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An Overview Comparison of the Most Common Wastewater Treatment Technologies in Egypt

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Abstract— *Water and Wastewater together beside Energy are both considered the liveliest key needed economically, socially, politically and environmentally for their strategic importance. They have significant consequences throughout the world, especially in developing countries. Billions of communities worldwide do not have adequate domestic wastewater treatment. This led to the proliferation of infectious diseases and an estimated of 2.1 million deaths every year. Recently, the improvement of sanitation and wastewater treatment had showed remarkable efforts from both developing and developed countries. The objective of the present study is to compare between different wastewater treatment technologies, as a biotechnology for the treatment of wastewater as a promising technique. The technologies presented in this study includes an overview comparison between: SBR, SFAT and MBBR. According to the overview of the pros and cons of the discussed wastewater treatment technologies, a technical and financial comparisons were drawn for contrasting between the three different technologies to summarize a qualitative comparison between them. From technical and financial technology presented above, it can be concluded that the SBR technology is the preferred treatment alternative.*

Keywords— *Step Feeding Aeration System, Wastewater, Membrane Bio-Reactor, Sequencing Batch Reactor, BIOLAK Technology and Hydraulic Loads.*

I. INTRODUCTION

Water and Wastewater together beside Energy are both considered the liveliest key needed economically, socially, politically and environmentally for their strategic importance [1]. They have significant consequences throughout the world, especially in developing countries [2]. Billions of communities worldwide do not have adequate domestic wastewater treatment. This led to the proliferation of infectious diseases and an estimated of 2.1 million deaths every year [3]. Recently, the improvement of sanitation and wastewater treatment had showed remarkable efforts from both developing and developed countries. The need of implementing wastewater treatment systems is more evident in developing countries, as per UNICEF and WHO (2012) [4]. Egypt faces serious problems in the sanitation sector. The Holding Company of Water and Wastewater (HCWW) in Egypt has prioritized the treatment of Wastewater in the cities [5]. Emerging Wastewater technologies nowadays, became an immediate demand for Egypt to provide wastewater treatment with higher qualities. However, sewage and sanitation treatment services still lag behind. Basic sanitation services through access to traditional septic tanks has risen markedly (from 52% to 93%), but socio-economic disparities mean that Egyptians in rural areas are still much less likely to have to have access to entirely safe drinking water supplies due to the lack of advanced sewage and sanitation service coverage. This underdevelopment of wastewater and sanitation treatment is causing significant problems for Egypt at the economic, environmental and individual levels [6]. Introducing new innovative technologies nowadays, became a key component in wastewater treatment. Developed technologies were used all over the world to boost the deep need for various treatment applications [7].

However, Wastewater treatment plants focus, among others, on sustainability issues through the recovery of energy and nutrients from wastewater. Aeration is one of the most energy-consuming processes in the conventional activated sludge systems of wastewater treatment technology [8]. The membrane bioreactor is a technology that has recently been applied to wastewater treatment for the purpose of reusing treated water and improving the sustainability of the water environment [9].

II. RESEARCH SIGNIFICANCE

The objective of the present study is to compare between different wastewater treatment technologies, as a biotechnology for the treatment of wastewater as a promising technique. The technologies presented in this study includes an overview comparison between: Sequence batch reactor (SBR), Step Feeding Aeration Tank (SFAT) and Moving Bed Bioreactor (MBBR). The focus is mainly on bioreactor technologies that are available for current and possible future implementation in the municipal wastewater treatment systems.

III. MATERIALS AND METHODS

As mentioned above this paper will concentrate on three different treatment technologies, the first technology SFAT has significant advantages of Low running cost and the need of a few staff with medium skilled level. As for the cons of this technology, it has high effect in System Efficiency due to low WW flow rate at beginning of operation. Moreover, it is a highly effected due to shock loads [10]. The second technology presented in this paper is the SBR, it has exceptional advantages of low foot print, no effect in System Efficiency due to low WW flow rate at beginning of operation, minor problems due to shock

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loads, and low effect of climates in treatment efficiency [11]. While, the disadvantages of SBR is emphasized in its high capital cost, operation and maintenance cost, required high skilled labors and high oxygen requirements [12].

