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ORIGINAL ARTICLE

Cost/Benefit Evaluation Of Wastewater Treatment Plant Types (SBR, MLE, Oxidation Ditch), Case Study: khouzestan, Iran

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ABSTRACT

In respect to the change of climatic conditions and global warming, the position of water sources in many countries is in crisis. Therefore, constructing sewage treatment plants is of the first priorities of developmental plans aiming at preventing from the pollution of water sources and reusing the sewage , but owing to investors' insufficient awareness of the economic interests of these plans and the lack of calculation of their cost and benefit indices (CBI) investment in this sector is limited to the governmental capital. To solve this problem, the selection of the best and most economic choice is a vital issue and wrong choice increases cost and does not bring about desired results. In this research, a comparison of a number of sewage treatment methods and their costs has been made to optimize using financial resources and creating an appropriate managerial view in this regard. In this direction, the calculation of per capita cost in different processes and the drawing of comparative diagrams as well as the economic benefits of the plans have been determined in order to determine CBI and break-even points for the use of private sector's investors. Furthermore, for a more suitable utilization of the research's results and the decrease of the effect of the price fluctuations, financial calculations are made based on Euro foreign exchange. While the examination of different methods of sewage treatment , appropriate method with population in the hot and dry climate are determined.

Keywords: *Financial Resources, Sewage Treatment Plant, CBI, MLE, SBR*

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INTRODUCTION

The increase of the public awareness of water pollution problems in recent years has made to enact new and strict laws of the environment concerning sewage draw.[1] This issue has increased the speed of constructing and installing sewage treatment plants particularly in the developing countries and similar to the all developmental plans, on of the most important issues regarding designing and constructing sewage treatment plants is selecting the best and most economic choice according to the existing conditions and future perspective[2] so the wrong choice can have an intense effect in increasing costs as well as the lack of achievement of desired result So while other research's has examined such as "Economics of wastewater treatment cost-effectiveness, social gains and environmental standards"[3] , "Economic feasibility study for intensive and extensive wastewater treatment considering greenhouse gases emissions"[4] , "Wastewater reuse in the absence of water scarcity and a market: A case study from Beaconsfield Tasmania "[5] , the cost of construction of wastewater treatment also has been studied in various methods. and calculating their construction cost to optimize financial resources of urban Water and Wastewater Company. According to the limitation of developmental credits of the administrative organizations as one of the major reasons of inaccessibility to the qualitative objectives of the projects and incompleteness of a major number of the mentioned plans, in this research, while technical and economic comparison of a number of sewage treatment methods and quantifying working values and construction costs of sewage treatment plants in the form of case, the required credit for constructing them is calculated as per capita (in lieu of each person). Compiling comparative table of costs substantially contribute to the selection of the most appropriate methods. The construction of urban sewage treatment plants not only develops and promotes regional hygienic indices, but also s among the most necessary developmental plans f the country owing to the global water crises as well as significant growth of population that have doubled the harmfulness of the occurred drought. According to the fact that investment of the governmental and private sectors requires accurate study of costs and incomes of the plans, the lack of accurate and case researches in this regard, seriously has challenged attracting capita and constructing sewage treatment plants. Therefore, in this research, it is attempted that while comparing designing sewage treatment plants in different methods, their construction costs and financial benefits of the plan, break-even points of the investment are determined.

MATERIALS AND METHODS

The methodology includes the following processes:

- Compiling initial information including quantitative and qualitative information.
- Selecting study methods.
- Initial design of the sewage treatment plants based on the intended processes.
- Calculating the initial estimation of constructing sewage treatment plants.
- Calculating cost per capita of constructing sewage treatment plants.
- Calculating CBI.
- Calculating break-even points and the ratio of benefit to cost.

Initial information including quantitative and qualitative information

Wastewater quality parameters are as follows and As you can see , all the Parameters are in the normal range (Table 1). : Qualitative Principles and Selecting Study Methods are presented in [Table 2] and [Table 3].

Table 1: Qualitative principles

Parameter	Sewage Treatment Plant A	Sewage Treatment Plant B	Sewage Treatment Plant C	Sewage Treatment Plant D	Sewage Treatment Plant E
mg/l BOD5	280	200	202	215	231
mg/l COD	300_500	300_500	300_500	300_500	300_500
No/100mL Coliform	10 million	10 million	10 million	10 million	10 million
Input Sewage Temperature	1530	1530	1530	1530	1530
mg/l NH3	25	25	25	25	25
mg/l TKN	35	35	35	35	35
PH	78.5	78.5	78.5	78.5	78.5

Table 2: Quantitative principles

Title	Principles	Year	
		Basis Year	First modulus
Sewage Treatment Plant A	Population (person)	246330	374550
	Capacity	46704	75060
Sewage Treatment Plant B	Population (person)	135423	176973
	Capacity	38308	48222
Sewage Treatment Plant C	Population (person)	55768	80179
	Capacity	12129	19604
Sewage Treatment Plant D	Population (person)	77100	101200
	Capacity	18536	25013
Sewage Treatment Plant E	Population (person)	175700	252500
	Capacity	40969	61731

Table 3: Sewage treatment methods

Order	Sewage Treatment Plant	Selection Process
1	A	SBR
2	B	MLE
3	C	CAROUSEL (Oxidation ditch)
4	D	MLE
5	E	MLE

Brief Description of Each Process

Process Description of SBR (Sequence Batch Reactor):

SBR is a type of biological process of sewage treatment in which all biological treatment processes including biological oxidation, secondary sedimentation, nitrification and mud digestion are carried out in a reservoir. This method is also called Draw & Fill and is considered a suitable choice for sewage treatment of types of industrial and hygienic sewage with a small population.

