Modification on Design Equation of Facultative Stabilization Ponds Due to Egyptian Circumstances

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Abstract: Stabilization ponds are established in various cities and villages in Egypt. There are about 38 ponds covering almost all the regions of the country. Some of these ponds are working with low efficiency. Some are under designed. One of the main problems is that the plants are not fenced properly which maximizes the wind effect and causes disturbance in the pond performance. Some ponds are designed to receive a certain flow but actually, it receives much less flow which increases the retention time.

In this study, eight working WSPs in different locations all over Egypt were monitored and their performances were evaluated with respect to ponds retention time and prevailing climate conditions. These locations had covered regions presented in (Al Beheira, Fayoum, New Valley, Luxor, Hurghada, Sharm El Sheikh, Areeesh & Abu Radies). Each location had been visited during season’s winter, spring, summer & autumn to obtain the different weather conditions and several samples were collected during the day over three days in each season.

It was found that reduced pond retention time could work perfectly with climate conditions in Egypt. Conclusions were drawn to suggest a modification on the design equation of the facultative stabilization ponds to meet Egyptian circumstances that minimize the required area for such technology in Egypt application.

Key Words: Wastewater treatment, Stabilization ponds, Design of stabilization ponds & Affecting Parameters.

I. INTRODUCTION

Waste stabilization pond (WSP) technology is considered the most economic wastewater treatment technology for its simplicity for construction and operation and its high removal efficiency even for the pathogenic micro-organisms. The working theory of (WSP) is treating raw sewage completely by just allowing sewage to stay in the ponds for the retention time needed depending on the Sun light, algae and bacterial actions. It is particularly well suited for tropical and subtropical countries because the intensity of sunlight and temperature are key factors for (WSP) removal efficiency of the pollutants which is suitable to climatic conditions in Egypt. Depending on natural biological action it doesn’t need highly trained operators for operation and maintenance [1].

Arthur [2] reviewed the design methods and performance of WSP in six developing countries. He reported that WSP have been grossly over-designed and the designs are not responsive to the growth encountered in developing countries.

This represents an uneconomic use of the land needed for a WSP system. Procurement of land is often the major capital investment for a WSP scheme.

Mara et al. [3] presented the status and performance of existing WSP in eastern Africa and its design and operational problems, resulting from poor process design, physical design and unsatisfactory operation and maintenance.

The US Environmental Protection Agency [4]. Reed et al. [5] and Shilton and Harrison [6] concluded that the performance of a WSP system depends on robust process and physical design methods. The process design should assume a realistic hydraulic flow regime that can be achieved by the physical design.

The design of facultative ponds focused on BOD removal. Modeling of the biochemical processes within facultative ponds has been attempted in an effort to provide accurate estimates of the surface BOD loading rate, so that the satisfactory performance of the ponds can be ensured. More recently, it has been considered that hydraulic transport processes also have an important influence on BOD removal in facultative ponds.

Mara [7] and Marconcio do Monte and Mara [8] described how the design of facultative ponds is currently based on rational and empirical approaches. The empirical design approach is based on correlating performance data of existing WSP. The empirical method fails in WSP design in different climate and environmental conditions than the empirical relationships have been established. The rational design method fails to determine confidently the first order BOD kinetics, which had been observed to vary widely.

Also, to determine dispersion numbers accurately requires tracer studies to be done in existing WSP. It has been suggested that dispersion numbers vary significantly from zero to infinity depending on environmental conditions, the mode of pond mixing and the hydrodynamics of the incoming flow [9].

Arceivala [10], Polprasert & Bhattachai [11] and Mara et al. [3] have suggested that secondary facultative ponds should be constructed in a rectangular shape with a high length-to-width (4:10:1). Such a geometric design of facultative ponds is thought to approximate a plug-flow regime. Design of facultative ponds assuming a complete-mix hydraulic flow regime is unrealistic and leads to over design.

The complete-mix hydraulic flow model proposed by Marais & Shaw [12] assumes that wind mixing and temperature are responsible for complete mixing in facultative ponds.

Reed et al. [5] proposed a plug hydraulic flow regime to design primary facultative ponds that depending on the BOD surface loading rate. The plug-flow model is used to calculate the retention time required for specified BOD removal requirements. The limitation of the application of this proposed model in warm
climate regions is the limited surface organic BOD loading rate range proposed. The plug hydraulic flow regime is considered unrealistic WSP because zero longitudinal mixing is impossible to achieve [13], [9], [8], [14].

