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Removal of escherichia coli using waste stabilization pond: A simulation in climatic conditions of Libya

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Abstract. The most important determinant when recycling of wastewater for agriculture is that related to public health. This paper investigates the removal of Escherichia Coli/coliform in the waste stabilization pond as simulation as assessing of mitigating health risk. A case study in climatic conditions of Libya. As a result of a computer program based waste stabilization pond design based on parameter uncertainty and 10,000-trial Monte Carlo simulations, were developed for a series of anaerobic, facultative and maturation ponds to produce on a 95%-ile value <1000 *E. Coli* per 100 ml. While a number of influent of *E. Coli* bacteria was (156.732×10^6 *E. Coli* /100ml). Where it decreased was a number of the effluent (10 *E. Coli* /100ml). Where the efficiency of removal *E. Coli* bacteria was (99.999 %). And the overall hydraulic retention time it took 89.548 days in the anaerobic pond, facultative pond, first maturation pond and twelve of the subsequent maturation ponds. To satisfy practice 2006 WHO guidelines for the safe use of wastewater in agriculture.

1 Introduction

Water is becoming scarcer and scarcer in developing countries and also in parts of some industrialized countries. In arid and semi-arid areas especially, but in fact, everywhere, wastewater is simply too valuable to waste. It contains scarce water and valuable plant nutrients, and crop yields are higher when crops are irrigated with wastewater than with freshwater [1]. Treated wastewater is used for crop irrigation in many parts of the world. and in the desert areas of the US, such as Arizona and California, there are large wastewater re-use schemes [2]. Australia is another good example [3]. In most of the countries of the Mediterranean region, wastewater is widely reused at different extents within planned or unplanned systems. In many cases, raw or insufficiently treated wastewater is applied. In other cases, wastewater treatment plants are often not functioning or overloaded and thus discharge effluents not suitable for reuse applications. This leads to the existence of health risks and environmental impacts and the prevalence of water-related diseases [4]. In Libya, At Hadba El Khadra (5 km from Tripoli on sandy soil), reuse of wastewater started in 1971. Wastewater is treated in a conventional treatment plant followed by sand filtration and chlorination (12 mg/L). The recycled wastewater is then pumped and stored in tanks with a 3-day storage capacity. Reuse was first conducted over 1,000 ha to irrigate forage crops and windbreaks. An additional area covering 1970 ha: 1,160 ha forage, 290 ha vegetables like potatoes, onions, lettuce, etc. and 230 ha for windbreaks and sand dune stabilization) was also irrigated with recycled wastewater. 110,000 m^3/d were applied using sprinkler irrigation (pivots). Reuse is also taking place in Al Marj (north-east of Benghazi: 50,000 inhabitants) after biological treatment, sand filtration, chlorination and storage [4, 5]. Also taking place in eastern Libya in Benghazi: (674,591 inhabitants) after biological treatment. But used treated wastewater for crop irrigation discontinued in many parts of Libya because wastewater treatment plants are often not functioning or overloaded and thus discharge effluents not suitable for reuse applications.

1.1 Waste Stabilization Ponds System

Waste stabilization ponds WSP are one of the most common types of wastewater treatment technologies worldwide, predominantly found in rural areas, small communities, and developing communities, as well as some large cities [6, 7]. WSP is shallow, rectangular lakes in which domestic and/or industrial wastewater is retained for between 10 and 100 days, depending on the climate, to allow the removal of BOD, excreted pathogens and nutrients. WSP are usually arranged in a series of anaerobic, facultative and maturation ponds to improve the efficiency of their performance [8]. WSP are shallow engineered basins (approximately 1-5 m in depth) that employ natural processes such as gravity settling, photosynthesis, microbial metabolism, and sunlight-mediated mechanisms to reduce the concentrations of organic matter (measured as biochemical oxygen demand, BOD), total suspended solids (TSS) and pathogens in wastewater [6]. The principal types of WSP are classified as either anaerobic, facultative, or maturation ponds, based on their depths,

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treatment objectives, and dissolved oxygen content. Anaerobic and facultative ponds are typically designed for biochemical oxygen demand (BOD) and total suspended solids (TSS) removal, and maturation ponds are designed for pathogen removal and further removal of (BOD) and (TSS). Maturation ponds can produce effluent with low concentrations of (BOD, TSS, and pathogens) if a series of ponds is properly designed [6].