The last technology covered in this paper is the MBBR. The MBBR in the past years has become simply spread innovative technology. This technology provides cost-effective treatment with minimal maintenance since MBBR processes self-maintain an optimum level of productive biofilm. From the vast advantages of the MBBR technology, ease to operate and required medium skilled labors, low capital and running cost, low impact to environment, and capability to facing shock loads without decreasing in system efficiency [13]. On the other side, it has only a disadvantage of the need of few staff with medium skilled level [14]. The flow line diagram and the layout of each technology is illustrated in the following figures respectively, Figures (1-6). Additionally, table 1 and table 2 represent the design criteria of the previous mentioned wastewater treatment technologies.

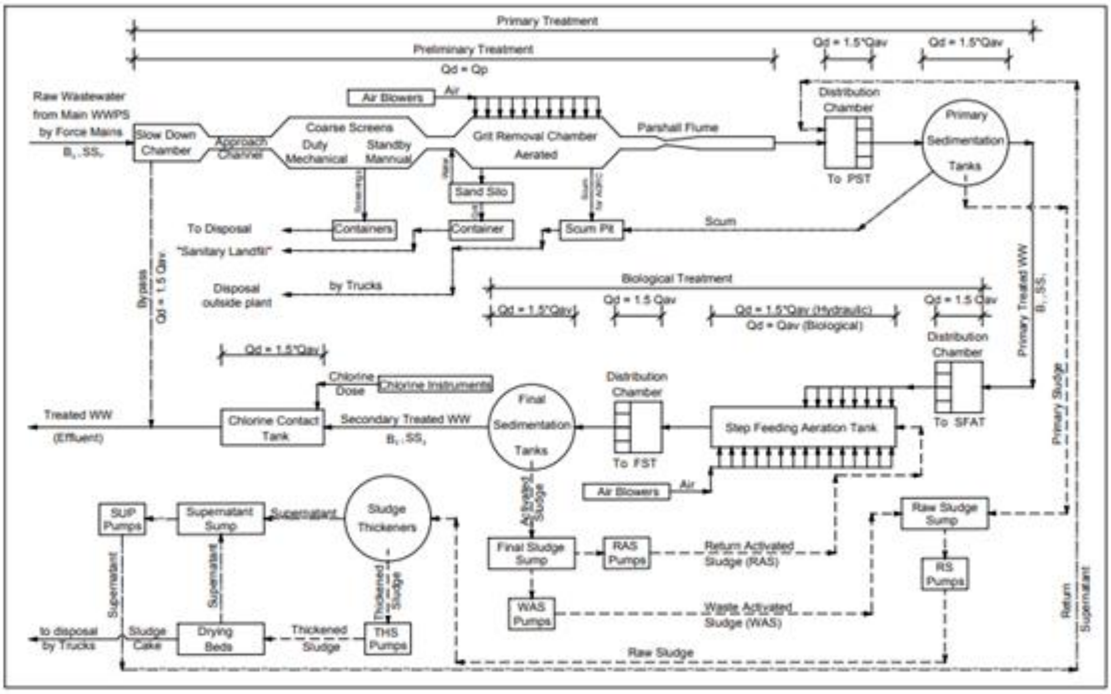

Figure 1: Flow line diagram in SFAT

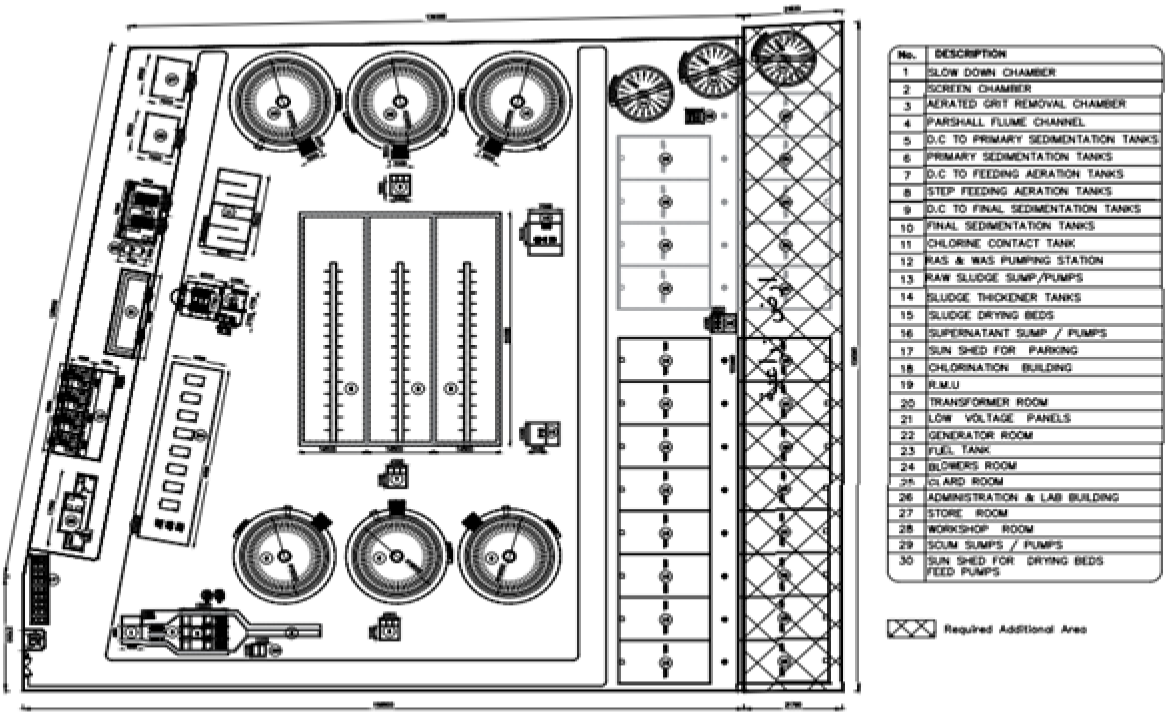

Figure 2: Layout of SFAT Treatment Plant

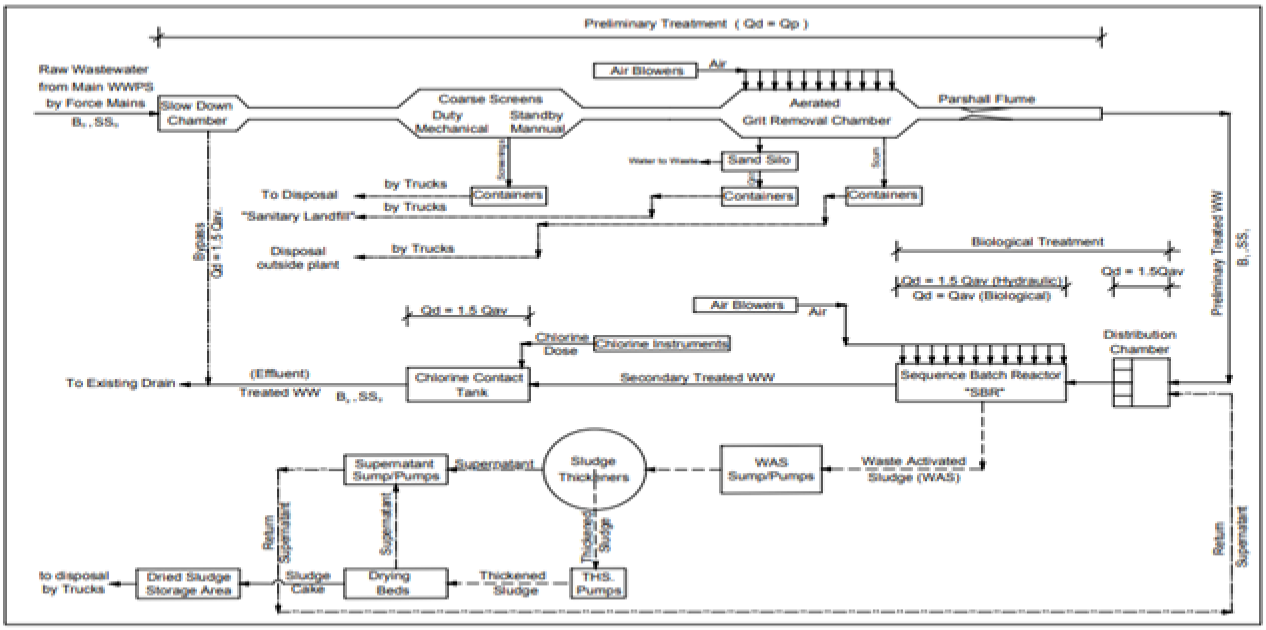

Figure 3: Flow line diagram in SBR

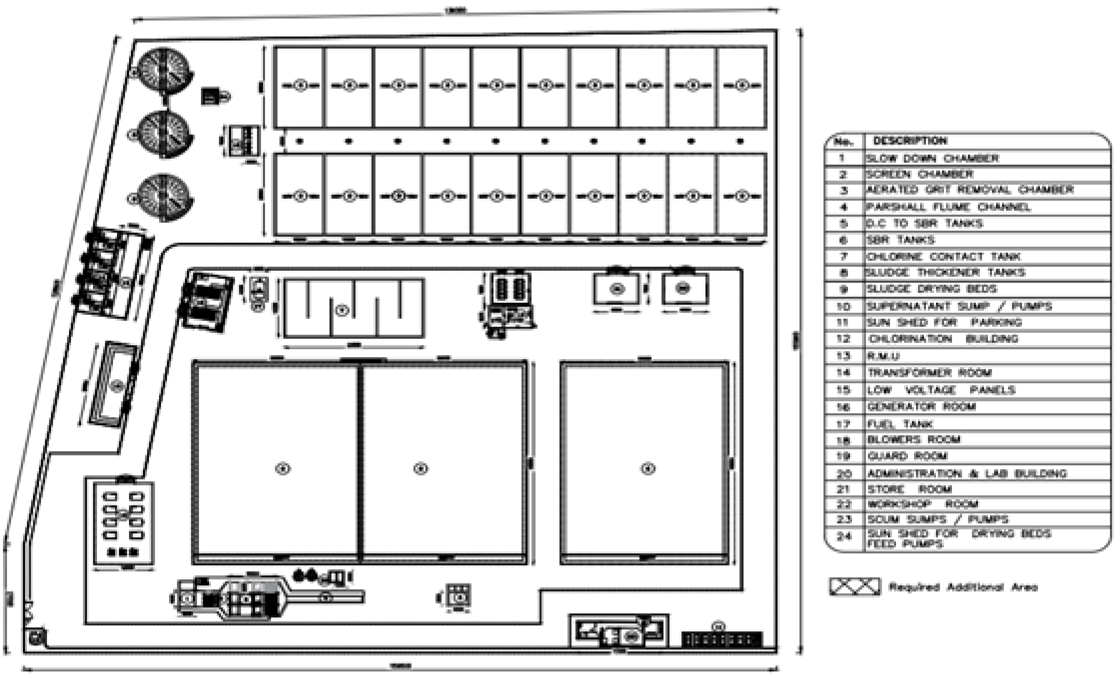

Figure 4: Layout of SBR Treatment Plant

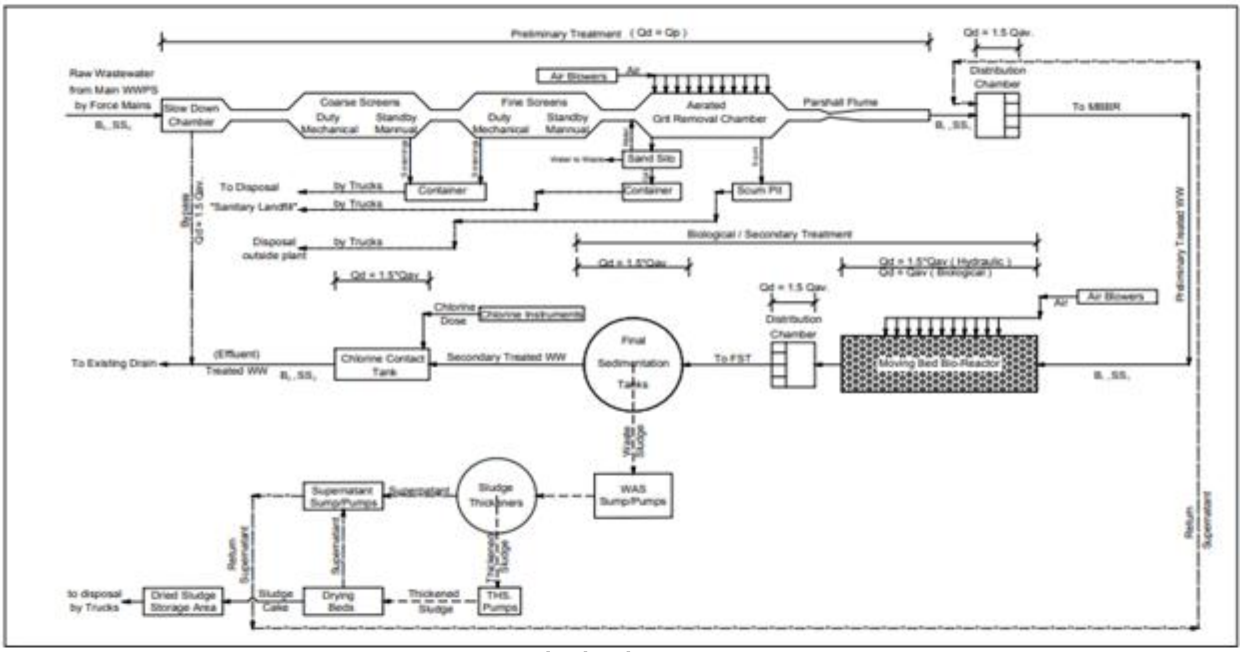

Figure 5: Flow line diagram in MBBR

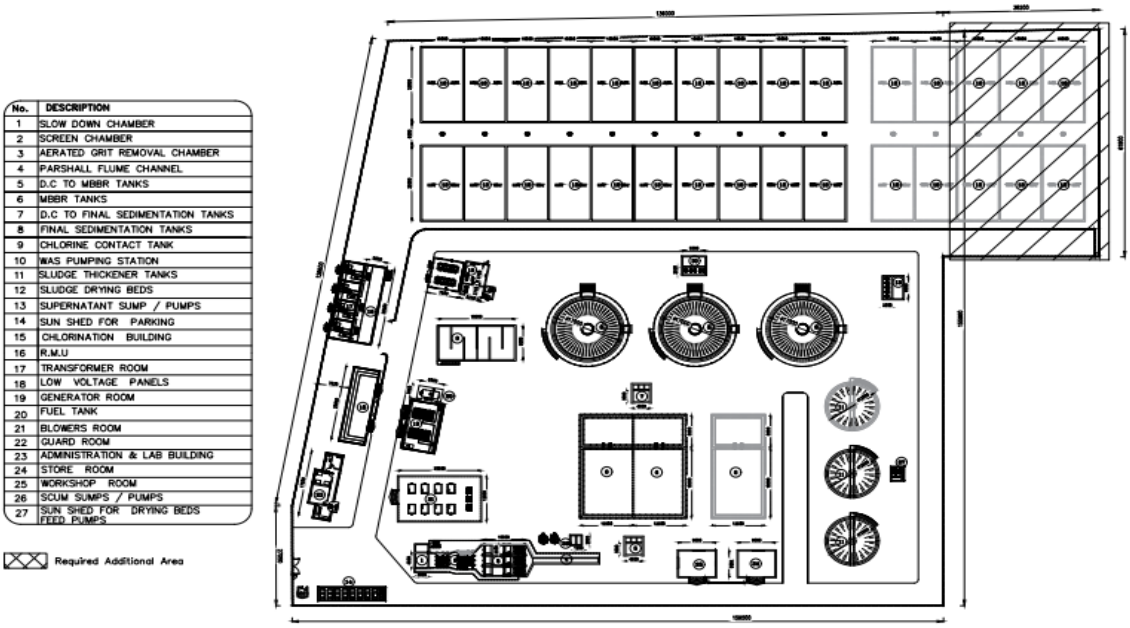

Figure 6: Layout of MBBR Treatment Plant

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Table 1: The Design Data of the Treatment Units for the Three Alternative Treatment Technologies

<table>
<tr><th colspan="2">Treatment Unit</th><th>SFAT</th><th>SBR</th><th>MBBR</th></tr>