Wehner & Wilhelm [15] argue that plug flow conditions could only be achieved if the length of liquid traveling in a reactor is close to infinity. The length of most facultative ponds is limited by practical considerations. Efforts have been made to use baffles to increase the length of liquid travel in facultative and maturation ponds [16], [17], [5]. However, an infinite length of liquid travel cannot be attained in practice and the proposed model by Reed et al. [5] cannot be realized in practice.

Thirumurthi [13] recommended that ponds be designed as dispersed flow reactors since they are neither plug flow nor completely mixed. He proposed the use of pond dispersion numbers (d_i) and the first order equation of Wehner & Wilhelm [15]. His equation was very difficult to be applied for the difficulty of determining the value of the dispersion number (d_f) and the first order reaction rate for BOD removal.

Polprasert & Bhattarai [11] proposed an equation for a dispersed hydraulic flow model in facultative pond design which with Thirumurthi [13] equation can be used to design a facultative pond by trial and error.

Arceivala [10] suggested that the dispersion numbers could be solved simultaneously with the dispersed flow model of Reed et al. [5] equation to determine the hydraulic retention time.

The surface BOD loading method is the recommended approach for designing facultative ponds according to the US Environmental Protection Agency [17] and Reed et al. [5], for every climate there is an appropriate value of surface BOD loading (kg BOD/ha/day) which can be applied to a pond for a given removal efficiency before failure. McGarry & Pescod [18] found that surface loading values give a closer correlation with performance data than volumetric loading values. They correlated data from ponds under 143 different climatic conditions and reported that BOD removal in primary facultative ponds was between 70 - 90%. Their statistical modeling of the data found that pond performance was related to surface BOD loadings, with a high correlation coefficient of 0.995. Mara [19] adapted the McGarry & Pescod [20] failure model by incorporating a factor of safety to ensure the safe design of facultative ponds. Experience of the surface BOD loading rate in Brazil and Europe enabled Mara to propose a global surface loading rate equation.

The surface BOD loading rate is the recommended empirical design approach that has been used in traditional process design methods. The calculation for the area of a facultative pond is determined by trial and error. The first order equation of BOD removal in primary facultative ponds was between 90%. Their statistical correlation coefficient of 0.995. Earlier studies of WSP by Mara [7] and Arthur [2] recognized the variability of some of these input design parameters as such as per capita BOD and per capita water requirement.

Surface BOD loading rate has been found to be a function of temperature. The traditional process design method uses the mean temperature in the coldest month as the design temperature. It has been suggested that this approach provides a factor of safety [7]; [2]. However, this approach requires more assessment as the temperature changes continuously from the cold season to the hot season each year. The author is of the opinion that surface loading rate should be manipulated to vary from 100kg/haday to 350kg/haday as proposed by Mara [19] to follow the pattern depicted by the temperature variation. The traditional design process method for facultative ponds is conservative and can result in the uneconomic use of the available land. It is more realistic for the designer to input a range of parameters which can be set with confidence upon a given level of uncertainty. This is a cost-effective and safe approach [20].

El Nadi & Abdel Azeem [21] performed a study which was applied on the stabilization pond in Abu-Rudies, South Sinai, Egypt and concluded that since the climate in Egypt may maintain highest temperature up to 30 - 40°C, the SLR may be higher and surface area may be reduced accordingly. A correct factor may be applied to the SLR equation of about 3.0 to make the equation. But, since only this data were collected from one site and it should be verified from other stabilization ponds plants. The proposed factor of safety may be applied could be only a correction factor of 2.0. This was confirmed by Ismail [22] during his work on other seven sites around Egypt.

II. MATERIALS & METHODS

Stabilization ponds are established in various cities and villages in Egypt there are about 38 ponds covering almost all the regions of the country some of these ponds are working with low efficiency some of them are overflow designed and some are under designed.

Several locations had been chosen for the study to cover the different climate conditions (Temperature, wind, humidity) all over Egypt. These locations covered both the north regions presented in: Waked village in Al Behera , Qouta Village in Al Fayoum and Al Areeesh city in North Sinai and the south regions presented in: Mout city in New Valley, Luxor city in Upper Egypt, Hurghada city in Red Sea and Sharm El Sheikh city in South Sinai as illustrated in figure (1).