1.2 Factors Affecting Pathogens in Waste Stabilization Ponds

Different factors affect different types of pathogens in different ways. The most important factor for the removal of viral and bacterial pathogens is sunlight exposure, although other factors such as temperature, dissolved oxygen and pH are also important. Sedimentation, hydraulic efficiency, sunlight exposure, and physical-chemical factors (including temperature and pH) are all important factors for the removal of protozoan pathogens, though sedimentation is perhaps the most important. Helminth eggs are primarily removed by sedimentation, and other factors are less important. Different pathogen types that are removed by the same mechanism are not necessarily removed at the same rate by that mechanism. For example, viruses and bacteria are both damaged by sunlight in WSP, but viruses are generally more resistant than bacteria [9, 10]. Different species of viruses and bacteria are also removed at different rates in WSPs, due to differences in their structural and genetic composition [11, 12, 13].

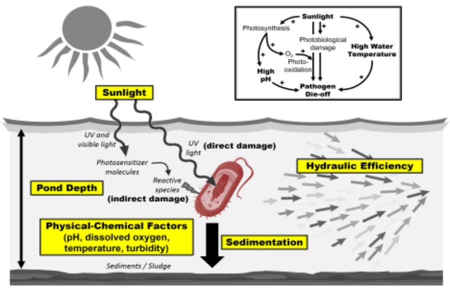

Fig. 1. Major factors affecting pathogen removal and diagram showing the influence of sunlight on pathogen die-off [14].

1.3 Summary of guidelines for the safe use of wastewater in agriculture

The 2006 WHO Guidelines [15], make the following recommendations, either explicitly or implicitly [16]:

1. To protect the health of those working in wastewater-irrigated fields against excessive risks of viral, bacterial and protozoan infections, there should be a 3−4-log unit pathogen reduction, which is to be achieved by wastewater treatment.
2. To protect the health of those consuming wastewater-irrigated food crops against excessive risks of viral, bacterial and protozoan infections, there should be a 6−7-log unit pathogen reduction, which is to be achieved by a wastewater treatment (a 3−4-log unit reduction as for restricted irrigation) supplemented by post-treatment healthprotection control measures providing together a further 2−4-log unit pathogen reduction.
3. To protect the health of those working in wastewater-irrigated fields and those consuming wastewater-irrigated food crops against excessive risks of helminthic infections, the treated wastewater should contain ≤1 human intestinal nematode egg per litre.

2 Materials and method

2.1 Location and climate

This study was carried on climatic conditions of Libya, were Jalu city is a place of wastewater sampling. Jalu is a small municipality with a population of 18873 in 2006. Located in the central South-East of Libya, as shown in Figure 2. The climatic conditions as showing in table 1. The main economic activity in Jalu municipality is agriculture.

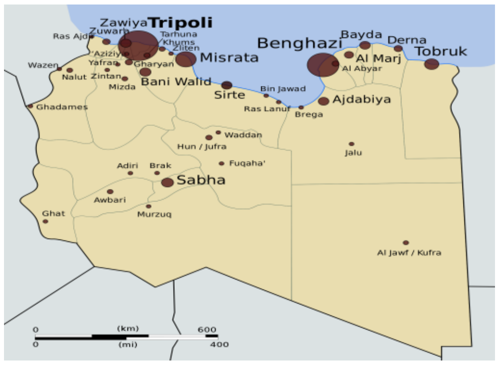

Fig. 2. A map showing the located Jalu city in Libya.

Table 1. The climatic conditions at Jalu, Libya.

Parameters	Lower value	Upper value
temperature	1 ºC	48 ºC
evaporation	0.43 mm/day	23.1 mm/day
Net evaporation	- 3.9 mm/day	23 mm/day
Average Rainfall	18.4 mm/day	

Source: Libyan national meteorological center [17].

2.2 Analyses

The samples were stored in a cooler during the transfer to the laboratory. When the samples arrived at the laboratory, sample preparations for the pathogen tests were performed immediately to minimize changes in the microbiology of the samples. Examination the samples were as the American public health association standard methods for the examination of water and wastewater [18]. Wastewater analyzed included (See table 2) biological oxygen demand (BOD), chemical oxygen demand (COD), coliform bacteria (MPN/100 ml).

Table 2. Wastewater composition at Jalu, Libya.

Parameters	Median value
BOD (mg L^{-1})	225
COD (mg L^{-1})	249
Coliform bacteria (MPN/100 mL)	$11×10^7$

Note: MPN stands for: most probable number.

