

Selecting the Optimal Urban Wastewater Treatment Process in the Various Climates by Using Analytic Hierarchy Process (AHP)

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Expanded Abstract

Introduction

Along with expanding urban population and development of cities, and resulting increase in demand for water, in recent years production of municipal wastewater has grown drastically. On the other hand, enhanced public awareness about the water pollution problems has mandated stricter environmental rules and penalties concerning wastewater discharge. These have led to rapid the construction and installation of urban Waste water treatment plants. Now production of significant volumes of domestic wastewater and uncontrolled discharge into receptive and underground water resources, faced the planners of the national projects with serious problems. Such that predictions indicate until the year 1400 about 800 urban wastewater treatment plants are obligatory in the country that necessitate enormous financial and human resources investment. Such an investment entails conscious selection of treating process according to the economical and engineering criteria. In recent years, many studies and optimization models are considered to choose the best wastewater treatment process. Although, most of them have only regarded the financial costs of the investment and operation, while the best option is not always the cheapest one. Selection of the optimized process of municipal wastewater treatment is an important and multi-dimensional issue. If we regard outcomes of a failed plan and wasted investment, the essence of satisfaction of environmental standards based on a systematic and scientific procedure to select the treatment process will be multifold. Such a process should maintain minimal environmental effects and economic feasibility together. In selecting the appropriate option for wastewater treatment, adoption of primary factors and decision criteria require close attention as well. Since most of these factors are complexly interrelated, i.e. change in one parameter nonlinearly affect rest of the parameters, setting up a decision-making model and interpolating it with a set of effective and independent parameters is challenging. Hence, the use of Multi-Criteria Decision-Making (MCDM) techniques would be helpful. Several MCDM methods are presented up to now, such as weighted sum model, the TOPSIS method and Analytic Hierarchy Process (AHP). AHP is a useful method while working with multiple and probably opposing criteria and objectives. Adoption of AHP enables us to evaluate the different objectives and to determine differences between two options by "priority vectors". The ultimate goal of this approach is to identify the best option and also sort all possible options according to compatibility with all decision criteria simultaneously.

Materials and Methods

Present contribution is an analytical- descriptive study that is conducted in 1392 in order to select the optimal municipal wastewater treatment process and to evaluate the adequacy of wastewater treatment processes based on the results from five categories sorted by climates of the country. The population of this study includes municipal wastewater treatment plants (both operational or under construction) existing in the country according to the latest statistics released by the National Water and Wastewater Engineering Company in 1389.

Climatic division of the country

To prepare any research proposal, gathering information about the target area is important. In other words, if

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information concerning the area is collected precisely, estimations of the plan will be more appropriate and during execution fewer problems will arise. In this research, due to the unique climatic diversity of the country and to decide the optimal process of wastewater treatment in these different climates, the country is divided into five categories of mountainous, Khazari, Mediterranean, semi-desert and desert climates. This division is adopted according to the climatic classification in Publication No. 117-3 (revised in 1392).

Treatment alternatives

According to available statistics and information, currently the most common methods in municipal wastewater treatment in the country are: activated sludge, stabilization pond, aerated lagoon and trickling filter methods. More than 90 percent of the municipal wastewater treatment plants in the country utilize one of these four processes. Then these four processes seem to be appropriate candidates for treatment options in different operating areas. In addition to popularity of these methods, another reason to choose them as optimal treatment processes is that facilities and most of the equipment needed during these processes are produced inside the country, and also underlying technologies are accessible in the country. In present situation that the country is under different sanctions, inaccessibility to a technology or its inherent equipment, will take it out of the possible implementation list. Therefore, different and innovative processes (such as membranous processes) that are currently implemented in developed countries, were not in our list of the appropriate treatment process choices.

Decision criteria

According to conducted studies and data gatherings, selection of the appropriate treatment process for each basin is regarded in terms of environmental, economic and technical criteria. Also because of extensive range of each of the mentioned criteria, sub-criteria were defined for each to achieve reliable results.