<tr><td rowspan="4">Inlet Chamber</td><td>n</td><td colspan="3">1</td></tr>
<tr><td>L</td><td colspan="3">4</td></tr>
<tr><td>B</td><td colspan="3">3</td></tr>
<tr><td>d</td><td colspan="3">2</td></tr>
<tr><td rowspan="4">Mechanical Coarse Screen</td><td>n</td><td colspan="3">3</td></tr>
<tr><td>S</td><td colspan="3">20</td></tr>
<tr><td>W</td><td colspan="3">0.65</td></tr>
<tr><td>d</td><td colspan="3">0.60</td></tr>
<tr><td rowspan="4">Manual Coarse Screen</td><td>n</td><td colspan="3">1</td></tr>
<tr><td>S</td><td colspan="3">25</td></tr>
<tr><td>W</td><td colspan="3">0.65</td></tr>
<tr><td>d</td><td colspan="3">0.6</td></tr>
<tr><td rowspan="4">Mechanical Fine Screen</td><td>n</td><td colspan="2" rowspan="8">N.E</td><td>3</td></tr>
<tr><td>S</td><td>6</td></tr>
<tr><td>W</td><td>0.85</td></tr>
<tr><td>d</td><td>0.60</td></tr>
<tr><td rowspan="4">Manual Fine Screen</td><td>n</td><td>1</td></tr>
<tr><td>S</td><td>6</td></tr>
<tr><td>W</td><td>0.90</td></tr>
<tr><td>d</td><td>0.60</td></tr>
<tr><td rowspan="4">Aerated Grit Removal Chamber</td><td>n</td><td colspan="3">3</td></tr>
<tr><td>L</td><td colspan="3">10</td></tr>
<tr><td>B</td><td colspan="3">2.5</td></tr>
<tr><td>d</td><td colspan="3">2.5</td></tr>
<tr><td rowspan="3">Primary Sedimentation Tanks</td><td>n</td><td>3</td><td colspan="2" rowspan="3">N.E</td></tr>
<tr><td>Φ</td><td>19.0</td></tr>
<tr><td>d</td><td>3.50</td></tr>
<tr><td rowspan="4">Aeration Tanks</td><td>n</td><td colspan="3">3</td></tr>
<tr><td>L</td><td>55.0</td><td>50.0</td><td>27.0</td></tr>
<tr><td>B</td><td>14.50</td><td>35.0</td><td>12.5</td></tr>
<tr><td>d</td><td colspan="3">5.50</td></tr>
<tr><td rowspan="3">Final Sedimentation Tanks</td><td>n</td><td>3</td><td rowspan="3">N.E</td><td>3</td></tr>
<tr><td>Φ</td><td>20.0</td><td>17.0</td></tr>
<tr><td>d</td><td>3.50</td><td>3.50</td></tr>
<tr><td rowspan="4">Chlorine Contact Tanks</td><td>n</td><td colspan="3">1</td></tr>
<tr><td>L</td><td>18.50</td><td>29.0</td><td>18.5</td></tr>
<tr><td>B</td><td>9.0</td><td>14.0</td><td>9.0</td></tr>
<tr><td>d</td><td>3.0</td><td>4.0</td><td>3.0</td></tr>
<tr><td rowspan="3">Sludge Thickeners</td><td>n</td><td colspan="3">3</td></tr>
<tr><td>Φ</td><td>12.5</td><td>10.0</td><td>12.5</td></tr>
<tr><td>d</td><td colspan="3">3.0</td></tr>
</table>