2.3 A computer program using Monte Carlo simulation methods

Banda and Banda et al. Have suggested that using modern methods for designing waste stabilization ponds WSP whose final effluent is to be used for the irrigation in developing countries [19, 20]. There is commonly some degree of uncertainty about the values of the parameters used to determine required log pathogen reductions. According to Von Sperling, that Monte Carlo simulation should be used when designing WSP because it is an efficient way to manage the uncertainty of the input design variables and coefficients. [21]. In this way, was the development of MATLAB a computer program for design waste stabilization ponds (See flowchart).

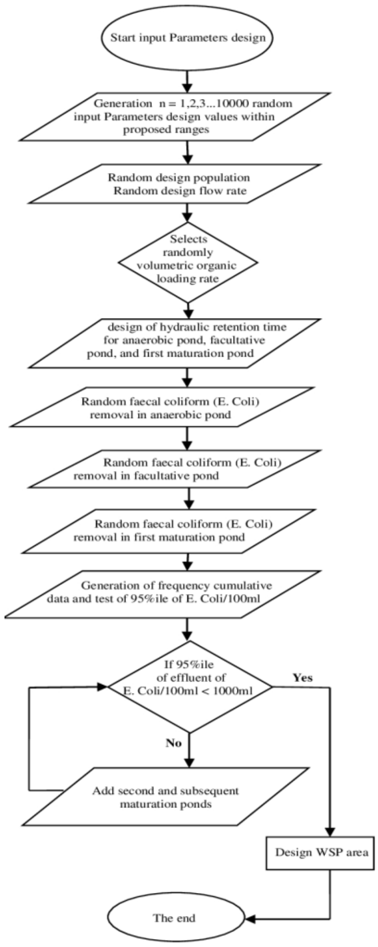

Fig. 3. Flowchart for the Monte Carlo simulation

The Monte Carlo simulation methods work by selecting at random a value of each input design parameter and the coefficient of the models within a specified range, the ranges based on (± 50 %) for *E. Coli*/ coliform. Other parameters based on (± 20 %). The procedures, based on parameter uncertainty and 10,000-trial. PC-based was developed for a series of anaerobic, facultative and maturation ponds. Finally, the output data were statistically analyzed as frequency cumulative data. The 95-%ile value of effluent faecal coliform is selected from the frequency cumulative data and is compared with 2006 WHO guidelines. If the effluent faecal coliform (*E. Coli*) concentration is more than 1000 *E. Coli* per100ml, the computer program adds subsequent maturation ponds until to satisfy the 2006 WHO guidelines for the safe use of wastewater in agriculture.

2.3.1 The design equations

Generation the input design range: Monte Carlo simulation uses a uniform probability distribution to generate a range of the input design parameter. Vose [22], suggested that the cumulative probability distribution function for a uniform distribution of any range that has known end values could be expressed as an equation:

$$F(x) = \frac{x - A}{B - A} \tag{1}$$

where:
x = any random input design value within a range.
A = the lower input design value of a range.
B = the upper input design value of a range.

Monte Carlo simulation utilizes the inverse function of the cumulative density function, which according to Vose [22], is given in equation as follows:

$$F^{-1}(x_i) = A + (B - A)v_i \tag{2}$$

$$x_i = A + (B - A)v_i$$

where:
v_i = any random number value (0 - 1).

The input range of the design parameters: Von Sperling [21], recommends that the lower and upper design values of the proposed range be determined by assuming a percentage value, which reflects the level of uncertainty of the average deterministic single value. the equations as follows:

$$X_{min} = \overline{X} - a\,\overline{X} \tag{3}$$

$$X_{max} = \overline{X} + a\,\overline{X} \tag{4}$$

where:
X_{min} = lower end value of the input design range.
X_{max} = upper end value of the input design range.
$\overline{X}$ = average value of the input design parameter.
a = any assumed percentage value based on the level of the uncertainty.

Design population: The design population is established by using equation as follows:

$$P_d = P_o(1 + r)^n \tag{5}$$

where:
P_d = design population of the served community.
P_o = initial population of the served community.
r = population growth rate.
n = design period of waste stabilization ponds.

Design flow: The values of the population range are then used in equation for establishing the design flow range as follows:

$$Q = \frac{P_d\,q}{1000} \tag{6}$$

where:
Q = design flow rate (m^3/day).
P_d = design population.
q = per capita wastewater production (l per person per day).