SBR reactor is a type of inconsistent reactor in which sewage current is intermittently entered into the reactor and then after sewage treatment operations, treated sewage is existed from the reactor in a certain period. Thus, if sewage current exists constantly, several SBRs should be used in a parallel way.

A SBR system may include one or several reservoirs. In the biological sewage treatment, each reservoir has five separate phases. Each of these phases is named according to the work that it does.

These phases include:

1- Fill phase: the phase of the raw sewage entrance.
2- React phase: the phase of conducting biological reactions.
3- Settle phase: the phase of separation of microorganisms from treated wastewater.
4- Draw phase: the exist phase of treated sewage.
5- Idle phase: the phase after drawing and before refilling reactor.

In each complete cycle, Draw & Fill phase should be existed, but other cases may be eliminated when if necessary in particular cases.

Process Description of MLE (Modie d Ludzack-En ger):

MLE process is a suspension growth process with a consistent current used to eliminate nitrogen biologically. This is the modified process of Ludzack-En ger Process. In this method, to supply greater nitrate density in anaerobic part, a return line from aerobic part is placed to the anaerobic part that increases denitrification and completely eliminates nitrogen in relation to the state of Ludzack-En ger.

MLE system is designed in a way that not only has suitable efficiency in eliminating sewage organic and microbial pollutions, but also has the potential to eliminate nutrients to draw wastewater to the shallow waters based on the standard of Iran's Environmental Conservation Organization.[6]

Process Description of CAROUSEL (Oxidation ditch):

CAROUSEL process is a type of oxidation ditches. In oxidation ditches, instead of an air-supply pool, a long and shallow ditch in the form of a closed ring is use. Using revolving pectinal air-suppliers, sewage in these ditches flows with low speed. Part of air supplying is provided through the mentioned air-supplying act and the rest through superficial contact of sewage and air along the long ditch path. The current in these ditches is of ditch-like ones.

Initial design of the Sewage Treatment Plants

Comparison of selected processes : Comparison the units used in the primary treatment and biological treatment. In this study, among the different methods of water treatment plants,activated sludge,MLE , Carosel and SBR methods are used [Tables 4 to 6].

Table 4: Introductory treatment

Sewage Treatment Plant	Introductory treatment			
	flow measurement unit	sieving by air-supplying	manual garbage separation	Mechanical garbage separation
A	√	√	√	√
B	√	√	√	√
C	√	√	√	√
D	√	√	√	√
E	√	√	√	√

Table 5: Biological characteristics :

Sewage Treatment Plant	Biological treatment						
	Oxidation channel	secondary sedimentation pools	final gathering little pool	Air upplying pools	Anoxic pools	surplus mud pumping station	SBR tanks
A	-	-	-	-	-	√	√
B	-	√	√	√	√	√	-
C	√	√	√	-	-	√	-
D	-	√	√	√	√	√	-
E	-	√	√	√	√	√	-

Table 6: Disinfection Units & Mud condensation and dehydration

Sewage Treatment Plant	Disinfection Units & Mud condensation and dehydration				
	Aerobic digestives and Mechanical dehydration	UV sterilization	mechanical condensation unit and mud dehydration	Mud saving tanks	Chlorination Unit
A	-	-	√	√	√
B	√	√	-	-	-
C	-	√	√	√	-
D	√	√	-	-	-
E	√	√	-	-	-

Plan Technical Specifications

1. Covered population in the horizon of the plan: 985000 persons (for the sum of the first modulus of sewage treatment plants).
2. Sewage per capita production: 220 liters per day.
3. Sewage medium quantity: 229630 cubic meters per day for the sum of the first modulus of sewage treatment plants).
4. Sewage treatment plant A process, SBR with the capacity of 75060 cubic meters per day.
5. Sewage treatment plant B process, MLE with the capacity of 48222 cubic meters per day.
6. Sewage treatment plant C process, CAS with the capacity of 19604 cubic meters per day.
7. Sewage treatment plant D process, MLE with the capacity of 25013 cubic meters per day.
8. Sewage treatment plant E process, MLE with the capacity of 61731 cubic meters per day.

Quantitative and Qualitative Plan Objectives:

1. Annual sewage treating approximately 83 million cubic meters and preventing from its entrance into shallow and underground water sources.
2. Supplying hygienic sewage through sewage treatment for different consumptions such as agriculture.
3. Preserving environment and preventing from the destruction of biological sources.
4. Reducing remedial costs and optimizing environment as well as improving social welfare.