Figure (1) Locations of the Studied Ponds

Several problems facing the study as the absence of fencing which maximize the wind effect and cause disturbance in the pond performance, the receiving of very low flow than designed flow which increases the retention time and the receiving of higher flows than designed one and these problems are taken into consideration in the evaluation study.
The intervals were chosen to cover the different climate conditions in Egypt as the weather conditions is an important factor in the design of the stabilization pond. The parameters were measured during three intervals in January 2014 for winter weather, in April 2014 for spring and autumn weather and in July 2014 for summer weather.

Samples were collected from the influent and the effluent of the facultative pond in order to determine the efficiency of this pond. Sampling was performed twice a week through each season for each site to ensure the coverage of different climate conditions. The investigated parameters were Total suspended solids (TSS), Chemical oxygen demand (COD), Biochemical oxygen demand (BOD), pH value, air temperature, Humidity and Wind intensity.

### III. RESULTS

The samples were collected from different plants all over Egypt in order to cover and take into account the different climate conditions. Each location had been visited during season's winter, spring & summer seasons.

#### Tables (3), (4) & (5) show the average wastewater analyses readings of six days for winter, spring & summer seasons samples in the studied plants all over Egypt to take the climatic variations effects according to location and time.

### Table (1) Facultative Pond Size Data for all Locations

| Facultative Pond Size Data | Waked - Al Behiera | Qouta - Al Fayoum | Mout - New Valley | Luxor - Luxor | Hurghada -Red Sea | Sharm ElSheikh - South Sinai | Abu Rudais - South Sinai | Al Arish -North Sinai |
|---------------------------|--------------------|------------------|------------------|--------------|-----------------|-----------------------------|------------------------|----------------------|
| Length m                  | 160                | 2x120            | 3x150            | 2x399        | 2x385           | 2x166                       | 2x35                   | 2x530                |
| Width m                   | 60                 | 50               | 90               | 227          | 175             | 113                         | 30                     | 230                  |
| Depth m                   | 4                  | 2                | 2.5              | 2.8          | 1.5             | 2                           | 1.5                    | 2                    |
| Volume m³                 | 38400              | 24000            | 101250           | 507209       | 202125          | 75032                       | 3150                   | 487600               |
| Q_actual m³/d             | 3000               | 100              | 6600             | 22000        | 9000            | 15000                       | 472                    | 50000                |
| Q_design m³/d             | 5200               | 900              | 4770             | 30000        | 8352            | 45000                       | 944                    | 38000                |

### Table (2) Climatic Conditions During all Study Seasons for all Locations

| Season         | Climatic parameter | Waked - Al Behiera | Qouta - AlFayoum | Mout - New Valley | Luxor - Luxor | Hurghada -Red Sea | Sharm ElSheikh - South Sinai | Abu Rudais - South Sinai | Al Arish -North Sinai |
|----------------|--------------------|--------------------|------------------|------------------|--------------|-----------------|-----------------------------|------------------------|----------------------|
| Winter         | Temp. C°           | 12                 | 17               | 26               | 26           | 27              | 26                          | 23                     | 13                   |
| Humidity %     | 26                 | 60                 | 23               | 29               | 34           | 32              | 34                          | 30                     | 20                   |
| Wind speed km/h| 9                  | 4                  | 6                | 4                | 12           | 2               | 16                          | 12                     |                      |
| Spring         | Temp. C°           | 19                 | 23               | 30               | 33           | 34              | 34                          | 30                     | 20                   |
| Humidity %     | 22                 | 49                 | 32               | 44               | 42           | 36              | 46                          | 46                     | 63                   |
| Wind speed km/h| 2                  | 5                  | 5                | 5                | 10           | 6               | 13                          | 8                      |                      |
| Summer         | Temp. C°           | 26                 | 27               | 41               | 39           | 40              | 39                          | 35                     | 30                   |
| Humidity %     | 26                 | 59                 | 44               | 31               | 56           | 49              | 44                          | 44                     | 74                   |
| Wind speed km/h| 6                  | 2                  | 2                | 6                | 10           | 10              | 11                          | 6                      |                      |