Table 2: Continue the Design Data of the Treatment Units for the Three Alternative Treatment Technologies

<table>
<tr><th colspan="2">Treatment Unit</th><th>SFAT</th><th>SBR</th><th>MBBR</th></tr>
<tr><td rowspan="4">Drying Beds</td><td>n</td><td>25</td><td>20</td><td>30</td></tr>
<tr><td>L</td><td colspan="3">20</td></tr>
<tr><td>B</td><td colspan="3">10</td></tr>
<tr><td>d</td><td colspan="3">0.30</td></tr>
<tr><td rowspan="3">Air Blowers for Aerated Grit Removal Chambers</td><td>n</td><td colspan="3">3</td></tr>
<tr><td>q</td><td colspan="3">350</td></tr>
<tr><td>p</td><td colspan="3">350</td></tr>
<tr><td rowspan="3">Air Blowers for Aeration Tanks</td><td>n</td><td>8</td><td>8</td><td>8</td></tr>
<tr><td>q</td><td>2500</td><td>4600</td><td>3700</td></tr>
<tr><td>p</td><td colspan="3">650</td></tr>
<tr><td rowspan="3">Return Activated Sludge Pumps</td><td>n</td><td>5</td><td colspan="2" rowspan="6">N.E</td></tr>
<tr><td>q</td><td>234</td></tr>
<tr><td>p</td><td>1500</td></tr>
<tr><td rowspan="3">Raw Sludge Pumps</td><td>n</td><td>3</td></tr>
<tr><td>q</td><td>72</td></tr>
<tr><td>p</td><td>1000</td></tr>
<tr><td rowspan="3">Waste Activated Sludge Pumps</td><td>n</td><td colspan="3">3</td></tr>
<tr><td>q</td><td>54</td><td>72</td><td>54</td></tr>
<tr><td>p</td><td colspan="3">1500</td></tr>
<tr><td rowspan="3">Thickened Sludge Pumps</td><td>n</td><td colspan="3">3</td></tr>
<tr><td>q</td><td>36</td><td colspan="2">54</td></tr>
<tr><td>p</td><td colspan="3">2000</td></tr>
<tr><td rowspan="3">Supernatant Sludge Pumps</td><td>n</td><td colspan="3">3</td></tr>
<tr><td>q</td><td>54</td><td>72</td><td>54</td></tr>
<tr><td>p</td><td colspan="3">2000</td></tr>
</table>

IV. Conclusion and Recommendation

According to the overview of the pros and cons of the discussed wastewater treatment technologies, a technical and financial comparisons were drawn for contrasting between the three different technologies to summarize a qualitative comparison between them. Two main summary tables were drawn for comparison among the three systems. The following table 3shows a technical comparison between the different alternatives of suggested treatment technologies for the studied wastewater treatment plant based on Degree System. The maximum degree of each comparison item is (10) marks. Where the item that has bigger degree is technically better than the other ones. Finally, at the bottom of the table, mean value of all comparison items is calculated for each alternative. The bigger mean value means the best alternative technically. Furthermore, table 4 shows a financial comparison between the different alternatives of suggested treatment technologies for the studied wastewater treatment plant based on the following assumptions: The costs according to total capacity of the studied plant (21000 m^3/day), the costs according to local prices during the duration of preparing the paper and Construction cost does not included drilling in rock soil.