Volumetric organic loading: At every run of a simulation, the computer program selects randomly the temperature from the proposed range and the selected temperature is compared with the four temperature conditions as suggested by Mara and Pearson [23], and Mara et al. [24].

The first temperature condition is satisfied when the selected random temperature (T) <10°C as presented as follows:

$$\lambda_v = 100 \quad (7)$$
$$(L_i)_f = 0.6\ (L_i)_a \quad (8)$$
$$(L_i)_{m1} = 0.3\ (L_i)_a \quad (9)$$

where:
λ_v = volumetric organic loading rate (g/m^3 day).
$(L_i)_a$ = random design value of influent BOD in anaerobic pond (mg/l).
$(L_i)_f$ = influent BOD in facultative pond (mg/l).
$(L_i)_{m1}$ = influent BOD into first maturation pond (mg/l).

The second temperature condition is satisfied when the selected random temperature is between 10 and 20°C as presented as follows:

$$\lambda_v = 20\ T - 100 \quad (10)$$

$$(L_i)_f = \frac{100 - (2\ T + 20)}{100} \times (L_i)_a \quad (11)$$

$$(L_i)_{m1} = 0.3\ (L_i)_a \quad (12)$$

where:
T and $(L_i)_a$ are random design parameters.

The third temperature condition is satisfied when the selected random temperature is between 20 and 25°C as presented as follows:

$$\lambda_v = 10\ T + 100 \quad (13)$$

$$(L_i)_f = \frac{100 - (2\ T + 20)}{100} \times (L_i)_a \quad (14)$$

$$(L_i)_{m1} = 0.2\ (L_i)_a \quad (15)$$

where:

T and $(L_i)_a$ are random design parameters.

The fourth temperature condition is satisfied when the selected random temperature is above 25°C as presented as follows:

$$\lambda_v = 350 \quad (16)$$
$$(L_i)_f = 0.3\ (L_i)_a \quad (17)$$
$$(L_i)_{m1} = 0.2\ (L_i)_a \quad (18)$$

where:

$(L_i)_a$ is a random design parameter.

The hydraulic retention time: The determination of the random value of the hydraulic retention time for the anaerobic pond is calculated as follows:

$$\Theta_a = \frac{(L_i)_a}{\lambda_v} \quad (19)$$

where:
the design parameters L_i, and λ_v are random values selected from a proposed range in order to determine the random hydraulic retention time in anaerobic pond.
θ_a = hydraulic retention time (days).
L_i = influent BOD concentration (mg/l).
λ_v = volumetric BOD loading (g/m^3 day).

The procedures for calculating the random hydraulic retention time for the facultative pond are presented as follows:

$$\lambda_{sf} = 350(1.107 - 0.002T\ )^{T-25} \quad (20)$$

$$A_f = \frac{10\ (L_i)_f\ Q_f}{\lambda_{sf}} \quad (21)$$

$$\Theta_f = \frac{2\ A_f\ H_f}{(2\ Q_f - 0.001e\ A_f)} \quad (22)$$

where:
the subscript "f" refers to facultative pond.
the parameters T, $(L_i)_f$, Q_f, λ_{sf}, A_f and e are random design values.
θ_f = hydraulic retention time in facultative pond (days).
λ_{sf} = surface BOD loading (kg/ha day).
T = temperature (°C).
A_f = facultative pond area (m^2).
$(L_i)_f$ = influent BOD concentration in the facultative pond (mg/l).
Q_f = mean flow (m^3/day).
H_f = pond depth (m).
e = net evaporation (mm/day).

The procedures for calculating the random hydraulic retention time for the first maturation pond are presented as follows:

$$\lambda_{sf} = 350(1.107 - 0.002T\ )^{T-25} \quad (23)$$

$$\Theta_{m1} = \frac{10\ (L_i)_{m1}\ H_{m1}}{0.75\ \lambda_{sf}} \quad (24)$$

where:
the subscript "$m1$" refers to first maturation pond.
the parameters T, $(L_i)_{m1}$ and λ_{sf}, are random design values.
θ_{1m}= minimum hydraulic retention time in first maturation pond (days).
H_{m1}= design depth of the first maturation pond (m).
$(L_i)_{m1}$ = influent BOD concentration in first maturation pond (mg/l).

λ_{sf} = surface BOD loading in facultative pond (kg/ha day).