### Table (3) Winter Season Average Readings for all Locations

| plant          | Time  | location | pH  | BOD  | COD  | TSS  |
|----------------|-------|----------|-----|------|------|------|
| Waked - Al Behiera | morning | Inf.   | 7.74 | 348  | 676  | 422  |
|                 |       | Eff.    | 8.08 | 53   | 134  | 42   |
|                 | Night | Inf.    | 5.89 | 315  | 611  | 382  |
|                 |       | Eff.    | 6.14 | 48   | 121  | 38   |
|                 | average | Inf. | 6.9  | 330  | 640  | 400  |
|                 |       | Eff.    | 7.2  | 50   | 127  | 40   |
| Qouta - Al Fayoum | morning | Inf.   | 8.00 | 495  | 606  | 312  |
|                 |       | Eff.    | 8.98 | 104  | 67   | 74   |
|                 | Night | Inf.    | 6.27 | 478  | 573  | 291  |
|                 |       | Eff.    | 6.83 | 94   | 60   | 67   |
|                 | average | Inf. | 7.21 | 488  | 588  | 300  |
|                 |       | Eff.    | 8.00 | 98   | 63   | 70   |
| El Sheikh - NW Val | morning | Inf. | 7.60 | 499  | 650  | 1460 |
|                 |       | Eff.    | 8.80 | 110  | 140  | 1320 |
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| Location                  | Day        | pH  | BOD | COD  | TSS  |
|---------------------------|------------|-----|-----|------|------|
| Luxor - Luxor             | Night      | 5.80| 366 | 540  | 1450 |
|                           | Eff.       | 6.70| 87  | 107  | 1350 |
|                           | Average    | 6.80| 402 | 590  | 1455 |
|                           | Eff.       | 7.80| 94  | 116  | 1340 |
|                           | Morning    | 8.13| 186.9| 250  | 203  |
|                           | Eff.       | 9.12| 21  | 29   | 62   |
|                           | Average    | 6.17| 177.8| 228  | 187  |
|                           | Eff.       | 6.92| 18  | 26   | 57   |
|                           | Night      | 7.26| 178 | 240  | 197  |
|                           | Eff.       | 7.14| 19  | 27   | 60   |
| Hurghada - Red Sea        | Morning    | 7.60| 299 | 650  | 1660 |
|                           | Eff.       | 8.80| 110 | 140  | 1520 |
|                           | Night      | 5.80| 266 | 540  | 1450 |
|                           | Eff.       | 6.70| 57  | 77   | 1350 |
|                           | Average    | 6.80| 282 | 590  | 1520 |
|                           | Eff.       | 7.80| 67  | 86   | 1460 |
|                           | Morning    | 7.65| 291 | 604  | 1605 |
|                           | Eff.       | 8.83| 137 | 238  | 1530 |
|                           | Night      | 5.82| 264 | 546  | 1452 |
|                           | Eff.       | 6.72| 124 | 216  | 1385 |
|                           | Average    | 6.82| 276 | 572  | 1520 |
|                           | Eff.       | 7.87| 130 | 226  | 1450 |
|                           | Morning    | 7.66| 410 | 890  | 461  |
|                           | Eff.       | 7.16| 40  | 97   | 48   |
|                           | Average    | 7.23| 330 | 870  | 419  |
|                           | Eff.       | 7.7  | 40 | 91   | 45   |
|                           | Night      | 7.44| 370 | 880  | 440  |
|                           | Eff.       | 7.43| 40  | 94   | 46.5 |
|                           | Morning    | 7.77| 254 | 430  | 1330 |
|                           | Eff.       | 8.00| 55  | 78   | 1570 |
|                           | Night      | 6.66| 167 | 334  | 1180 |
|                           | Eff.       | 6.90| 34  | 50   | 1400 |
|                           | Average    | 7.00| 209 | 380  | 1240 |
|                           | Eff.       | 7.90| 45  | 65   | 1470 |