Table 3: Technical comparison between the different alternatives of suggested treatment technologies

Face of Comparison/Items	SFAT	SBR	MBBR
Required area for production of cubic meter of treated wastewater per day (m^2/m^3 WW/day)	1.2 – 1.4	1.0 – 1.2	1.1 – 1.3
Total capacity of the studied plant (m^3/day)	21000		
Required area for the studied plant (1000 m^2)	25.2 – 29.4	21.0 – 25.2	23.1 – 27.3
Mean required area for the studied plant (1000 m^2)	27*	23	25.5*
Available area of the studied plant (1000 m^2)	23.165		
Electrical power consumption (K.W/hr/1000 m^3 WW)	160 - 180	200 - 220	150 - 170
Mean Electrical power consumption for the studied plant (K.W/hr/1000 m^3 WW)	3570	4410	3360
Construction cost (1000 LE/m^3 WW/day)	9 - 11	11 - 13	12 - 14
Mean construction cost for the studied plant (10^6 LE)	210	252	273
Cost of supply and installation of electromechanical equipment for the studied plant (10^6 LE)	100	177	150
Cost of civil works for the studied plant (10^6 LE)	110	177	150
Operation and maintenance cost (LE/m^3 WW/day)	1.1 – 1.2	1.2 – 1.3	0.9 – 1.0
Mean operation and maintenance cost for the studied plant (1000 LE)	24.15	26.25	19.95
Operation and maintenance cost during 20 years for the studied plant (10^6 LE)	176.3	191.63	145.64
Total Cost for Construction, Operation, and Maintenance during 20 years for the Studied Plant (10^6 LE)	**386.3**	**443.63**	**418.64**

Table 4: Financial comparison between the different alternatives of suggested treatment technologies

Face of Comparison/Items	SFAT	SBR	MBBR
Required area for production of cubic meter of treated wastewater per day (m^2/m^3 WW/day)	1.2 – 1.4	1.0 – 1.2	1.1 – 1.3
Total capacity of the studied plant (m^3/day)	21000		
Required area for the studied plant (1000 m^2)	25.2 – 29.4	21.0 – 25.2	23.1 – 27.3
Mean required area for the studied plant (1000 m^2)	27*	23	25.5*
Available area of the studied plant (1000 m^2)	23.165		
Electrical power consumption (K.W/hr/1000 m^3 WW)	160 - 180	200 - 220	150 - 170
Mean Electrical power consumption for the studied plant (K.W/hr/1000 m^3 WW)	3570	4410	3360
Construction cost (1000 LE/m^3 WW/day)	9 - 11	11 - 13	12 - 14
Mean construction cost for the studied plant (10^6 LE)	210	252	273
Cost of supply and installation of electromechanical equipment for the studied plant (10^6 LE)	100	177	150
Cost of civil works for the studied plant (10^6 LE)	110	177	150
Operation and maintenance cost (LE/m^3 WW/day)	1.1 – 1.2	1.2 – 1.3	0.9 – 1.0
Mean operation and maintenance cost for the studied plant (1000 LE)	24.15	26.25	19.95
Operation and maintenance cost during 20 years for the studied plant (10^6 LE)	176.3	191.63	145.64
Total Cost for Construction, Operation, and Maintenance during 20 years for the Studied Plant (10^6 LE)	**386.3**	**443.63**	**418.64**

From technical and financial technology presented above, it can be concluded that the SBR technology is the preferred treatment alternative, it has a low foot print, no effect in system efficiency due to low wastewater flow rate at beginning of operation, minor problems due to shock loads. Moreover, low effect of climates in treatment efficiency, as well as, it has the minimum construction cost, and it is the only alternative that can be spread out in the available area of the suggested treatment plant. On the other hand, the other alternatives have a major disadvantage that is presented in the huge construction cost, and the need for additional area above the available one.

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