Data collection and evaluation of the parameters

In order to collect data and comments to resident experts in each climate category, five types of questionnaires were prepared. Each of the questionnaires consisted of two sections. In first part, criterion and sub-criterion priorities was investigated in target climates with the help of paired comparison matrices and in the second part, significance of each treatment option is evaluated relative to respective criterion and sub-criterion. After data collecting by questionnaires, obtained information are reviewed and analyzed by a team of experts.

Results

In order to choose the optimal wastewater treatment process in the five climate categories, four popular processes were regarded, *i.e.*, activated sludge, aerated lagoon, stabilization pond and trickling filter, in current study. Considering environmental, economic and technical factors and respective sub-criteria the mentioned options are sorted by feasibility for each category utilizing AHP.

In the mountainous climate, activated sludge, aerated lagoons, stabilization ponds and trickling filter processes have obtained these weights: 0.347, 0.269, 0.209 and 0.174 respectively. Also in this climate, among the deciding factors, environmental criterion with a weight of 0.558 has greatest importance. Technical criterion (0.320) lies in second place of importance.

In the Khazari climate, activated sludge, trickling filter, aerated lagoons and stabilization ponds obtained these weights: 0.340, 0.273, 0.204 and 0.183 respectively. Also in this climate, among the main factors, environmental (0.683) and technical (0.200) criteria are most affective factors.

In the Mediterranean climate, activated sludge, aerated lagoons, trickling filter and stabilization ponds possess weights of 0.334, 0.234, 0.231 and 0.201 respectively. Also in this climate, among the deciding criteria, environmental criterion with 0.540 weight is more important and technical criterion lies in second place of importance with a weight of 0.297.

In the semi-desert climate of the country, stabilization ponds, activated sludge, trickling filter and aerated lagoons processes showed these weights: 0.276, 0.273, 0.270 and 0.181 respectively. Also in this climate environmental criterion with 0.493 weight, technical criteria with 0.311 weight are the most important factors.

In the desert climate of the country, stabilization ponds, trickling filter, activated sludge and aerated lagoons processes are sorted by their weights of 0.292, 0.266, 0.247 and 0.195 respectively. Among the affecting criteria, environmental criterion has a greater contribution (0.493) while economic criterion takes the second place with a weight of 0.311.

Discussion and Conclusions

According to the results of Analytical Hierarchy Process to select the optimal urban wastewater treatment procedure for different climates, environmental criterion is the most important among the three mentioned criteria in all climates and its highest weight is obtained for the Khazari climate (0.683) and the lowest weight is in the desert and semi-desert climates (0.493). the high priority of environmental criterion for the Khazari

climate can be explained due to natural conditions of mentioned region and factors such as tourism industry, high groundwater levels, numerous rivers and other environment-related factors to the of region. Also, technical criterion is in second place of importance in four categories: mountainous, Khazari, Mediterranean and semi-desert climates. Its highest weight is observed in the mountainous climate (0.320) and the lowest weight in the desert climate (0.196). The priority of technical criterion in the mountainous climate is a result of the sensitive ecological conditions and poor performance of the most wastewater treatment processes in cold weather.

Based on the results in three climates of mountainous, Khazari and Mediterranean activated sludge process is observed as the most appropriate treatment option. Its highest weight is in the mountainous climate (0.347) and the lowest weight is in the desert climate (0.247). Also, in desert and semi-desert climates stabilization pond is obtained to be the most appropriate treatment option. The highest observed weight for this process is in the desert climate (0.292) and the lowest weight is in the Khazari climate (0.183). The highest and lowest weights of aerated lagoon process is achieved in mountainous (0.269) and semi-desert (0.181) climates, respectively. Finally, the highest and lowest weights of trickling filter process is respectively achieved in Khazari (0.273) and mountainous (0.174) climates.

Keywords: analytical hierarchy process, optimal process selection, urban wastewater treatment.

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