Table (4) Spring Season Average Readings for all Locations

| plant          | Time       | location | pH | BOD | COD | TSS |
|----------------|------------|----------|----|-----|-----|-----|
| Wad el - Al Behiera | morning    | Inf.     | 7.33| 290 | 718 | 313 |
|                 | Eff.       | 8.44| 51  | 180 | 43  |
|                 | Night      | Inf.     | 5.57| 263 | 650 | 284 |
|                 | Eff.       | 6.42| 46  | 163 | 39  |
|                 | Average    | Inf.     | 6.53| 275 | 680 | 297 |
|                 | Eff.       | 7.52| 48  | 171 | 41  |
| Qena - Al Fayyum   | morning    | Inf.     | 7.8  | 215 | 457 | 216 |
|                 | Eff.       | 8.30| 51  | 76  | 58  |
|                 | Night      | Inf.     | 5.93| 195 | 414 | 196 |
|                 | Eff.       | 6.31| 46  | 69  | 53  |
|                 | Average    | Inf.     | 6.95| 204 | 433 | 205 |
|                 | Eff.       | 7.40| 48  | 72  | 55  |
| Mout - New Valley  | morning    | Inf.     | 7.90| 395 | 592 | 1526 |
|                 | Eff.       | 8.80| 89  | 106 | 1268 |
|                 | Night      | Inf.     | 5.90| 362 | 536 | 1322 |
|                 | Eff.       | 6.20| 56  | 75  | 1190 |
|                 | Average    | Inf.     | 6.90| 378 | 564 | 1414 |
|                 | Eff.       | 7.50| 62  | 90  | 1229 |
| Luxor - Luxor     | morning    | Inf.     | 7.12| 241 | 345 | 225 |
| plant                      | Time         | location | pH   | BOD  | COD   | TSS  |
|---------------------------|--------------|----------|------|------|-------|------|
| Waked - Al Behira         | morning      | Inf.     | 8.09 | 211  | 317   | 413  |
|                           | Eff.         | 8.87     | 40   | 53   | 91    |      |
|                           | Night        | Inf.     | 6.15 | 191  | 286   | 374  |
|                           | Eff.         | 6.74     | 36   | 48   | 82    |      |
|                           | average      | Inf.     | 7.21 | 200  | 300   | 391  |
|                           | Eff.         | 7.9      | 38   | 50   | 86    |      |
| Qouta - Al Fayoun         | morning      | Inf.     | 8.25 | 242  | 539   | 259  |
|                           | Eff.         | 8.80     | 44   | 65   | 56    |      |
|                           | Night        | Inf.     | 6.27 | 219  | 489   | 234  |
|                           | Eff.         | 6.69     | 40   | 59   | 51    |      |
|                           | average      | Inf.     | 7.35 | 229  | 512   | 245  |
|                           | Eff.         | 7.84     | 42   | 62   | 53    |      |
| Mout - New Valley         | morning      | Inf.     | 8.00 | 273  | 560   | 1210 |
|                           | Eff.         | 8.90     | 74   | 98   | 1180  |      |
|                           | Night        | Inf.     | 6.10 | 259  | 505   | 1050 |
|                           | Eff.         | 6.80     | 47   | 78   | 1000  |      |
|                           | average      | Inf.     | 7.20 | 264  | 530   | 1150 |
|                           | Eff.         | 8.00     | 54   | 88   | 1100  |      |
| Luxor - Luxor             | morning      | Inf.     | 7.94 | 303  | 491   | 239  |
|                           | Eff.         | 9.16     | 60   | 96   | 53    |      |
|                           | Night        | Inf.     | 6.03 | 277  | 445   | 220  |
|                           | Eff.         | 6.95     | 54   | 87   | 48    |      |
|                           | average      | Inf.     | 7.09 | 289  | 469   | 232  |
|                           | Eff.         | 8.18     | 57   | 92   | 51    |      |
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| Location                          | Morning | Night | Average |
|----------------------------------|---------|-------|---------|
| Hurghada - Red Sea               | Inf. 8.00 | Eff. 8.90 | Inf. 6.10 | Eff. 6.80 | Inf. 7.20 | Eff. 8.00 |
|                                 | 253 101 | 229 75 | 240 68 | 200 78 | 580 1182 | 1100 1070 |
| Sharm El Sheikh                  | Inf. 8.08 | Eff. 8.98 | Inf. 6.14 | Eff. 6.83 | Inf. 7.20 | Eff. 8.00 |
|                                 | 253 101 | 229 75 | 118 118 | 67 118 | 580 1182 | 1100 1070 |
| Abu Rudeis - South Sinai         | Inf. 6.9 | Eff. 7.8 | Inf. 6.96 | Eff. 7.9 | Inf. 6.93 | Eff. 7.85 |
|                                 | 300 80 | 32 30 | 260 30 | 35 30 | 820.5 374 | 77.5 34 |
| Al Arish - North Sinai           | Inf. 7.81 | Eff. 8.89 | Inf. 5.94 | Eff. 6.83 | Inf. 6.96 | Eff. 8.00 |
|                                 | 203 58 | 183 52 | 192 55 | 36 55 | 401 1072 | 55 1476 |

IV. DISCUSSIONS

The study conducted to stand upon the current situation of the visited plant, to check the actual removal efficiency. Then compare results against the design criteria and compare it with the theoretical removal ratio, so the comparison was conducted in four steps by applying four different conditions:

1. The first was applying Mara equation (depending on pond sizing) with respect to the actual flow to calculate the SLR for the current situation and was called “current”.
2. The second was applying Mara equation (depending on pond sizing) with respect to the designed flow, and this was to check the SLR for the studied plant as per designed and was called “designed”.
3. The third was applying Mara equation (depending on temperature) with respect to the designed flow, and this was to check the SLR for the studied plant and show the effect of the temperature on the plant efficiency and SLR and was called “Mara”.
4. The fourth was applying ElNadi & Abd El Azim (NA) equation with respect to the designed flow, and this was to check the SLR for the studied plant and show the effect of the NA equation on the plant efficiency and SLR and examines the validity of this equation and was called “NA”.

Mainly, the main point that could illustrate this is the climatic conditions of Egypt that differs than the other countries which the design equations for such system depends on its weather conditions.

This leads to change the design equation for the system according to the country climatic conditions (mainly average air temperature and may be humidity) in addition to the main design parameters as organic load and hydraulic load.

The effect of country weather seems to be high in all the studied sites that raises the need to investigate the possibility to have a special design equation for Egypt. This could be also leads to divide Egypt to north zone weather and south zone weather. But our trials will concentrate to produce one equation could be applied for the whole Egypt weather and similar areas as Arab countries.

The NA equation is the only equation produced from Egyptian experiment and applications. So, it was the start for our trials for all sites producing results shown in table (6). For the NA equation was built on one site data so it can not be suitable for all Egyptian sites but it will be a good start. This what made Ismail [22] to investigate other sites around Egypt and confirm the applicability of NA equation with error varied between +17% & -23% which is good as a start but not sufficient to be Egyptian equation.

To produce an Egyptian Equation simulates the effects of climatic conditions of Egypt on the facultative stabilization ponds design, a comparing between the SLR that produced from the applied NA equation of 2(20T-60), where T is the average temperature all over the year, was made with SLR that obtained from the traditional optimum equation of current step, that achieved very close values. These comparison shown in table (6) as follows.
The difference was slightly small and move on range with limited margin. This indicates that the NA constant could be modified to be a variable called K varied between 1.5 and 3.2 to simulate the results happened under Egyptian conditions for all studied sites around Egypt.

A revision with the plants efficiency and loadings in each site was made to determine K variable value affected parameters.

The results produce that the equation variable K is affected by the BOD removal ratio and its influent concentration. This could be simulated by a variable called organic load factor (K) calculated as follows:

\[ K = \frac{\text{BOD influent in ppm}}{\text{BOD Removal efficiency as } \%} \]

And used instead of NA constant number as a variable depends on the site and loading in the equation. Accordingly the Egyptian equation for facultative WSP design could be presented as follows:

\[ \text{SLR} = K \times (20T - 60) \]

Where

- \( K \) is Organic Load factor = 1.5 – 3.2
- \( T \) is the average temperature all over the year.

It was found that reduced pond retention could work perfectly with climate conditions in Egypt. Conclusions were drawn to suggest a modification on the design equation of the facultative stabilization ponds to meet Egyptian circumstances. This leads to the use either minimum retention period or higher limit of volumetric organic loading that will benefit the minimization of area needed for such treatment plant on increasing the capacity of existing plants.

**CONCLUSIONS**

The study covered eight WSP treatment plants in different locations covering all Egypt climate conditions. They were monitored and evaluated with respect to ponds retention time and prevailing climate temperature and humidity conditions.

The main conclusions drawn from these results and discussions were:

1. Reduced pond retention time could work perfectly with operating climate conditions in Egyptian circumstances.
2. Hot climate may allow for better environment and operation condition for the behavior and performance of the stabilization ponds.
3. Surface loading rate of the facultative pond may be calculated by a modified equation that applied the average temperature with a correction factor ranging between 1.5 to 3.2 that making the equation:

\[ \text{SLR} = K \times (20T - 60). \]

Where

- \( K \) is Organic Load factor = \( \frac{\text{BOD influent}}{\text{Removal efficiency}} \) = 1.5-3.2
- \( T \) is the average temperature all over the year.

4. This show the possibility to decrease the pond retention time with no drop in the plant efficiency due to the good climate conditions this may lead to decrease in the area needed for the plant.
5. This also may raise the application of such technique in Egypt after the land & cost saving resulted from this study.

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