory research. For this reason food processing wastewaters were selected as significant wastewater streams to be evaluated. These wastewaters present high concentrations in oils and fats and may act

as inhibitors in the treatment process. In many cases their complete removal and degradation is enforced by law. Oil and grease separation tanks do not reach complete removal. As a result these compounds show high concentrations in the following stages of treatment where they significantly decrease biological reaction rates and organic removal [5]. High concentrations may cause problems as: a) toxicity when discharged in receivers and ecosystems, b) reduce or cut down the activity of microbial communities responsible for degradation and c) are not easily biodegraded and specific microorganisms and enzymes are needed.

4.1 Novel Applications on Industrial Wastewater Treatment.

For the laboratory work samples from meat and poultry industries, fruit and beverage industries and dairy industries were collected. These wastewaters had high organic loadings, significant variations in pH values and different flow rates. The aim was to focus on new techniques for wastewater biodegradation in order to remove oils and fats from the waste to compare with conventional methods. Microbial growth and enzymatic activity were studied for each case in order to isolate the predominant microorganism responsible for maximum biodegradation and grow it in specific substrate concentrations. Moving from laboratory research to industrial-scale applications gave the ability for improving techniques, redevelop installations and produce environmental-safe effluents.

Microbial growth was studied in batch and continuous systems-reactors. Main parameters studied were carbon source, phosphorus and nitrogen, inorganic substances present in the substrate, biomass concentration, substrate concentration, temperature and pH [7]. The metabolic activity was realized by the presence of enzymes performing as endogenous biochemical catalysts in living organisms. The majority of enzymes produced were lipases (EC 3.1.1.3.) They proved to be versatile biocatalysts while their concentration was controlled in respect to temperature pH and substrate concentration.

Experimental results showed that in all samples there were two predominant groups of microorganisms responsible for biodegradation. Microbial identification procedures (isolation techniques, API kits etc) showed that bacterium *Pseudomonas Aeruginosa* (figure 4) and fungus *Rhizopus Oligosporus*. Maximum specific growth rates μ_{max} and saturation constants K_s were determined. Optimum temperature and pH were also determined. *Pseudomonas* showed high relativity to the substrate since it was obvious that it could grow in low substrate concentrations. By altering and modulating treatment conditions according to the microbial communities, temperature, pH and enzyme concentration maximum performance would be obtained [6].

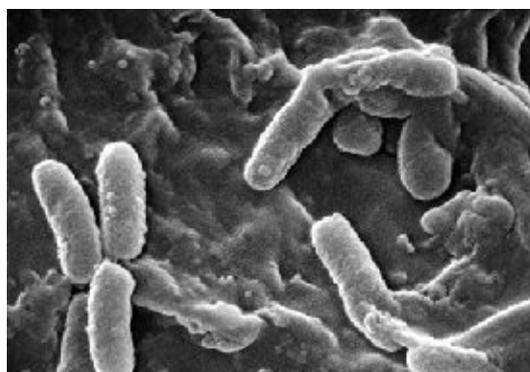


Figure 4. *Pseudomonas Aeruginosa*.

Source:www.bacteriamuseum.org/species/pseudomonas.shtml

5. CONCLUSIONS

Existing wastewater treatment processes in the Prefecture of Thessaloniki have proven in many cases inappropriate for degrading and removing organic matter in high concentrations. This study took place concerning the industrial units which operate during the last eight years in the area. The research constitutes in three parts. Collection and analysis of detailed information on industrial water pollution and industrial effluents was performed and gave an overall idea for the present situation. Categorization according to organic loading, biological characteristics and treatment methods of industrial wastewater took place. The research results showed that typical treatment processes are many times inappropriate and for that reason further study on innovative methods and techniques was introduced.

This study showed that by applying laboratory research in specific types of wastewater will increase the performance of treatment processes by adjusting it to particular needs, will consequently increase removal rates of organic substances. Using new technologies on industrial wastewater treatment such as adding or cultivating specific microbial communities in the treatment process, is cost and time-efficient and is a reliable way of monitoring and control for industrial wastewater treatment processes. This research if expanded in more industrial applications shall give useful information on wastewater capable of co-treatment, and reformation of wastewater processing.

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