The random design values of the hydraulic retention time in the second and subsequent maturation ponds is selected from the minimum retention time range of 3 to 5 days, as recommended by Marais [8].

The faecal coliform removal: The effluent faecal coliform concentration in the anaerobic ponds is carried out by applying the empirical equation of Mara [25]. as presented as follows:

$$(N_e)_a = \frac{(N_i)_a}{(1 + K_{FCT}\,\phi^{(T-20)}\,\Theta_a)} \quad (25)$$

where:
the design parameters N_i, θ_a, T, K_{FCT} and ϕ are random values selected from proposed range,
$(N_e)_a$ = effluent faecal coliform concentration (per 100 ml).
N_i = influent faecal coliform concentration (per 100 ml).
K_{FCT} = first-order rate constant for faecal coliform removal (day^{-1}) = (2.0 at 20 ^{oC}).
ϕ = temperature coefficient for faecal coliform removal = 1.07
Θ_a = hydraulic retention time (days).
T = air temperature (ºC).

The faecal coliform removal in the facultative pond and maturation ponds based on a dispersed hydraulic flow regime using Von Sperling.s empirical equation of the dispersion number model [26]. and the Arrhenius equation (equation 30). The first-order equation of Wehner and Wilhelm [27]. as presented in equations as follows:

The effluent faecal coliform concentration in the facultative pond as presented as follows:

$$(N_e)_f = (N_e)_a \times \left(\frac{4a_f\, e^{\frac{1}{2df}}}{(1+a_f)^2\, e^{\frac{a_f}{2df}} - (1-a_f)^2\, e^{\frac{-a_f}{2df}}} \right) \quad (26)$$

$$a_f = \sqrt{(1 + 4\, K_{FCTf}\, \Theta_f\, d_f)} \quad (27)$$

$$d_f = \frac{1}{\left(\frac{L}{W}\right)_f} \quad (28)$$

$$K_{FC\,20\,f} = 0.91\, H_f^{\,-0.877}\, \Theta_f^{\,-0.329} \quad (29)$$

$$K_{FC\,T\,f} = K_{FC\,20\,f}\, \phi^{(T-20)} \quad (30)$$

where:
the subscript "f" refers to facultative pond.
$(N_e)_f$ = effluent faecal coliform concentration (per 100 ml).
$(N_e)_a$ = influent faecal coliform concentration (per 100 ml).
$K_{FC\,T\,f}$ = faecal coliform die-off rate at temperature T ºC.
$K_{FC\,20\,f}$ = faecal coliform die-off rate at 20ºC.
H_f = pond depth (m).
ϕ = temperature coefficient for faecal coliform removal = 1.07
d_f = dispersion numbers.
L = pond length (m).
W = pond breath (m).
θ_f = hydraulic retention time (days).
T = air temperature (ºC).

The effluent faecal coliform concentration in first maturation pond as presented as follows:

$$(N_e)_{m1} = (N_e)_f \times \left(\frac{4a_{m1}\, e^{\frac{1}{2d\,m1}}}{(1+a_{m1})^2\, e^{\frac{a_{m1}}{2dm1}} - (1-a_{m1})^2\, e^{\frac{-a_{m1}}{2dm1}}} \right) \quad (31)$$

$$a_{m1} = \sqrt{(1 + 4\, K_{FCT\,m1}\, \Theta_{m1}\, d_{m1})} \quad (32)$$

$$d_{m1} = \frac{1}{\left(\frac{L}{W}\right)_{m1}} \quad (33)$$

$$K_{FC\,20\,m1} = 0.91\, H_{m1}^{\,-0.877}\, \Theta_{m1}^{\,-0.329} \quad (34)$$

$$K_{FC\,T\,m1} = K_{FC\,20\,m1}\, \phi^{(T-20)} \quad (35)$$

where:
the subscript "$m1$" refers to first maturation pond.
$(N_e)_{m1}$ = effluent faecal coliform concentration (per 100 ml).
$(N_e)_f$ = influent faecal coliform concentration (per 100 ml).
$K_{FC\,T\,m1}$ = faecal coliform die-off rate at temperature T ºC.
$K_{FC\,20\,m1}$ = faecal coliform die-off rate at 20ºC.
H_{m1} = pond depth (m).
ϕ = temperature coefficient of faecal coliform removal = 1.07
d_{m1} = dispersion numbers.
L = pond length (m).
W = pond breath (m).
θ_{m1} = hydraulic retention time (days).
T = air pond temperature (ºC).