RESULTS AND DISCUSSION

According to the method described in the Materials and Methods, Calculation of costs and benefits and was brought out in the following tables:

Cost Estimation

Generalities

In the estimation calculation of costs, owing to the foreign exchange fluctuations as well as the effect of these fluctuations on the cost of work implementation, Euro is used as the reference for calculating prices and using conversion rate of Rial into Euro anytime, the calculation of costs is possible anytime.

Considered costs in the initial estimation include following cases:

Separated Summary of Costs are presented in [Table 7] And Separated Summary of Costs are listed in [Table 8].

1. Engineering Services and Design
2. Product Providence Including:
   Mechanical equipments and installations – electrical equipments and installations – instrumentation equipments and installations – spare parts.
3. Building and Administrative Operations Including:
   Processing buildings – lateral buildings – enclosure-building – enclosing with a fence and green space.
   Point: Building materials providence, loading, deliverance, and implementation are considered in the costs.
4. One-year utilization
   Personnel costs - chemical materials consumption – electricity consumption – sampling and experiments – other costs.

Table 7: Separated Summary of Costs

Title	Costs			
	Engineering Services	Product Providence	Building Operations	Utilization
Sewage Treatment Plant A	408,480	4,329,490	5,568,691	621,098
Sewage Treatment Plant B	61,960	,017,474	,953,472	471,646
Sewage Treatment Plant C	99,800	,490,886	,229,796	349,707
Sewage Treatment Plant D	22,000	3,653,690	5,568,691	322,315
Sewage Treatment Plant E	32,206	3,681,860	7,887,466	541,328

Table 8: Sum Total of Costs

Order	Title	Sum Total of Construction Costs
1	Sewage Treatment Plant A	€10,927,758
2	Sewage Treatment Plant B	€8,704,551
3	Sewage Treatment Plant C	€7,270,188
4	Sewage Treatment Plant D	€9,766,697
5	Sewage Treatment Plant E	€12,442,859

Calculation of Incomes of the Plan

According to the fact that plan period is considered fifteen years and the amount of input sewage to the sewage treatment plant and consequently, the amount of productive wastewater and mud are increasing, the incomes of the plan are determined as follows and the general results are outlined in [Table 9].

Unit Rate of the Incomes of Sewage Treatment:

1. Selling wastewater for 0.058 € for each cubic meter.
2. Selling productive fertilizer for 0.015 € for each kilogram.
3. Sewage disposal wage 0.132 € for each cubic meter.
4. Subscription fee 182 € for each subscriber.

Table 9: Summary of the Incomes of the Plan

Number of Utilization Year	Obtained Incomes (€)	Number of Utilization Year	Obtained Incomes (€)
First	18394777	Ninth	11066744
Second	9017653	Tenth	11370049
Third	9302575	Eleventh	11676052
Fourth	9590050	Twelfth	11984827
Fifth	9880079	Thirteenth	12280327
Sixth	10172806	Fourteenth	12583777
Seventh	10468087	Fifteenth	13021519
Eighth	10766066	Sum Total	357755635

Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) is a relatively simple and common technique for decision-making concerning an attempt and making a change. As its name implies, the value of the obtained incomes of an attempt are merely added and are subtracted from the relevant costs.[7],[8] Costs are incurred altogether or it might be incurred gradually, but benefits are reaped after a period. We have expressed and brought this time factor with the calculation of a period of income return in our analysis. This is the very time that should be spent for the return of obtained incomes of a change in lieu of its costs.[9]

Analyze the results of the study show that benefits arising from the construction of wastewater treatment brought back the initial investments. According to the tables treatment plant. construction costs, and summary of Revenue projects, ten years is a long return on investment. General analysis results are shown in [table10]

Table 10: CBA

Order	Title	Result
1	Capital Return Duration	10 Years
2	Break-even Point	97.9 of Capacity
3	Cost-Benefit Ratio	1.64
4	Direct Employment	75 Persons
5	Indirect Employment	110 Persons

CONCLUSION

In order to develop sewage treatment plants and with the objective of preventing from polluting water sources, appropriate methods of biological treatment should be chosen and the capital of private sector should be attracted through identifying CBI and incomes of such plans as well as reforming laws can provide utilization of the private sector's sewage treatment plants. In this paper, according to Table 5, the construction cost of sewage treatment plant is more economic by MLE method and this process not only eliminates organic and microbial materials, but also has the potential to eliminate nutrients to draw wastewater to the shallow waters based on the standard of Iran's Environmental Conservation Organization.[10] Furthermore, this method has the other advantages of the study methods such as SBR and CAROUSEL and is less sensitive to seasonal changes and environment temperature. The required ground for this method is small like the other systems of active mud. In addition, it requires lesser energy in relation to CAROUSEL and SBR methods and has a higher efficiency in accepting incoming organic shock to sewage treatment plant. Thus, this method is recommended as the optimum one.

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