The effluent faecal coliform concentration in second and subsequent maturation ponds as presented as follows:

$$(N_e)_m = (N_e)_{m1} \times \left(\frac{4a_m\, e^{\frac{1}{2d\,m}}}{(1+a_m)^2\, e^{\frac{a_m}{2dm}} - (1-a_m)^2\, e^{\frac{-a_m}{2dm}}} \right)^n \quad (36)$$

$$a_m = \sqrt{(1 + 4\, K_{FCT\,m}\, \Theta_m\, d_m)} \quad (36)$$

$$d_m = \frac{1}{\left(\frac{L}{W}\right)_m} \quad (37)$$

$$K_{FC\,20\,m} = 0.91\, H_m^{\,-0.877}\, \Theta_m^{\,-0.329} \quad (38)$$

$$K_{FC\,T\,m} = K_{FC\,20\,m}\ \phi^{(T\text{-}20)} \quad (39)$$

where:
the subscript "m" refers to second and subsequent maturation ponds.
$(N_e)_m$ = effluent faecal coliform concentration (per 100 ml).
$(N_e)_{m1}$ = influent faecal coliform concentration (per 100 ml).
$K_{FC\ T\ m}$ = faecal coliform die-off rate at temperature T ºC.
$K_{FC\ 20\ m}$ = faecal coliform die-off rate at 20ºC.
H_m = pond depth (m).
ϕ = temperature coefficient of faecal coliform removal = 1.07
d_m = dispersion numbers.
L = pond length (m).
W = pond breath (m).
θ_m = hydraulic retention time (days).
T = air pond temperature (ºC).
n = number of second and subsequent maturation ponds.

Additionally, the efficiencies of the various parameters were calculated as presented as follows:

$$\eta = \frac{C_r - C_f}{C_r} \times 100 \quad (41)$$

where
η = removal or reduction efficiency in %.
C_r = the concentration in the raw wastewater.
C_f = the concentration in the final pond effluent.

3 Results and discussion

The results of the Monte Carlo simulations are given in Table 3 based waste stabilization pond design based on parameter uncertainty and 10,000-trial. Were shown a low efficiency of the anaerobic pond in the removal of *E. Coli* bacteria which (19.735 %) while a number of influent was (156.732×10^6 *E. Coli* /100ml). A hydraulic retention it took (2.855 days), and the effluent was (125.800×10^6 *E. Coli* /100ml).

Also, low efficiency of the facultative pond in the removal of *E. Coli* bacteria which a total removal efficiency (38.848 %) with a hydraulic retention time (21.049 days) while a number of the effluent (See figure 4) was (95.844×10^6 *E. Coli* /100ml). Reasons that can explain the low efficiency Because anaerobic and facultative ponds are designed for removal of biochemical oxygen demand (BOD) and maturation ponds for pathogen removal. However, some BOD removal also occurs in maturation ponds and some pathogen removal in anaerobic and facultative ponds [28]. On the other hand, A series of anaerobic and facultative ponds can treat wastewater to a sufficient degree to allow it to be used in a restricted way for irrigating crops [29]. Anaerobic and facultative ponds only a relatively weak wastewater (up to 150 mg BOD/l). Maturation ponds are required only when the treated wastewater is to be used for unrestricted irrigation and when stronger wastewaters (BOD > 150 mg/l) [6, 30].

Table 3. Summary of data PC-Monte Carlo simulations on *E. Coli* removal in waste stabilization ponds.

Pond type	Area (ha)	Retention time (d)	Effluent *E. Coli* (100 ml)	Total Efficiency (%)
Influent wastewater	—	——	156.732×10^6	——
Anaerobic Pond	0.418	2.855	125.800×10^6	19.735
Facultative Pond	9.942	21.049	95.844×10^6	38.848
First maturation Pond	6.986	7.453	76.664×10^6	51.085
First addition maturation Pond	4.754	4.850	49.779×10^6	68.239
Second addition maturation Pond	4.898	4.849	29.316×10^6	81.295
Third addition maturation Pond	4.955	4.850	14.578×10^6	90.698
Fourth addition maturation Pond	4.566	4.849	6.087×10^6	96.116
Fifth addition maturation Pond	5.145	4.849	2.134×10^6	98.638
Sixth addition maturation Pond	5.161	4.849	6.285×10^5	99.598
Seventh addition maturation Pond	5.296	4.849	1.554×10^5	99.900
Eighth addition maturation Pond	5.859	4.849	3.227×10^4	99.979
Ninth addition maturation Pond	5.756	4.849	5.627×10^3	99.996
Tenth addition maturation Pond	5.490	4.849	824	99.999
Eleventh addition maturation Pond	5.999	4.849	102	99.999
Twelfth addition maturation Pond	5.900	4.850	10	99.999
The overall	**81.125 ha**	**89.548 days**	**10 *E. coli* per 100 ml**	**99.999 %**

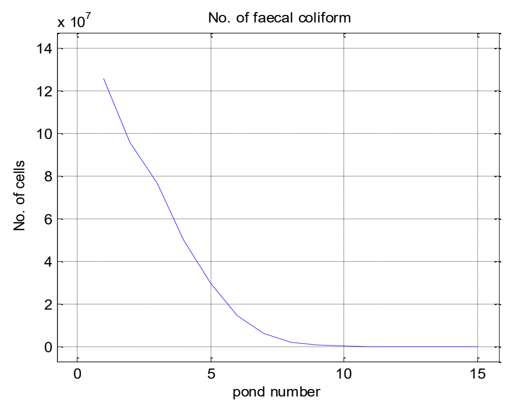

Fig. 4. The effluent of *E. coli* from WSP.

The extremely high removal of *E. Coli* in maturation ponds is shown in Table 3. While in the first maturation pond (See figure 5) a total removal efficiency (51.085%) and the effluent was (76.664×10^6 *E. Coli* /100ml) with a hydraulic retention time (7.453 days), but the effluent *E.*

Coli concentration in the first maturation pond still more than 2006 WHO guidelines. However, the computer program adds subsequent maturation ponds with a hydraulic retention time between (4.849 days) to (4.850 days) until to satisfy 2006 WHO guidelines − for example, The efficiency dramatically rose in subsequent maturation ponds where from (68.239%) a total removal efficiency in the first addition maturation pond with effluent (49.779×10^{6} *E. Coli* /100ml). And reach to (99.999 %) in the twelfth addition maturation pond, which the effluent E. Coli concentration was (10 *E. Coli* /100ml), which becomes less than 2006 WHO guidelines for the safe use of wastewater in agriculture. Possible reasons that can explain the high removal of *E. Coli* in maturation ponds because the maturation ponds are typically aerobic throughout their depth. shallower ponds achieve higher faecal bacterial removals due to greater light penetration. Sunlight is one of the most important factors for pathogen removal in (WSP).
Thus, the clarity of the water in WSP and the amount of sunlight penetration is a very important factor. *E. Coli* loses viability almost 20 times faster in WSP with sunlight exposure compared to dark conditions, and it is also inactivated faster in shallower WSP [31]. Although the sedimentation is more effective in WSP with less turbulence. While the WSP systems have hydraulic retention times on the order of days, weeks, or even months, which allows particles to sedimentation [14]. Moreover, there are other factors is important for bacterial pathogens removal in WSP. The physical-chemical factors are most important for pathogen inactivation are pH, temperature and dissolved oxygen in the presence of dissolved organic matter [32].

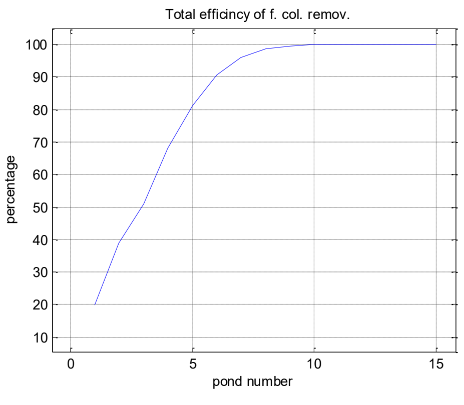

Fig. 5. The total efficiency of remo.

4 Conclusions

In conclusions, that 89.548 days waste stabilization pond WSP in climatic conditions of Libya at Jalu municipality (anaerobic pond, facultative pond, first maturation pond and twelfth of the subsequent maturation ponds) produces an effluent less than 2006 WHO guidelines for the safe use of wastewater in agriculture. Finally, the recycling of wastewater for agriculture may result in too high economic benefits that can offset the operation and maintenance costs of the ponds. However, there are also negative aspects related to wastewater reuse which include soil salinity, the health of farmers and consumers, public acceptability, marketability of produce, economic feasibility and sustainability of wastewater irrigation.

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